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(Eighth International Scientific-Technical Conference)
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- University of Studies of Campania "Luigi Vanvitelli", Italy;
- University of Florence, Italy;
- University of Lisbon, Portugal;
- Riga Technical University, Latvia;
- University of Ioannina, Greece.

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The proceedings are containing the papers of the authors from Czech Republic, Greece, France, Italy, Latvia, Portugal, Russia, Ukraine, which were selected by the International Scientific Committee.
The papers were included to the main congress proceedings after an anonymous peer-review by two members of the International Scientific Committee.

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- Waste management;
- Life safety;
- Noise and vibration control;
- Ecological education;
- Sustainable development.

PEER REVIEW

Scolars has been invited to submit researches on theoretical and methodological issues related to ecology and life protection of industrial-transport complexes and show advanced experience and achievements in this field. Based on the blind peer review, abstracts has been accepted, conditionally accepted or rejected.
Authors of accepted and conditionally accepted abstracts have been invited to submit full papers. These have been again peer-reviewed and selected for the publications in the main conference proceedings or for the publications in the symposia in framework of the congress.

CONGRESS REPORTS

More than 250 abstracts and papers and more than 400 authors from Czech Republic, Greece, France, Italy, Latvia, Portugal, Russia, Ukraine, Belarus, Kazakhstan.

41 selected papers have been published in congress main proceedings after double blind review by the International Scientific Committee.

113 scientists are authors of congress main proceedings.

PREFACE

The ELPIT conferences project started in September 2003. Since that time in interval every two years conferences are arranging in Samara region of Russia and increasing the scale. In year of 2007 ELPIT conference has received the name of the international congress. Now ELPIT Congress became the largest event in the field of ecology and of environmental and life protection in Russia (over 1500 participants from USA, Italy, France, Germany, Denmark, Latvia, Greece, Spain, Poland, South Africa etc.). ELPIT-2017 congress is continuing such good tradition. Main congress organizers are the leading scientific centre of fundamental research of Russia - Russian Academy of Science, presented by Samara Scientific Center and Institute of Ecology of Volga Basin; and Ministry of science and education of Russian Federation, presented by one of the biggest universities of Russia, having the flagship university - Samara State Technical University. Among of the other congress organizers are International Academy of Ecology and Life Protection Sciences (IAELPS), famous european universities.

The International Scientific Committee of the congress includes outstanding scientists from the leading scientific institutions and universities.

The proceedings are containing the papers of the authors from Czech Republic, Greece, France, Italy, Latvia, Portugal, Russia, Ukraine, which were selected by the International Scientific Committee after an anonymous peer-review by two members of the Committee.

Andrey V. Vasilyev,
Doctor of Technical Science,
Professor, Congress Scientific Head

SIXTH INTERNATIONAL ENVIRONMENTAL CONGRESS ELPIT-2017

20-24 September 2017, Samara-Togliatti, Russia

OBJECTS OF ACCUMULATED ENVIRONMENTAL DAMAGE AS A FACTOR OF REDUCING ECOLOGICAL AND ECONOMIC EFFICIENCY OF URBANIZED TERRITORIES USE

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ABSTRACT

In the market-driven economy, economic mechanisms for regulating land use and land relations in cities come to the fore. The technogenic impact on the environment, which has grown to a global scale, leads to the emergence of land in towns with "accumulated" environmental damage. The presence of objects of accumulated environmental damage can lead to emergencies, negatively affects the health of the urban population and influences the possibility and cost-effectiveness of land use. However, existing methods for assessing the efficiency of urbanized areas use focus on economic indicators, and there are no environmental indicators in this methodology. This leads to an underestimation of the environmental component during planning the use of the territory.

Key words: accumulated ecological damage, lands of settlements, pollution of lands

Currently, urbanized areas are the main human habitat. More than 50% of the world population lives in the territories of megacities. Urban areas are marked by a significant change in the components of the natural environment, in the territory of cities there are land plots that represent objects of past or "accumulated" environmental damage (AED). Such objects include large areas of land contaminated with hazardous chemical waste, radioactive elements, petroleum products, heavy metals, etc., which affects the health of the urban population.

In market-driven economy, while creating a new urban infrastructure, economic mechanisms for regulating land use and land relations come to the fore. An important role is played by the price of land, which becomes a powerful incentive for the redistribution of land in order to use it effectively. The larger the city, the higher its area and population, the greater the differentiation of the value of land in the center of the city and on its outskirts. The ratio of land prices in the central and peripheral parts of major cities can reach 10: 1 or more. Therefore, at present, there is a decrease in the share of industrial zones in the central part of cities. The high price of land in the center, a large area, a low number of jobs per unit of land area, significant costs for environmental activities - all this makes the products of enterprises uncompetitive. There is a process of redeployment of industrial enterprises from the central regions of cities to the outskirts. At the same time, large land plots of former industrial zones are being vacated, which are often used for residential development [1].

The changes in the political system in the country lead to change of the owners of these lands, and enterprises using the territory with the NEU now often do not want to bear the financial costs for improving the environmental situation, preventing the consequences of the damage caused to the environment earlier. At the same time, the effects accumulated as a result of long-term irrational treatment of resources can lead to emergencies that require prompt response. The interest of scientists in this field is confirmed by a number of publications [2]. The solution of environmental and economic problems applied to the objects of individual industries, territories and in general for Russia is one of the most important problems determining development in the medium- and long-term context.

Accumulated environmental damage (AED) is the monetary damage caused to the environment or its components as a result of economic and other activities, including as a result of violation of environmental legislation, as well as losses (costs) for eliminating and preventing the negative consequences of the harm done to the Environment. The objects with the past (accumulated) environmental damage are contaminated areas (including unattended ones) that were formed as a result of past economic activity, as well as waste disposal sites and other objects (contaminated land plots, buildings, structures around which pollution has formed or themselves polluted), where the activities under the management of the organization were carried out in the past, and on which waste remains, currently affecting the natural environment.

According to [5], currently in the economic practice, while determining the cadastral value of agricultural land, their ecological state is practically not up for, in contrast to the cadastral valuation of the settlements' lands, where the ecological state (the state of the environment) is one of the main pricing factors. Besides, today there is no integrated, updated and systematized information on natural objects and territories polluted as a result of economic activity and on pollution levels, which makes it impossible to assess the extent of the problem of environmental damage accumulated as a result of past economic activities and prevents adequate and integrated Solving problems on its elimination. The reason for such a serious state of affairs lies in the fact that the privatization of Russian

industrial enterprises took place without being up for the responsibility for environmental damage caused by past economic activity. Environmental damage should be considered as a socio-ecological category due to its negative impact on public health, and its elimination is currently determined not only by the requirements for preserving the environment, but also by the need to prevent the development of morbidity in the territory. 55 million people live in contaminated areas, and the total economic damage from environmental pollution as a result of past economic activity reaches 5-6% of GDP. Polluted in the past, the territories became a deterrent to economic growth, a reason for the decline in environmental ratings of the territories and, as a consequence, a barrier to foreign and domestic investment [6].

To eliminate the consequences of AED, the Federal Target Program was developed. The purpose of the Federal Target Program "Elimination of Accumulated Environmental Damage for 2014-2015" is the restoration of damaged natural systems that were previously subjected to negative anthropogenic and technogenic impacts as a result of past economic activity. Interestingly, in most countries of Western Europe and North America, the initial interest in the problem of AED and the basis for the development of special state policies and legislation in this area was the pressure of the public - as a rule, in response to situations that received a wide response, created a direct threat for the local population and caused the degradation of valuable natural resources. The basis for assessing the state of the natural environment in the impact zone of a particular territory (object) of AEDs of previous years are the results of ecoanalytical studies of the state of the main natural environment components: atmospheric air, surface and groundwaters, soils, vegetation. A great help in assessing the scale of the accumulated environmental damage can be provided by space images of ultra-high spatial resolution [7, 8].

In the methodological recommendations the classification of AED objects was given (Table 1).

One of the most dangerous contaminants of the soil cover, surface and groundwater are oil products. It is known, that their accumulation can cause serious changes in the properties of the soil, leading to a depletion of the biological diversity of the plant community, the suppression of the beneficial microflora of the soil, the appearance of toxic compounds in the process of transformation, that have carcinogenic, teratogenic and mutagenic activity. It should be noted, that the process of soil self-purification and restoration of biocoenoses is very slow and takes, as a rule, 20-40 years or more. Therefore, the on-time identification and inventory of AED facilities exposed to oil pollution is of particular importance.

Let us explain this thesis using the example of the situation described in [5]. As a result of long-term economic activity of railway infrastructure enterprises the AED -oil lens object was formed in Syzran, Samara region, where the locomotive depot is located.

The infrastructure of fuel and lubricants for diesel locomotives on the railway network was formed 50-60 years ago. During the process of exploitation of such objects, oil products leakage occurs, which appear both on the surface of the

soil and in the composition of groundwater. Spreading together with groundwater, oil pollution goes to the surface, changing the natural structure of the soil. The special environmental danger is represented by oil products that come together with groundwater into natural reservoirs, violating the conditions of ichthyofauna and flora, limiting the use of water for household and household needs. This required the adoption of operational measures to localize and eliminate oil product pollution after it was discovered on the soil surface.

Table 1 - Classification of objects of accumulated environmental damage

N	Classification criteria	Result of assessment / scores			Total score
1	The population in the nearby village from the AED object	less than 10 thousand people /1	from 10001 up to 40 thousand people /3	more than 40 thousand people /5	1-5
2	Environmental hazard class	IV-V /1	III /3	I-II /5	1-5
3.	Distance from the residential area, m	more than 10 000/1	3 000-10 000/3	up to 3 000/5	1-5
4.	The location of AED object in the territory with a special regime for the implementation of economic and other activities, as well as having a special environmental significance	not located /1		located /5	1, 5
5.	Location of AED object in the territory of the ecological disaster, emergency situations zone	not located /1		located /5	1, 5
6.	Area of the AED object (ha)	5-7 ha /1	7-12 /3	>12 ha /5	1-5

In 2011, the output of oil products increased to the surface, the plots of land and the cellars of four houses were flooded. Petroleum products appeared both on the surface of the soil and in the composition of groundwater. The situation was complicated by the location of pollution in the residential sector and the difficult terrain - a ravine with natural drains on the thalweg in the Volga River.

Pollution elimination was carried out with the use of modern technologies for cleaning soils and groundwater from oil products contamination. To intercept

the flow of lens migration, extracting oil contamination and cleaning groundwater at the site of the maximum concentration of oil products, a cleaning station operating around the clock in automatic mode was built. In addition, an observation network has been established to monitor groundwater status (13 wells) and a double-barricade has been installed to minimize the risk of oil products entering the Volga River.

All project activities carried out to clean ground and groundwater from oil products contamination required significant investments - about 35 million rubles. (more than 580 thousand dollars), including the costs of resettlement of citizens whose homes and land plots fell into the pollution zone.

The illustrated example of the liquidation of one of the AED facilities testifies to the principle possibility of carrying out highly effective measures to eliminate AED facilities and their high cost in the event of an emergency. It should be noted, that the railway is a responsible nature user with an active environmental policy and an effective system of environmental activities based on operational monitoring data. However, AED facilities, especially those associated with long-standing oil pollution of territories, have a number of features in assessing possible risks to the population and the environment.

The problem of identifying and eliminating AED facilities is very urgent not only in the Samara region, but also in many industrialized regions of Russia. Various mechanisms are used to solve environmental and economic problems, including the implementation of programs aimed at minimizing the negative impact on the environment and eliminating environmental damage associated with past economic and other activities. For example, the Federal Target Program "Elimination of Accumulated Environmental Damage for 2014-2025". The goal of the program is to restore the damaged natural systems that were previously subjected to negative anthropogenic and technogenic effects.

On the territory of the Samara region, including the territory of urban districts, there are several large AED facilities. Two of them are included in the Federal Target Program "Elemination of accumulated environmental damage" for 2014-2025. The first facility is the territory of the former "Phosphor" Inc. As a result of the implementation of the program's activities, it is planned to liquidate an orphaned hazardous waste site, recultivate the industrial site of the former "Phosphor" Inc, process 7 thousand tons of hazardous waste (including 5 thousand tons - hazard class I). At the same time, the environmental conditions for 185 thousand people will improve. The second object is located in the village of. Rozhdestveno, it is planned to recultivate the territories technogenically degraded by the unauthorized disposal of waste from the production of alcohol (60 hectares). As a result of the program activities, it is planned to ensure the environmental safety of the population (7.25 thousand people) and reduce the negative impact on the Samarskaya Luka National Park. Problematic in determining the ecological state of the territory, especially at the micro level, is an episodic approach to the collection of material on the actual state of land at the municipal level.

It should be noted that the presence of AED objects can be assumed in the territory of almost all large industrial enterprises, both existing and already

liquidated at the present time. At the same time when planning the further use of land in industrial zones, this factor is not taken into account at all. Landowners hide the existence of AED facilities, for fear of high penalties. Thus, the existing mechanism of land resources management of urbanized territories does not contribute to solving the issue of liquidation of AED facilities.

The formation of a new residential development in the territory of former industrial zones that have AED facilities not included in the relevant register, poses a real threat to environmental safety and public health. Solving this issue requires the development of a coordinated land policy based not only on economic mechanisms for land management.

The existing methodology for assessing the efficiency of land use is based on integrated indicators for assessing the effectiveness of the use of certain categories of land (for example, the volume of agricultural products to the area of agricultural land (RUR/ha), the size of the housing stock in relation to the area of land in settlements/ha), the retail trade turnover to the land area of settlements (RUR/ha), the ratio of the total volume of shipped goods of own production, works performed and By own forces by types of economic activity to the sum of the areas of industrial and other special purpose lands, lands of specially protected natural areas and the reserve (thousand rubles /ha), the volume of use of clean water to the area of water fund lands (thousand m^2/ha); Timber reserves to the area of forest land (m^3 / ha), the volume of the gross profit of the economy in relation to the area of all land resources (thousand rubles/ha), while the main emphasis is on economic indicators, and there are no environmental indicators in this methodology [9, 10].

The importance of solving the problem of liquidation of AED objects shows the fact of including this indicator in the priority project "Conservation and restoration of the Volga River" for 2017-2025, considered at a session of the Presidium of the Presidential Council for Strategic Development and Priority Projects on June 28, 2017.

As a result of the regulatory documents various programs, methodologies, articles and other sources analysis, it becomes clear that studies of complex systems, including urbanized areas, will not lead to breakthrough results in the existing paradigm, but they risk discrediting the respect of taking actions over time. In order to achieve real action in favor of the ecological components of the systems under study, it is necessary to change the paradigm by moving from the paradigm of contrasting anthropogenic systems and natural systems in the framework of the model of the ecological and economic system to the paradigm of coordinated managed development, subject to certain control restrictions [11].

The transition to a control paradigm will allow us to concretize the answers to questions posed by the person (the end user) before the socio-economic system from the position of multi-criteria control according to the chosen criteria of optimality (Figure 1).

THE PRINCIPIAL SCHEME OF AN ECOLOGICAL AND ECONOMIC SYSTEM

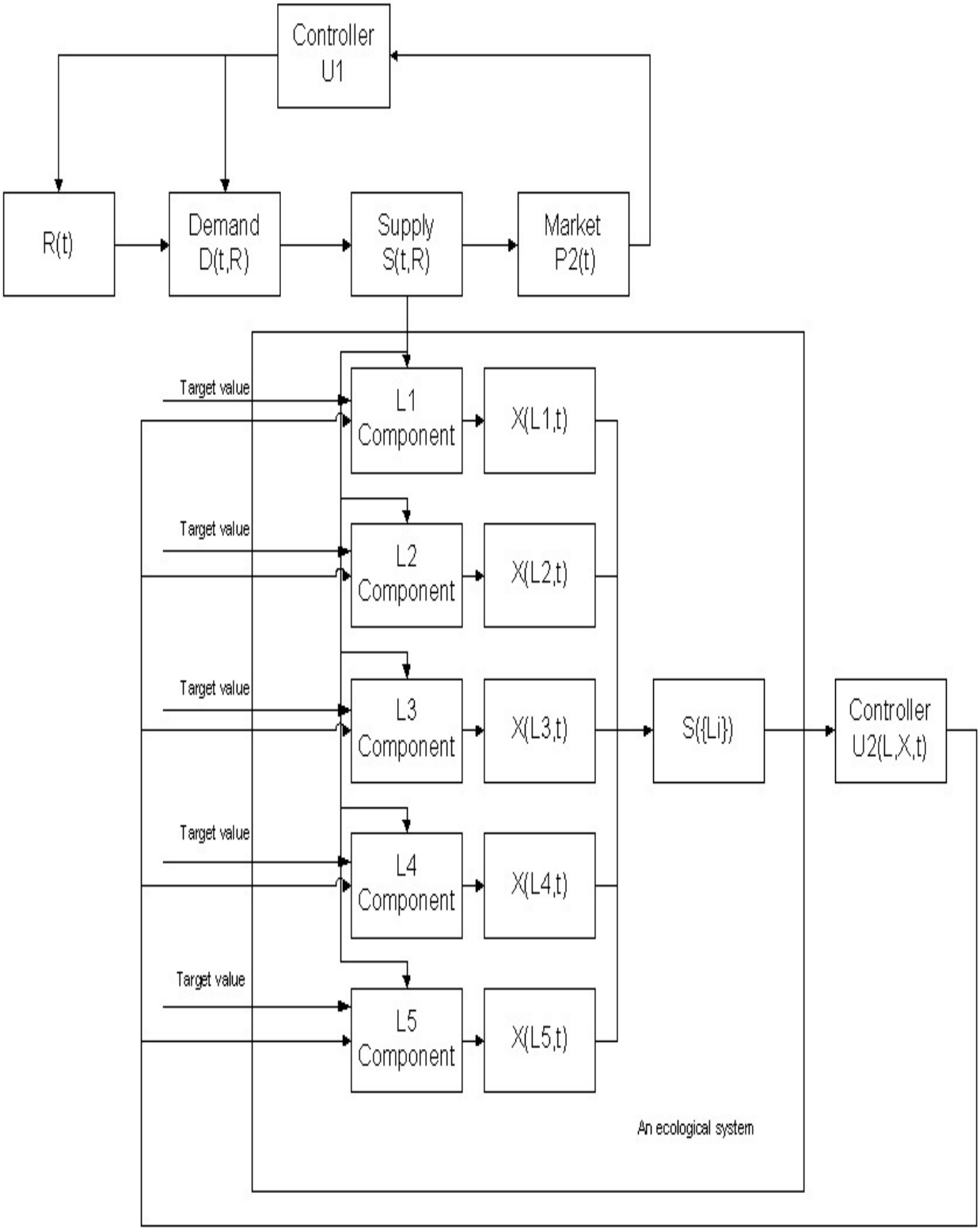

Figure 1 - Schematic diagram of the ecological and economic system [11]

Thus, the presence of objects of accumulated environmental damage is an important factor affecting the possibility and cost-effectiveness of land use, but at

present this factor is not taken into account when assessing the efficiency of land use in urbanized areas.

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EVALUATION OF POLAR AIRBORNE COMPOUNDS MONITORING BY SOLID-PHASE MICROEXTRACTION/FAST GAS CHROMATOGRAPHY

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ABSTRACT

Polar compounds require polar stationary phases to be analyzed satisfactorily. The stationary phase is the most important step in choosing a column, and should be selected based on the application to be performed. Phase selection is based on the general chemical principle that "likes dissolves like" and relates to the specific analyte-stationary phase interactions that each group of columns can perform. Derivatization render polar compounds sufficiently volatile so that they can be analyzed with conventional 5% phenyl polysiloxane column and eluted at reasonable temperatures without thermal decomposition or molecular re-arrangement. Understanding the chemistry of the analytes, derivatizing reagents used in sample preparation, and the detailed functionality of gas chromatography are important to get reliable results. The research presented a new approach for diffusive sampling of airborne polar compounds based on solid-phase microextraction (SPME) for occupational exposure assessment. It is focused on automation and miniaturization for multiple and specific fast gas chromatography analysis by flame ionization, electron capture and mass spectrometry detectors. O-(2,3,4,5,6-pentafluorobenzyl)hydroxylamine, hydrogen bromide, 1-pirenyldiazomethane on-fiber derivatization reagents for SPME sampling were studied. The automation of the procedure by new DANI Master COMBO – SPME Mode autosampler, through change of the SPME fibers, allowed a friendly use of fast GC apparatus with a number of advantages including reduced analyst time and greater reproducibility (2.31-5.79%). The detection limits were less than 0.030

µg/mc. The compared results obtained using current and standard methods were shown to be satisfactory.

Key words: solid-phase microextraction, polar compounds, air monitoring, derivatization

1. INTRODUCTION

In the last 10 years, miniaturization has attracted much attention in analytical chemistry and has driven solvent and sample savings, sample enrichment, rapid sample preparation, and easier automation. Sample preparation remains one of the more time-consuming and error-prone aspects of analytical chemistry. To overcome drawbacks of conventional extraction techniques, alternative miniaturized methods have been proposed both as solid phase microextraction, as Solid Phase MicroExtraction (SPME) *[Bianchi, F. et al. 2011; Bianchi, F. et al. 2014; Chericoni, S. et al. 2011; Dugheri, S. et al. 2010; Dugheri, S. et al. 2016; Dugheri, S. et al. 2017; Marini, F. et al. 2007; Pacenti, M. et al. 2008; Pacenti, M. et al. 2009; Pacenti, M. et al. 2009; Toscano, P. et al. 2011]*, MicroExctraction by Packed Sorbent (MEPS) *[Abdel-Rehim, M. et al. 2011]*, Stir Bar Sorptive Extraction (Twister, SBSE) *[David, F. et al. 2007]*, Solid Phase Dynamic Extraction (Magic Needle, SPDE) *[Rossbach, B. et al. 2012]*, In-Tube Extraction (ITEX) *[Laaks,J. et al. 2015]* and liquid phase microextraction like Single-Drop MicroExtraction (SDME) *[Singh, D. et al. 2011]*, Hollow Fiber LiquidPhase Microextraction (HF-LPME) *[Singh, D. et al. 2011; Saraji, M. et al. 2015]*, Dispersive Liquid–Liquid Microextraction (DLLME) *[Rezaee, M. et al. 2006]*, Solvent Bar MicroExtraction (SBME) *[Kamarei, F. et al. 2010]*. On-fiber derivatizations applied in miniaturized extraction systems and their simultaneous GC and liquid chromatography analysis has been described for the determination of analytes in aqueous matrices *[Ferreira, A. et al. 2013; Baghdady, Y.Z. et al. 2016]*. These methods employ a sample derivatization technique to convert such polar substances into hydrophobic compounds whose volatility is sufficiently high for a GC determination. Within analytical chemistry, the SPME analysis is considered one of major breakthroughs that shaped 20th-century analytical chemistry *[Handley, J. et al. 2001]*. SPME integrates sampling, extraction, concentration and sample introduction into a single step and the extraction requires no polluting organic solvent. The research presented a new approach for diffusive sampling of airborne polar compounds (PC) based on solid-phase microextraction (SPME) for occupational exposure assessment. It is focused on automation and miniaturization for multiple and specific fast gas chromatography (GC) analysis by flame ionization, electron capture and mass spectrometry detectors. O-(2,3,4,5,6-pentafluorobenzyl)hydroxylamine (PFBHA) *[Bourdin, D. et al. 2014; Pieraccini, G. et al. 2002]*, methyl-p-tolyl-sulfide (MTS) *[Pacenti, M. et al. 2010]*, hydrogen bromide (HBr) *[Tsai, S. W. et al. 2003; Tsai, S. W. et al. 2004]*, 1-pirenyldiazomethane (PDAM) *[Pan, L. et al. 1995]* on-fiber derivatization reagents for Fast Fit Assemblies (FFA)/SPME fiber sampling of aldehydes and

ketones, peroxy acids, ethylene- and propylene-oxide and fatty acids were studied. Important parameters influencing the extraction and derivatization process such as type of fiber coating, type and volume of derivatizing reagent, extraction time, and desorption conditions were investigated and optimized. PC vapours were generated by use of a syringe pump in a dynamic system in which temperature, relative humidity, and air velocity were monitored. The theoretical sampling rate for time weighted average- (TWA) and rapid-FFA/SPME were, furthermore, estimated by use of the Fuller-Schettler-Giddings diffusion coefficient and were in accordance with experimental values.

2. MATERIALS AND METHODS

Sampling was performed under non-equilibrium conditions both as rapid-FFA/SPME (Figure 1) with completely exposed fibers for short-term sampling and by TWA-FFA/SPME for long-term sampling. In the latter case, the fiber is retracted inside the needle up to 0.1–3.5 cm.

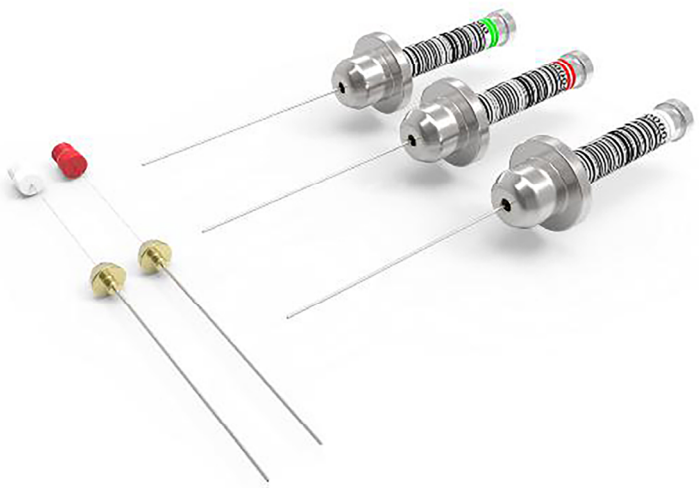

Figure 1 - FFA/SPME fiber

To calibrate the FFA/SPME fiber, PC vapors were generated in a dynamic system by a syringe-pump Harvard Plus 11 (Harvard Apparatus, Holliston, United States), equipped with a 1 ml gas-tight syringe set to 2 µl/min connect to ATIS Adsorbent Tube Injector System (Supelco, Bellefonte, United States). The PC solution was set from 2.0 to 19.5 µg/µL. The PC air concentrations ($C_{PC\ air}$) were calculated according to the following formula:

$$C_{PC\ air} = C_{Sol\ Fsyringe} / F_{air,} \quad (1)$$

where C_{PC} air is the concentration of analyte in air (µg/L), C_{Sol} is the concentration of the solution (µg/µL), $F_{syringe}$ is the syringe-pump flow (µL/min), and F_{air} is the air flow (L/min).

The ranges in microclimatic parameters registered in the dynamic atmosphere during the PC calibration were: air temperature (15–30 °C), relative humidity (0–50 %), air speed (0.9–8.5 cm/s).

The experimental sampling rates (SR) of the rapid- FFA/SPME and TWA-FFA/SPME systems were obtained using the equation:

$$SR = uptake / C_{PC\ air}, \quad (2)$$

The uptake is the slope of the line obtained by correlating the mass of PC adsorbed on the fiber with the sampling time at calibrated air concentrations ($C_{PC\ air}$). The theoretical sampling rate SR of the TWA-FFA/SPME sampler can be defined as followed:

$$SR=D_{AB}(A/Z), \quad (3)$$

where SR is the sampling rate; Z is the retracted fiber path length; A is the surface area of the needle opening (0.00086 cm^2 for 24 gauge); and D_{AB} is the diffusion coefficient of the analyte in the gaseous phase. Diffusion coefficient of compounds in air can be estimated by the following equation:

$$D_{AB} = \frac{0.00143 \cdot T^{1,75}}{PM_{AB}^{1/2}\left[\left(\sum_V\right)_A^{1/3} + \left(\sum_V\right)_B^{1/3}\right]^2}, \quad (4)$$

where D_{AB} is the binary diffusion coefficient of analyte in air in cm^2/s at T; T is temperature, K; M_A and M_B are molecular mass, g/mol; $M_{AB}=2\ [(1/M_A) + (1/M_B)]^{-1}$; P is the external pressure, bar; Σ_V is the summation of atomic diffusion volumes, unitless; *I* is all the contributing species; A is air; B is the analyte.

For the determination of aldehydes, the technique of on-fiber derivatization where oximes formed after PFBHA reacted with aldehydes and ketones has been reported elsewhere. Polydimethylsiloxane/divinylbenzene (PDMS/DVB) 65µm FFA/SPME fiber (Chromline, Prato, Italy) was selected because it adsorbed PFBHA with greater reproducibility. For the trapping element preparation, PFBHA aqueous solution with concentration of 17 mg/mL was placed in a PTFE-capped vial. The solution was in agitation and the PDMS/DVB FFA/SPME fiber was placed in the headspace (HS) of the PFBHA solution for 2 min.

To evaluate the fatty acids, SPME passive sampling using 85 µm polyacrylate (PA) FFA/SPME fiber after on-fiber derivatization with PDAM. Prior of the air sampling, the fiber was placed into 5 mg/mL PDAM/hexane solution for 30 min to saturate PDAM onto the stationary phase.

To determine airborne peroxy acids exposure we used the SPME technique, with a phase thickness of 85 µm Carboxen/PDMS FFA/SPME fiber. The fiber was doped for 10 s in the headspace of a PTFE-capped amber vial containing 5 µl of MTS. From the reaction between peroxy acids and MTS, methyl-p-tolyl sulfoxide was obtained.

2-Bromoethanol and 1-bromo-2-propanol was detected after the Carboxen/PDMS FFA/SPME fiber was first exposed 30 s to HS 48% HBr solution for 5 min followed by ethylene- oxide and propylene-oxide air sampling.

After sampling, PC were analyzed with Master GC Dani using a narrow bore DN5 column by Dani (5 m × 0.10 mm × 0.4 µm film thickness). The ionization was performed with a Dani Master TOF MS Plus and with FID and ECD detectors. Oven settings were 50 °C held for 0.30 min, with a ramp of 150 °C/min up to 100°C and 50°C/min up to 250 °C. Inlet pressure and column flow were 348.8 KPa and 1.21 ml/min, respectively. The injector (280 °C) was set in split mode 10:1. Full automation of the procedure was achieved using the autosampler Master COMBO–SPME (Fig.2).

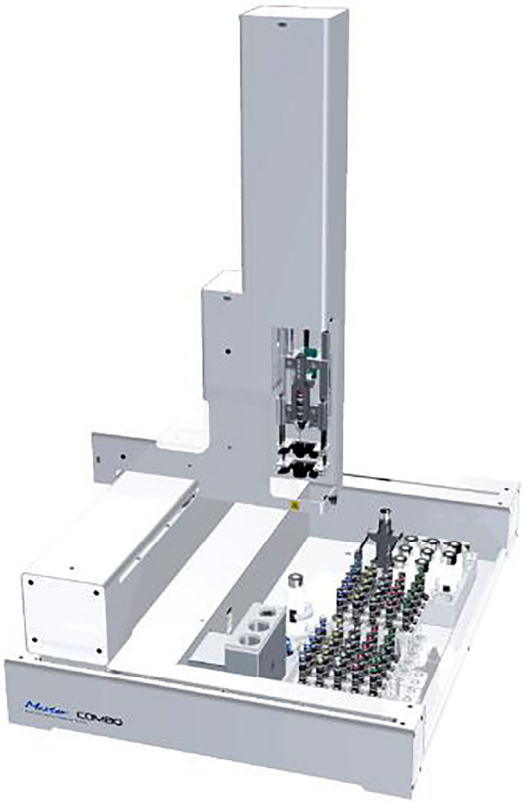

Figure 2 - Dani autosampler Master COMBO–SPME

3. RESULTS AND DISCUSSION

The results and an example of chromatogram are showed in Figure 3-5 as to TWA-FFA/SPME with Z=0.3 cm, the experimental average SR values were between 0.0157 and 0.0435 mL/min, in good agreement with theoretical SR values. The experimental average SR values for rapid-FFA/SPME were from 6.74 to 8.97 mL/min. The detection limits were less than 0.030 µg/mc. The automation

of the preparation and injection procedure by new device, through change of the FFA/SPME fibers, allowed a friendly use of fast GC apparatus with a number of advantages including reduced analyst time and greater reproducibility (2.31-5.79%). The compared results obtained using current and standard methods were shown to be satisfactory. So, the introduction of dedicated, automated, and robotic systems DANI Master COMBO – SPME Mode allowed a friendly use of fast GC apparatus for high-throughput screening so as to reduce the costs of the monitoring campaigns.No significant change in mass adsorbed was observed after storage (–20 °C) for one week. The robustness of the fiber allowed more than 150 analyses for each fiber.

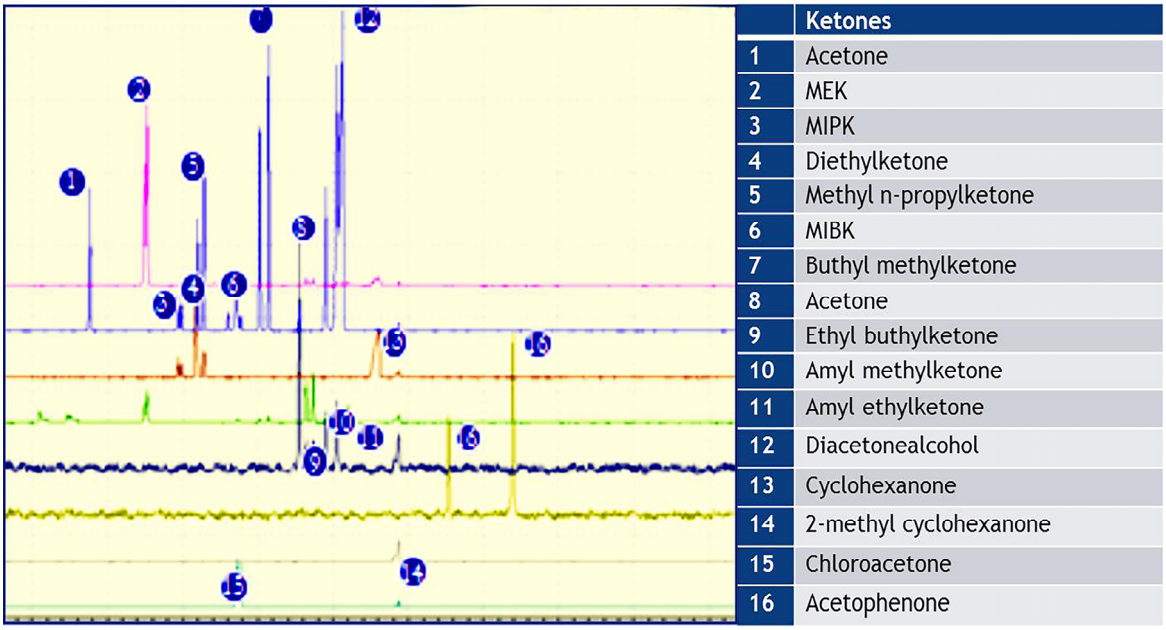

Figure 3 - Ketones profile GC-MS chromatogram

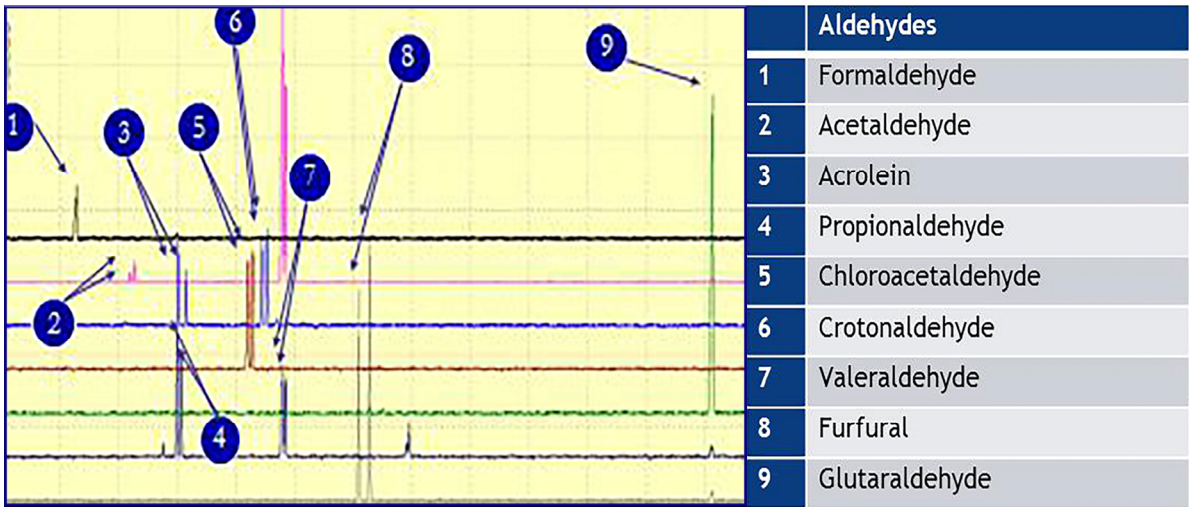

Figure 4 - Aldehydes profiles GC-MS chromatogram

High-throughput automated analysis of airborne PC using the autosampler DANI Master COMBO /Fast GC robotic system was here evaluated. The high sensitivity of the methods allowed PC concentrations also with extremely short sampling periods, producing instantaneous values of PC levels. In addition, long-term sampling are allowed with TWA-FFA/SPME device. Finally, the proposed technology reduces analytical costs, is easily applicable and uses no solvents, therefore having no environmental impact. The diffusive sampling with the FFA/SPME has an advantage over other methods because no pumps are required which reduces the sampling costs and the time for sample analysis. The on-fiber derivatization technique will not only increase the sample stability but also allow high efficiencies and can be used in remote field applications.

Compounds	FFA/SPME fiber	Rapid-FFA/SPME (15 min) GC-MS GC-FID GC-ECD				TWA-FFA/SPME (8 h, Z=3 mm) GC-MS GC-FID GC-ECD			
		LOQ (µg/m³)	Precision (CV,%)		% Accuracy (n.10 replicates)	LOQ (µg/m³)	Precision (CV,%)		% Accuracy (n.10 replicates)
			Intra day	Inter day			Intra day	Inter day	
Formaldehyde, acetaldehyde, acrolein, valeraldehyde, furfural, glutaraldehyde, acetone, MEK, MIBK, MIPK	PDMS/ DVB (65µm)	1-6 21-32 0.05-1	3.9-6.4 5.1-8.9 4.4-8.4	5.9-8.4 7.3-11.9 4.9-9.4	93.6-95.4 92.7-93.2 92.2-95.6	4-9 26-57 0.2-7	2.8-4.5 3.1-9.9 5.4-7.4	5.9-8.4 7.3-10.1 4.8-10.6	95.6-96.1 94.7-95.2 93.2-96.1
Peroxyacetic acid	Carboxen/ PDMS (85µm)	3 21 -	3.5-7.5 4.1-6.9 -	6.5-11.4 6.4-12.9 -	93.9-95.6 91.9-97.5 -	9 68 -	5.7-7.9 4.4-7.9 -	5.4-12.2 6.5-11.5 -	94.1-98.1 92.9-94.5 -
Ethylene-, propylene-oxide	Carboxen/ PDMS (85µm)	22-38 281-392 6-12	5.1-8.4 4.8-10.1 5.1-9.4	5.9-12.4 4.9-13.5 6.3-11.2	94.3-98.1 93.2-96.9 94.9-94.8	65-98 875-992 29-57	7.1-9.4 5.6-11.5 4.1-9.9	6.7-11.8 4.9-11.6 7.1-13.2	96.3-97.6 92.1-95.8 92.9-93.9
Acetic-, propionic-, formic-, butyric-, valeric- acid.	PA (85 µm)	2-11 26-33 -	3.5-7.4 4.3-5.9 2.5-8.4	4.5-11.4 6.1-13.9 5.7-12.4	94.6-97.3 94.1-95.5 92.1-95.7	23-91 126-233	5.4-8.9 6.3-7.9 4.1-10.4	6.6-9.8 4.1-11.8 8.7-12.1	95.5-98.9 93.7-96.1 94.1-96.7

Figure 5 - Comparison of rapid-FFA/SPME and TWA-FFA/SPME results

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SIXTH INTERNATIONAL ENVIRONMENTAL CONGRESS ELPIT-2017

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COMPARING OF BÍLINA RIVER POLLUTION WITH HEAVY METALS BEFORE, DURING AND AFTER THE FLOODS IN THE CZECH REPUBLIC 2013

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ABSTRACT

Floods do not bring about immediate damage caused by the direct effects of high water levels and accelerated flow. During the floods, sedimentation of entrained particles is occurring, which results in the redistribution of fixed heavy metals. Raised sediment with high content of heavy metals, which is carried by flowing water, can contaminate the near vicinity of the river. The Bílina River which is flowing through the industrial area of Northern Bohemia belongs to medium-sized rivers, with an average flow of 6.5 m^3/s (reported profile in Trmice). Bílina River has been monitored for pollution for many years. Monitoring of pollution on the river is also provided by the Faculty of Environment, Jan Evangelista Purkyně University. This work compares the results of heavy metal content in sediments and in river water before the flood, immediately after the flood and approximately one year after the flood. The result is an overview of the redistribution of heavy metals that occurred during the flood in 2013.

Keywords: heavy metals, pollution, sediments, river water, flood

The river Bílina is a left-side tributary of the Elbe river, 81 km long, flowing in the total length of 12 km by the city districts - Jirkov, Most, Bílina, Ústí nad Labem. The catchment area of the Bílina River is 1071 km^2. The water catchment area is burdened by industry and anthropogenic pollution - North Bohemian Mines, where brown coal mining takes place in Most, Ledvice coal-fired power station, heating plant in Trmice and Spolchemie in Ústí nad Labem. The river largely

replicates the main road link between Most and Ústí nad Labem, so heavy metals pollution can come from large industry companies and also from traffic. The bottom of the river is laid out in the city areas by stone blocks. The pool area is 933 - 1071 km^2, with an average flow of 5 - 9 m^3 / s.

The following sampling points were selected on the Bílina River: 1. Most (near lake Most, N 50°30', E 13°39'), 2. Most (Station N 50°30', E 13°40'), 3 Bílina (city center N 50°33', E 13°46'), 4. Chotějovice (at power station N 50°34', E 13°48'), 5. Trmice (hydrological station N 50°38', E 14°00'), 6. Trmice - the inlet of Žďrnický Creek (N 50°39', E 14°00'), 7. Ústí nad Labem (West Station N 50°39', E 14°01') and 8. Ústí nad Labem (confluence with Elbe N 50°39', E14°02'). The selected sites copy the river flow, and places near major industrial plants.

Water analysis was focused on determination of the concentration of selected heavy metals (Cd, Cr, Cu, Ni, Pb, Zn). Sediment analysis was focused on same heavy metals as in case of water samples.

The obtained results are evaluated according to the environmental quality standards set out in the Government Regulation No. 401/2015 on indicators and values of permissible pollution of surface waters and waste water treatment, details of the permit to discharges wastewater into surface water and into sewers.

Water samples for heavy metal analysis were stabilized with nitric acid to a final concentration of 0.5 % and kept refrigerated until analysis.

Samples of sediments were frozen immediately after collection. Prior to processing, the sediment samples were dried, and sieved through a sieve with a mesh size of 1 mm. To 2 g of the thus prepared sample was added 7 ml of nitric acid and after 2 hours 21 ml of hydrochloric acid, the resulting mixture stand overnight and the next day was boiled on the heating plate for 2 hours. The decomposed samples were filtered and transferred to a 100 ml volumetric flask. The samples were filled with distilled water in a volumetric flask. In all samples were all selected elements determined by the ICP-OES technique.

Sediment samples were taken along the Bílina River in three different time periods. Sampling sites were chosen to cover the whole flow of the Bílina River from Lake Most to the confluence with the River Elbe, and also included places where potential polluters are located on the river. Sampling of water and sediment was collected at sampling points. Water sampling was performed according to ČSN ISO 5667-6 Water quality - Sampling - Part 6: Instruction for sampling from rivers and streams. Sediment sampling was carried out according to ČSN ISO 5667 12 Water quality - Part 12: Guidance on sampling of bottom sediments. Water samples were taken at the same sampling points as sediment samples. Samples were preserved immediately after collection by addition of nitric acid to a final concentration of 0.5 %.

The results of heavy metal analyzes have shown that most heavy metals prefer binding to a solid matrix (Nábělková, 2011). In the collected water samples, heavy metals occur at low concentrations, usually at or below the limit of quantification, and do not exceed the immission criteria. For all the metals specified, the concentration values in the sediment were significantly higher than in water, see Table 1, 2 and 3.

Table 1 - Heavy metal content in sediment samples mg / kg before the flood, sampling carried out in 2012

	1	2	3	4	5	6	7	8
Cd [mg/kg]	0.5	1.5	0.5	1.0	< 0.5	0.5	1.2	0.8
Cu [mg/kg]	18	70	21	38	17	73	32	41
Pb [mg/kg]	25	32	12	35	22	61	47	40
Zn [mg/kg]	73	144	86	170	129	133	215	238
Ni [mg/kg]	22	38	26	41	31	41	43	42

Table 2 - Heavy metal content in sediment samples mg / kg during the flood, sampling carried out in 2013

	1	2	3	4	5	6	7	8
Cd [mg/kg]	1	1	1	1	1	1	1	1
Cr [mg/kg]	38	49	40	26	31	53	54	49
Cu [mg/kg]	70	81	57	43	41	71	73	76
Pb [mg/kg]	34	38	30	29	32	51	46	54
Zn [mg/kg]	151	342	208	204	201	337	364	368
Fe [g/kg]	26.5	31.1	27.7	24.0	25.7	24.4	26.7	30.3
Ni [mg/kg]	38	60	47	28	31	59	60	63

For all metals, low concentrations in water and higher sediment concentrations can be observed. No limits have been exceeded according to Government Regulation No. 401/2015 on indicators and values of permissible pollution of surface waters and waste water treatment, details of the permit to discharges wastewater into surface water and into sewers.

Most of the heavy metals detected showed higher concentration at the time of the flood. One year after the flood, the heavy metal concentration in the sediment returned to average value measured before the flood. From heavy metals which was measured was highest concentration in zinc, the source of which is mainly atmospheric fall (fossil fuel burning, zinc processing), as well as fertilizers containing zinc. In the case of copper, floods increased up to four times the

original value at Lake Most. In the case of zinc, an increase of 20 – 140 % occurred during along the river Bílina.

Table 3 - Heavy metal content in sediment samples mg / kg after the flood, sampling carried out in 2014

	1	2	3	4	5	6	7	8
Cd [mg/kg]	1	1	1	1	1	1	1	1
Cr [mg/kg]	52	53	59	55	51	51	55	57
Cu [mg/kg]	32	32	36	33	32	32	32	34
Pb [mg/kg]	30	29	29	43	29	32	31	32
Zn [mg/kg]	118	116	124	121	115	121	120	124
Fe [g/kg]	36.4	37.2	39.5	39.6	34.7	35.6	36.9	39.2
Ni [mg/kg]	28	29	31	30	28	28	30	30

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DYNAMAP: A POWERFUL TOOL TO IMPROVE ENVIRONMENT

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ABSTRACT

In order to improve the acoustic environment inside big cities as well as around villages close to transport infrastructure or to industrial plants is necessary to depict a clear image of the actual situation to make the proper strategic choices for noise reduction. Noise models are obviously a powerful tool to simulate acoustic field and predict benefits of mitigations. However, in many situations, sources' sound power are unknown and, moreover, very often noise emission is function of the period of the day, the day of the week, the week of the month and the month of the year. This dynamic situation is particularly frequent when sound sources are related with railways or roads, which change their emission according to traffic flows. In addition to the above, when receivers are located hundred meters away from the sources, the meteo strongly affects noise propagation and thus makes more complicated the approach to the problem.
For an effective approach to a so variable scenario, a dynamic investigation tool is the best choice to understand the acoustic environment and plan more proper action plans. In 2013 a group of people from Universities and private companies presented a proposal to European Commission for a co-financed project in LIFE+ framework, finalized to develop an integrated platform for calculating dynamic noise maps according to real-time acquired noise data. The project, named Dynamap, was approved; it started in 2014 and it is still in progress. In this paper the principle of operations and the obtained results up to now are presented.

Key words: dynamic noise maps, traffic flows, monitoring, noise models

1. DYNAMIC NOISE MAPS

Dynamic noise maps are acoustic maps automatically updated using measured data provided by monitoring stations located close to sound sources,

such as roads, rails and industrial plants. This application is now days extremely fast as no further recalculation of the sound propagation is required to adapt the noise map to the measured data. The monitoring stations are installed at relevant receiver locations where sound pressure levels are dominated by sources. For each of the monitored source and for the remaining sources a complete noise map is calculated and saved for the entire mapping area.

Noise maps updating is achieved scaling the noise levels of pre-calculated (basic) noise maps as a function of the difference observed between measured and calculated original grid data. This operation is provided for each source present in the mapping area. The updated total map is achieved by energetic summation of all updated noise maps. The updating process can either be based on automatically registered traffic count data or other source parameters.

The idea of linking the output of sound level meters to noise calculation models to produce automatic and updated noise maps is not new, but its implementation in a real complex environment with many sources, variable sound propagation scenarios and ‘low cost approach' is the aim of the project.

2. PILOT AREAS

The Dynamap project [1 - 4], foresees the implementation in two pilot areas: part of the city of Milan and ring road around city of Rome. The two areas have different kind of traffic and different propagation scenarios. Inside the city of Milan the traffic is quite complex and the number of roads is very high and includes intersections, one-way roads and hot spots which can influence a big number of roads. In Rome the scenario is more simple but the meteo has a great influence on propagation. Without go too much in-depth on how these different situations are treated, the next chapters will describe the components of the system, how they interacts to give real-time results on noise environment and how the output of the system can be used for a possible noise governance.

3. BASE MAPS

In order to make a map scaling, first of all is necessary to have some base noise maps, each one related with each elementary source.

For the city of Milan were computed six different noise maps, each one related with group of roads with similar characteristics. The road clusterization [5] was performed after a very in-depth study which involved acousticians and road traffic experts.

For the ring around Rome were computed six basic noise maps related to six possible configuration of noise propagation during working days, plus six similar maps suitable for week-end days [6]. The study for Rome basic maps involved acousticians and meteorologists.

4. MONITORING STATIONS

Standard monitoring station, as well as sound level meter, are not very cheap equipment and, unfortunately, in order to make the system properly working, many measuring points are needed. More in details, for the part of the city of Milan involved in the project, 24 measuring point were defined, whereas in Rome one measuring point for each arch of ring (between two intersection) was identified. So, in total, the number of measuring points necessary for the two pilot area is 43.

To measure the noise in the selected points was developed a new low-cost sensor [7], able to measure and transmit by cellular network, 1-second LAeq values. The sensor has also the capability to compute 1/3 octave spectrum and to exclude anomalous events on its time-frequency behaviour basis and by means of its internal database. The image shows one sensor placed on a road portal on Rome ring.

Figure 1 – Monitoring Station

5. SYSTEM CORE

In order to scale the basic maps according to the measured data, and sum them together to obtain the global map, some calculation is necessary. Next picture shows how the data coming from the monitoring stations interact with the system in order to produce the global map.

The computer who implements calculation has also the task to publish noise maps on a web site for information to citizens and for technicians' investigations.

More in details, each of the two systems (Milan and Rome) uses two different servers: one for data collection and the other for map sum and scale.

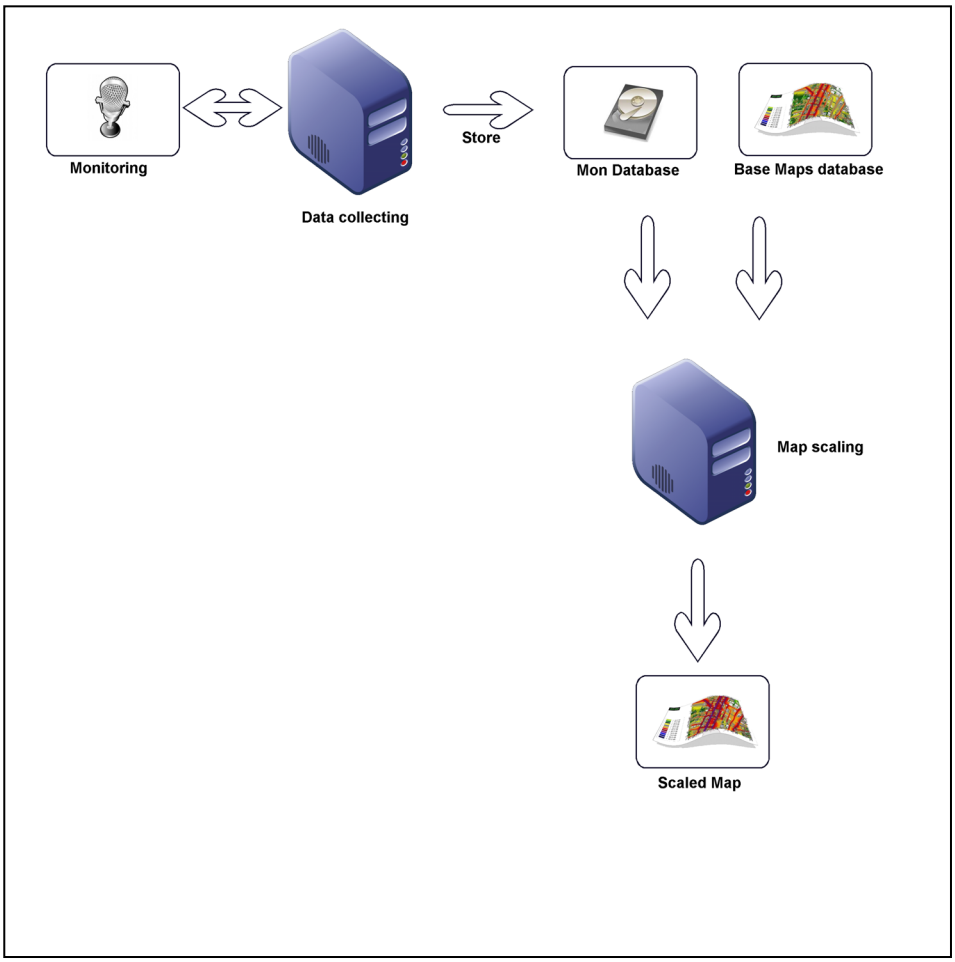
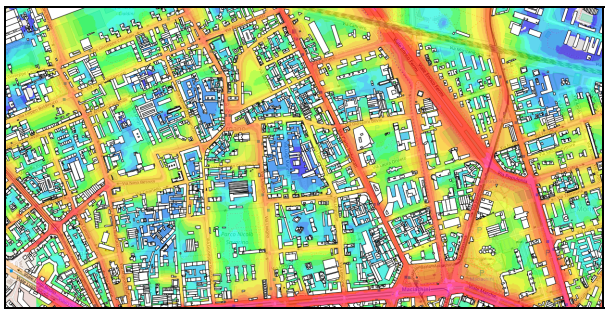
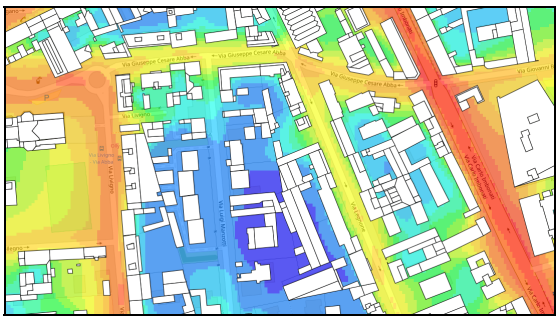


Figure 2 – Algorithm of Scale the Basic Maps

The choice to use different machines for the two systems and for the two tasks, for a total of four server, is due to the fact that the number of operation to collect data continuously from the 43 stations and operate the scale and sum process consumes a lot of computing power. In fact both Milan and Rome have maps of about 300,000 points and, in order to produce a new global map every 30 seconds, is necessary to perform a very huge number of operations; practically Milan requires 300,000x6=1,500,000 products plus 300,000 sums and 300,000 logs every 30 seconds, whereas Rome requires 300,000x19=5,700,000 products plus 300,000 additions and 300,000 logs with the same rate. In addition to the above Rome systems produce also a second map based on Harmonica Index [8], which practically consists in 600,000 more products and 600.000 more sums. Both server for maps calculation have also to make interpolations to produce contour maps, and to prepare results for the geo-portal which takes care of their publication [9]. Next figure shows a portion of Milan dynamic noise map with low zoom level (left) and zoomed in (right), published on the geo-portal on the web.



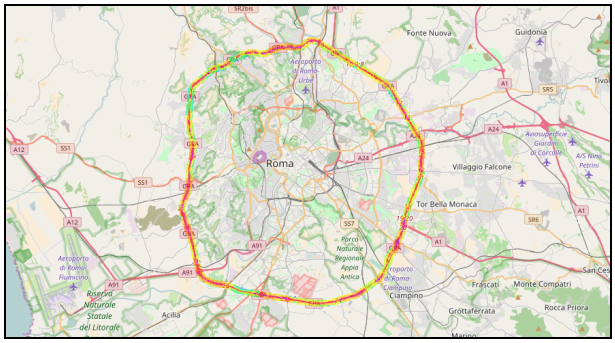
Milan: zoomed-out map



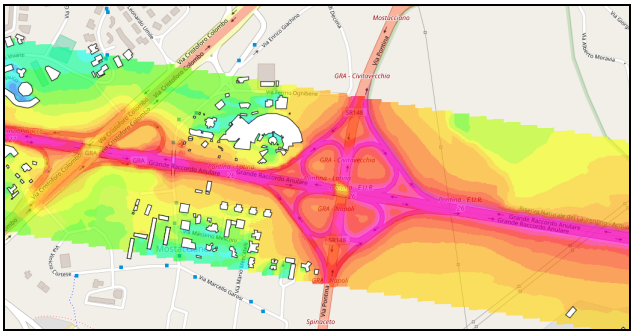
Milan: zoomed-in map

Figure 3 – Milan Dynamic Noise Maps

Next pictures are showing the same output for Rome ring map: on the left the zoomed-out map and, on the right, a zoomed-in portion related to a roads intersection.



Rome: zoomed-out map



Rome: zoomed-in map

Figure 4 – Rome Ring Dynamic Noise Maps

SYSTEM VALIDATION

At the moment the two systems are going under a validation procedure and are still subjected to some minor tuning in order to fit as best as possible the needs the people who have to deal with them.

NEXT STEPS

After the validation procedures and the dissemination processes, the systems will be used to produce periodic noise maps according EU and local regulations, including the identification of hot spots, calculation of number of people exposed at more than a certain level, etcetera. A further step considers the possibility to drive dynamic speed limits signs or other road sign in order to automatically control the noise in a specific area. The Dynamap project will terminate in 2019.

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ASSESSMENT OF LATVIAN WASTE MANAGEMENT SYSTEM AND ITS DIRECTION TOWARDS 2020 TARGETS

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ABSTRACT

Within present research the authors assess Latvian waste management system from market player perspective. In addition the authors have developed a survey targeted at household landfill management companies and waste management experts in Latvia and abroad. The aim of the research is to evaluate the vision of waste management players concerning 2020 targets for recycling and recovery set by the European Union and to assess readiness of the companies to shift to circular economy. The authors conclude that one of the options for municipalities to secure reaching the targets is to unite within waste management regions and for landfill management companies a solution for their sustainable development could be evaluation of industrial symbiosis development possibilities.

Key words: waste management, landfill, recycling, survey

1. INTRODUCTION

European Union has developed a common legislation framework regarding waste management still it is becoming more and more obvious that there is not a “one size fits all” solution but rather many different mixtures of technologies, institutional frameworks and policies applied. The coexistence of different waste management systems that must achieve the same results in terms of recycling targets, diversion of biodegradable waste from landfills and waste prevention is a strong driver towards the development of benchmarking techniques that will allow a deeper comparison of different systems. Member States apply different waste

calculation methods, interpretation of statistics varies and there even exists strong distinction in the interpretation of the definitions [10, 8].

The World Business Council for Sustainable Development estimates that by 2050 a 4 to 10 fold increase in resource efficiency will be required, with important improvements achieved already by 2020. This also means that significant measures in the field of waste management are to be taken instantly [16].

Harmonisation of Latvian legislation with European Union legislation has led to the fact that Latvia, being a EU member stare has to achieve certain per cents within decrease of waste landfilling and increase of waste sorting, preparation for re-use and recovery. According to European Commission it is important to promote innovative industrial processes, for example, industrial symbiosis, which allows waste or by-products of one industry to become inputs for another [11].

Historically Latvia's waste management was focused on landfilling. Annually 670 000 - 700 000 tons of household waste are being generated, from which 500 000 tons are disposed on landfills, which results in 71% from collected waste amount. Latvia currently has 11 landfills for household waste, 1 for hazardous waste and 1 for construction waste in operation [4].

The entire Latvian waste management infrastructure (except for one biggest landfill in Riga city) was financed from Cohesion Fund (previously ISPA), with co-financing from 65% to 85% of the referral costs. It has been summarized that up to 2011 overall public investments into waste management field reached almost 100 million Euros (covering two most financially-intense planning periods 2000-2006 and 2007-2013).

The main institution in the waste management system is Ministry of Environmental Protection and Regional Development. According to the Law on Waste Management, it is in charge of policy planning, supervision and coordinating functions. Ministry has subordinate institutions: Latvian Environment, Geology and Meteorology Centre (in charge of hazardous waste management and waste management statistics); Administration of Latvian Environmental Protection Fund (until 2016 in charge of exemptions from Natural Resources tax, starting from 2017 is in charge mostly for environmental projects); State Environmental Service (ensures the compliance of implementation of legislation framework in the area of the environment and natural resources protection, and control on radiation and nuclear safety, starting from 2017 It is in charge of exemptions from Natural Resources tax).

Self-governments are obliged to follow public procurement procedures in order to choose a waste management company for collection of household waste, sorted waste and in some cases also construction and demolition waste. Other types of waste management companies can offer their services within self-government's territory without any additional contracts, working directly with legal or private persons.

When analysing waste management companies, which are operating in Latvia, following types of companies can be identified: household waste collection companies – both municipal and private companies, operating across Latvia (a contract with municipality is required, based on the results of the public

procurement); construction & demolition waste collection companies, operating across Latvia (a contract with municipality is required, based on the results of the public procurement); hazardous waste collection companies, operating across Latvia (no particular contract with municipality is required); waste management intermediaries (Extended producer responsibility companies), operating across Latvia (no particular contract with municipality is required); waste recycling companies, operating across Latvia (no particular contract with municipality is required); landfill-management companies – municipal companies, operating in particular waste management region.

It has to be mentioned that apart from landfill management companies, all the other types of companies vary by number annually.

In addition, waste management sector has extended producer responsibility companies, like – "Latvijas Zaļais punkts", "Zaļā josta", "Latvijas Zaļais Elektrons", "Zaļais Centrs" etc. These companies are engaged in developing waste collection schemes for packaging waste, and offering tax exemptions from natural resources tax for the companies, working in Latvia.

Waste management also includes a range of Non-governmental organizations – associations, advisory boards, etc. Two most notable waste management associations are: LASA (Latvian Waste Management Association), and LASUA (Latvian Association of Waste Management Companies).

This short insight into the waste management field shows that it has a variety of players on the market, but within present research, the authors chose to analyse the "landfills" – i.e. landfill management companies, which are municipality owned (inter-municipality, to be precise – as each waste management region has only 1 landfill site and it's management company is owned by all the municipalities, that are covered by a particular region). One precondition for EU ISPA/Cohesion Fund aid was to have a LLC, which would include all the municipalities of the region, as these municipalities would also have their liabilities within the project. It has to be noted, that waste management regions differ from administrative (statistical) Latvia's regions – which also brings a degree of complexity to the system, making it more difficult to benchmark the economic, social and managerial aspects. Waste management in each of regions is also slightly different. Landfill management companies are regulated by State Revenue Service and it's issued A category pollution permits. Public Utilities Commission regulates the operation of landfill management companies, in accordance with Waste management Law article 39. Public Utilities Commission approves the waste disposal tariff [13].

Main activities of a landfill management company include but are not limited to: weighting and registration of incoming waste flow; waste sorting, preparation for recycling, reuse or recovery; waste temporary storage; landfilling (including all management aspects of a landfill cell); composting of biodegradable waste; management of leachate; management of biogas; production of electricity and heat; environmental state monitoring; management of landfill infrastructure objects and society education activities. The graphic illustration of a simplified waste flow in a landfill is depicted in Figure 1.

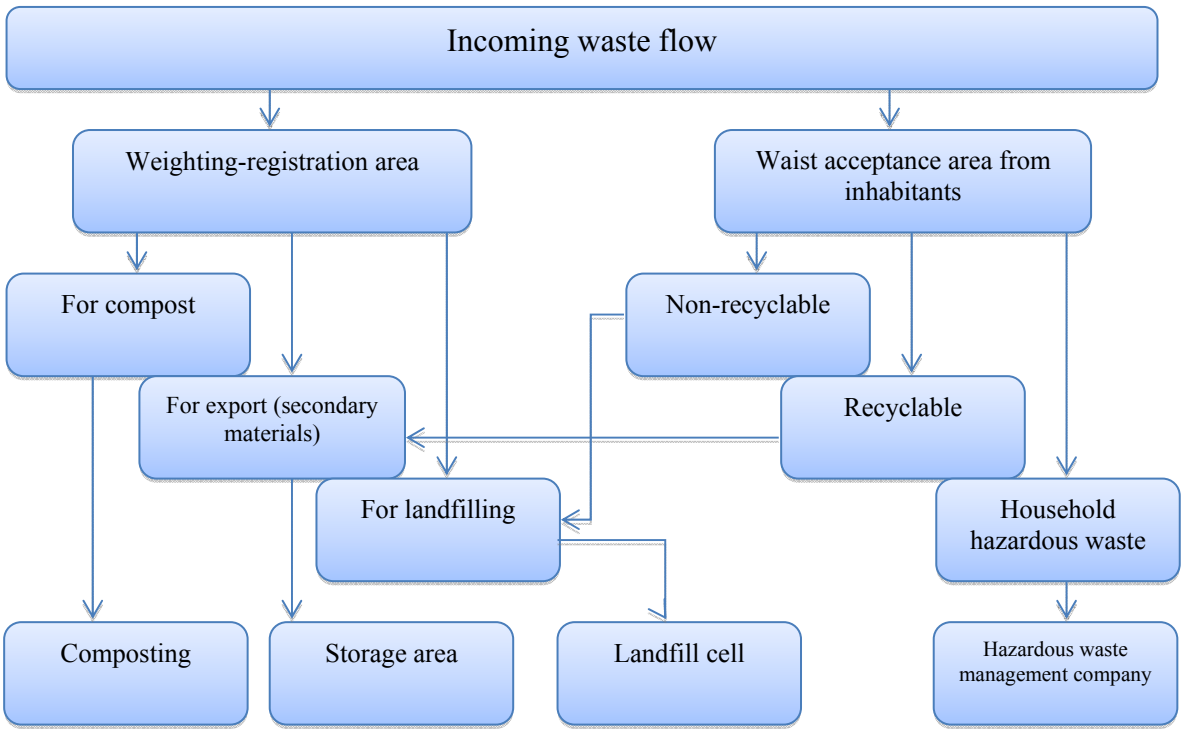

Figure 1 - Schematic waste flow within landfill management company
Source: by authors

Analysis of current situation within Latvian LMC's has revealed a negative trend that some of the companies have problems with keeping together managerial, entrepreneurial and environmental decisions – companies dealing only with landfilling are interested in the increase of landfilled waste volumes, but this goes into a direct conflict with EU latest trends on the landfill of waste, saying that Member States are to focus on decrease of landfilled waste as much as possible [7, 5].

WRAP has developed a set of KPI's for waste management [15]. These indicators are mostly not for landfill management companies, but for landfills themselves, although they can be applicable within the boundaries of current research.

The authors have adopted the Key performance indicators and applied them to landfill management companies. Table 1 provides a summary of the results. From the table it may be seen that currently only part of landfill management companies are engaged in waste sorting and its preparation for recycling or recovery. One landfill management company has a bio-cell that is dedicated for energy production (biogas generation, which is further collected and reprocessed into heat and electricity).

Table 1 - Key performance indicators applied to landfill management companies

Source: by authors

Ratio	*AADSO*	*ALAAS*	*AP Kaudzites*	*Geltini EKO*	*Liepajas Ras*	*Piejura*	*Vidusdaugavas SPAAO*	*VLK*	*ZAAO*	*Zemgales EKO*
Waste disposal	*99,6%*	*94%*	*96%*	*95,6%*	*88%*	*91%*	*94,2%*	*80%*	*45%*	*94%*
Energy	*n/a*	*n/a*	*n/a*	*5,4%*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Recycling	*0,4%*	*0%*	*3,9%*	*0%*	*12%*	*8%*	*0%*	*15%*	*12%*	*12%*
Composting	*0%*	*6%*	*0,1%*	*0%*	*10%*	*1%*	*3,8%*	*5%*	*43%*	*4%*
Electricity (kWh/capita)	*n/a*	*n/a*	*n/a*	*37,76*	*12,81*	*n/a*	*n/a*	*22,51*	*7,18*	*n/a*
Heat (kWh/capita)	*n/a*	*n/a*	*n/a*	*23,89*	*14,73*	*n/a*	*n/a*	*14,18*	*6,29*	*n/a*

Although, it has to be noted, that for example, Getlini Eko in 2016 already have only 17% of landfilled waste, as 70% of received waste is being pre-treated and sent to the bio-cell for energy recovery.

Basing on the undertaken research the authors have come up with a conclusion that present situation of landfill management companies is not sustainable and a change in their development has to be undertaken in order to secure their further efficiency and engagement into circular economy.

2. RESEARCH RESULTS AND DISCUSSION

The authors have developed a survey with particularly developed questions in order to confirm or dispel authors theory, that industrial symbiosis is the direction landfill management companies should following order to improve their sustainability and increase efficiency.

The survey's design is based on three main principles: wording, planning of issues and general appearance [14]. It consists of 19 open-ended and closed questions and it is divided into three sub-sections. First sub-section covers landfill management companies, their functions, output of landfill daily operation activities, potential resources for industrial symbiosis and disposal rates. Following sub-section covers waste management tendencies in Latvia, it is aimed to disclose a landfill management company's vision on further development. And the last sub-section tackles decision-making practices in waste management companies.

Question No. 3 provided us with the picture of the resources that are produced during landfill daily operations. Figure 2 shows that landfills do rely on sorting, gaining from it sorted waste (such as paper & cardboard, plastics, metals), as well as other reusable materials with market value. Purified leachate is obtained

by all landfills – thus it has to be mentioned, that this product has negligible value, as being used internally as technical water or for fire-extinguishing pools.

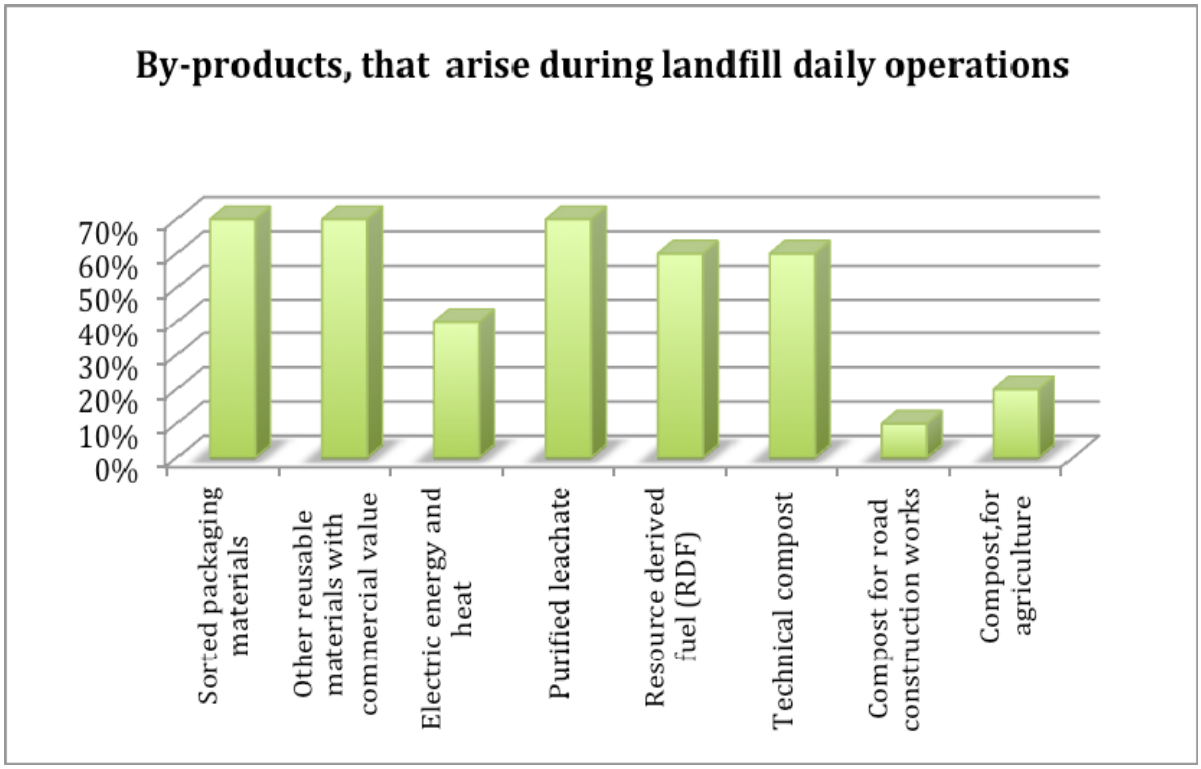

Figure 2 - Question No.3 – response of Landfill group
Source: by authors

The Expert group sees as the main by-products all of the options (70%-90%), except for RDF (60%) and compost, that is used for road construction (40%) and compost for agricultural purposes (25%). This is explained by the fact, that production of RDF in many countries is done prior waste reaches landfill. Regarding compost production – unless separate collection of biodegradable waste is ensured, no high quality compost production is possible. Compost composition will be full with residual waste and heavy metals that would be a problem for meeting the agricultural fertilizer quality [6].

Analysis of this question leads to industrial symbiosis, which is the "physical exchange of materials, energy, water, and by-products" among geographically proximate firms [2]. Further on, Chertow *et al.* identified many types of collaborative arrangements for businesses that lead to the development of it [3]. In addition to the more "traditional" approach i.e. "byproduct exchanges" there are other typical approaches included in the definition of industrial symbiosis, such as the sharing of utilities and infrastructures and joint provision of services. Sharing utilities and infrastructures are defined as the "pooled use and management of commonly used resources such as steam, electricity, water, and wastewater". Industrial symbiosis stems from industrial ecology, which emphasizes the importance of life-cycle thinking in resource use [1, 9, 12].

When analysing, what are the resources that could be offered for other companies that are either not used in an efficient manner, or not used at all, the Expert group has identified following resources (Fig. 3), mostly focusing on education of society and awareness creation. They also pointed out that the landfills should be as open as possible to teach people sorting waste. Next step is to promote waste reduction and prevention. That means promotion of repair and reuse, especially for electric, electronic and bulky waste. When analysing the responses of the landfills, they see themselves fully involved in sharing experience, education of the society (80%), organization of excursions and trainings (90%), followed by technical equipment (60%), Infrastructure required for establishment of business (fenced territory, supply road, premises, etc.) (50%) and exchange of energy commodities (30%).

This leads to a very important question, analysed within the questionnaire – question No. 5 "What could be as a stimulating factor for a landfill management company to involve into industrial symbiosis?"

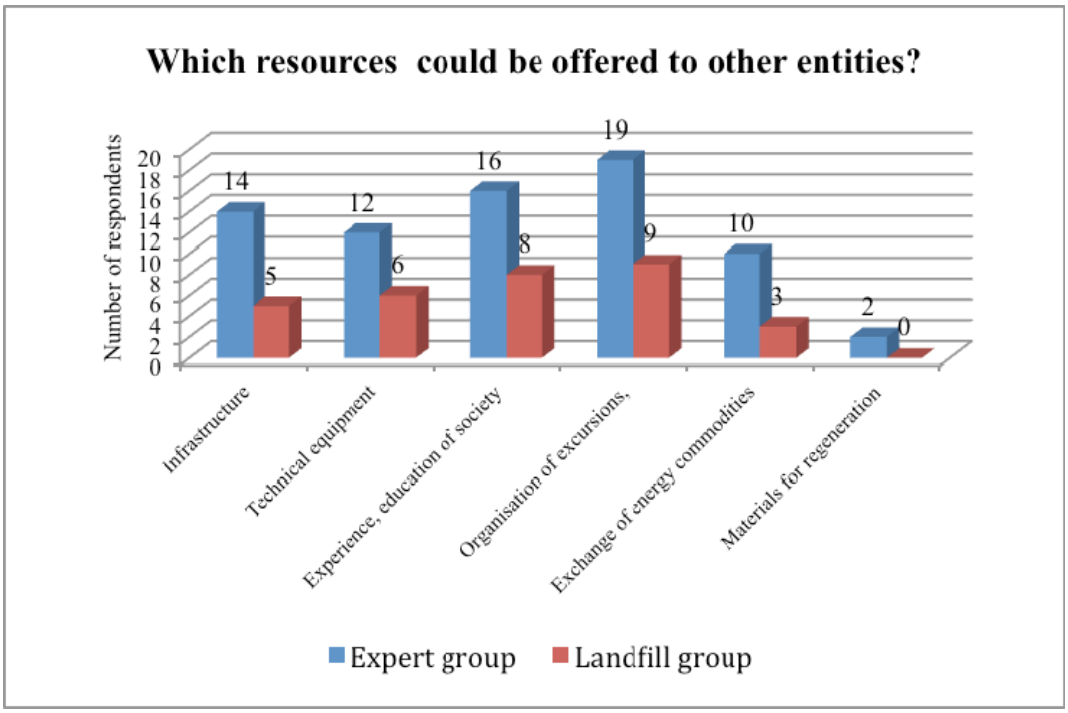

Figure 3 - Question No.4
Source: by authors

Landfill management companies point out as the most stimulating factor 44% of respondents - Education of the society, explaining that modern landfill is environmentally safe and different types of manufacturing can be allocated within it's territory. This is followed by necessity of development of state support programs in order to facilitate cooperation of different sectors – identified by 39% of respondents. 6% see the main obstacle in legislation, pointing out that it has to be redeveloped in order to promote inter-disciplinary cooperation. On the other hand 11% of the respondents consider that the existing legislation is sufficient and

the companies themselves already start to develop industrial symbiosis on landfill basis. When turning to Expert group, within the same question, 75% of respondents support the idea of state aid necessity, followed by reconsideration and revision of legislative base (45%), only 15% of the respondents consider the legislative basis to be sufficient and 25% of Expert group stress the necessity of society education.

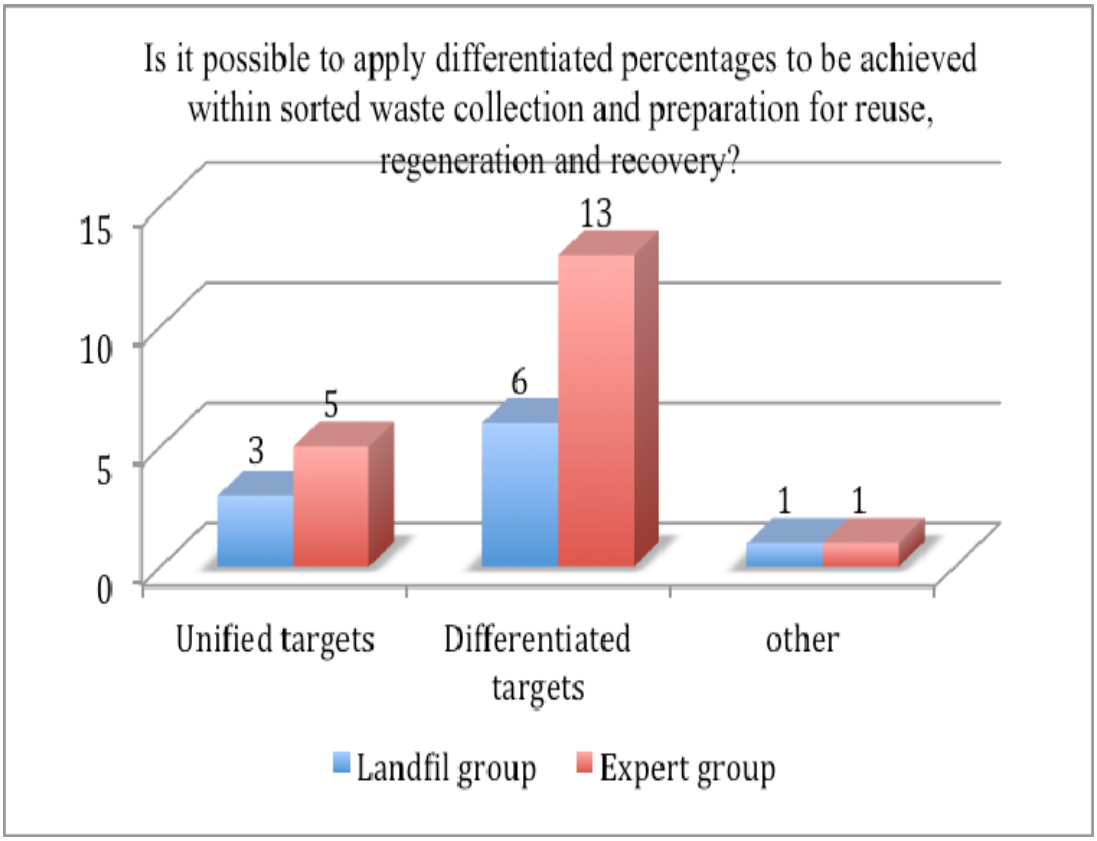

Figure 4 - Question No.15
Source: by authors

Very important topic of present days is the 2020 targets – their achievement possibilities, responsibilities and liabilities. Currently the author is also engaged in changing of the Cabinet of Ministers regulations, as present version does not state the responsibilities for achievement of recycling, recovery and reuse targets for household waste. It is quite notable, that the Directive 2008/98/EC on waste speaks of a target, but does not provide in-depth information, weather the target has to be unified for all regions of the country, or there is a possibility to differentiate it, but the average per country has to reach 50%. During the survey, the authors revealed, that both in expert group and in landfill group the respondents support the second option, i.e. a situation, when within one country, regions have different targets, depending from region's nuances, development of waste management system and other aspects, although on the country level it has to be ensured that the EU defined goals are fulfilled. The experts say, that it is very precisely pointed out that regions differ both by economic situation, by geographical situation and by

migration flow intensity, this is why, they consider an "internal rate" system has to be designed. According to latest forecasts, in 2020 we can have a situation when 60-70% of all working inhabitants will be working and living in the capital. The targets have to differ, varying by life quality possibilities, cost calculations and other factors; an appropriate algorithm has to be developed. It is quite notable, that there were also responses "other", where the respondents opted for "We consider that the situation can be settled when one waste management company would operate within a country, which would be liable for achieving the targets and their fulfilment. This would allow all regions to set unified requirements, provide unified circumstances and unified price for waste management." or "Theoretically, differentiation can be a solution, but one has to consider economic feasibility. For example Riga region or more industrially developed region could reach the targets or on the contrary, not be able to reach certain flow targets. Some flow recycling/recovery can be extremely expensive as composition of particular type of waste could be negligible, and recycling or recovery of this percentage can result economically ineffective. Differentiation can complicate the situation. Possibly, one could consider quota system, but in this case the system has to be very understandable and transparent".

3. CONCLUSIONS

Over the twentieth century, the world increased its fossil fuel use by a factor of 12, whilst extraction of material resources increased by a fold of 34 [10]. Across the EU 28 average domestic material consumption in 2014 reached 13.296 tons per capita, in comparison Latvia's domestic material consumption was 21.504 tons per capita [11]. This leads to a conclusion that a paradigm shift is required – to turn from waste management to resource management, otherwise sustainable consumption and use of the resources would not be achieved. No best practice or one-size-fits-all solution can be applied in the field of waste management. Despite unified targets set by current legislation, each member state is free to choose a combination of economic gears, applied in the country with the aim to secure sustainable waste management system, taking into account it's social, economic and historic distinctions. Currently it is seen as logical option, for Latvia to develop unified targets for recycling and preparation for reuse within waste management regions, as for individual municipality it is a complex and difficult task.

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ECOLOGICAL NETWORK AND OPEN URBAN SPACES: THE CASE STUDY OF POMPEI AREA IN ITALY

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ABSTRACT

Within a wider Project on Pompei area, this paper develops a multidisciplinary study on some places of Pompei area characterized by a strong urbanization, sometimes very far from sustainable development of the area itself. The wide number of tourists that every year visit the archaeological sites is one of the main and dangerous cause of the degradation for Pompei and other towns around. The study presents also some proposal for urban open spaces as starting point for land regeneration. The inclusion in the model of functional areas can help to increase the resilience of the urban environment through the correct balancing of the surfaces that characterize the space reservoirs and implementing strategies for the rational management of the water cycle.

Keywords: Pompei area, archaeological sites, urban environment

1. INTRODUCTION

The research, concerning the analysis and rehabilitation of a highly urbanized area of archaeological, historical and cultural value, is part of the CAMPUS Project “Urban eco-tourism for sustainable use of Cultural Heritage” (Scientific Coordinator: Prof. Carmine Gambardella) – Benecon SC.aR.L. Research Center. The application concerns to a sensitive context in the Pompei area. This context is particularly significant for the aim of this research, in particular for its highly urbanized area and natural areas strongly affected by anthropization.

The goal of the research is the identification of eco-oriented technological strategies for the regeneration of natural space in anthropic contexts with particular reference to the improvement of ecological and environmental quality.

Specific attention has been given to the analysis phase of the land context also through the experimentation and the integrated use of techniques and methodologies for the multidimensional digital survey at different scales and through the observation of the context, of the infrastructures and building heritage.

The purpose of the study has been to identify the elements of the existing ecological system, to hypothesize its future scenarios and to offer development guidelines for the preservation and improvement of urban areas.

2. TERRITORIAL ANALYSIS AND REPRESENTATION (Nicola Pisacane)

The research activities related to the representation of the Pompeian territory are articulated in strategic objectives emerging from the analyzes carried out, including the identification and reuse of large buildings (now dismantled or improperly used) and urban voids (greenhouses, gardens) in order to confer a new identity on the outskirts of the city by configuring them as attractors; the introduction of renewable energy sources to innovate in a new quality the relationship between environment, life and work; the recovery of street, central and peripheral waves, to restore greater organicity to the urban contexts. The preliminary knowledge of the territory has been the critical approach in the collection of data and in their analysis. At this stage, the disciplines of architectural and environmental survey and representation have played a central role, both for knowledge than for design (Figure 1).

The project is innovative already in its premises, i.e. considering the entire territory as a living organism and constantly evolving, to be analyzed in every component, material and immaterial, involving aspects ranging from studying the technical and performance aspects of buildings, to the psychological aspects associated with the enjoyment of cultural heritage.

This strategic line aims to promote eco-sustainable development of the territory through the protection and enhancement of the natural and cultural resources present in order to combine the improvement of the quality of the environment with the economic growth resulting from the development of tourist activities, productive and cultural, with a view to sustainability.

The results of these analyzes were allocated to a single technology platform, a georeferred information system capable of managing the environmental multi-dimensionality. This representation system has enabled transferring information on geology, morphology, hydrology, vegetation, history, physics, chemistry, environment, structures, cultural heritage, psycho-perceptual, socio-economic, administrative aspects, and so on, which constitute an open and dynamic system of knowledge. The information contained in the layers can in fact be linked to each other according to multiple combinations, also providing judgment and evaluation tools, analytical and synthetic of the territorial area, competing with the representation of reality and its critical description for the exploitation of the

territory through choices made based on active, dynamic and multidimensional monitoring.

The knowledge tools we have come from today's technology and computing, which extend the traditional notions. The innovation of this approach is based on the production of a complex and dynamic system of knowledge.

In particular, the study here is part of a broad research project that, integrating knowledge and technology, is a driving force for innovation in the cycle of protection and regeneration of cultural, environmental, landscape and industrial assets.

The project has enabled the integration of knowledge and multidisciplinary skills, identified as an indispensable premise for the governance of the modification.

It is important to clarify that the territory of Pompei area is not the only fence of archaeological excavations, but the whole common, carries critical elements but also has enormous potential to be highlighted and valued. It is a site of enormous cultural and tourist value (2,500,000 tourists visit the archaeological excavations yearly, and 4,000,000 pilgrims visit the sanctuary of Our Lady of Pompeii), but burdened with strong problems arising from the current mode of tourist enjoyment, which in the absence of sustainable planning damages the local heritage and identity, without bringing wealth and well-being to the population. It was therefore a matter of analyzing a vast and heterogeneous territory, on which only the geometrical and morphological aspects of the survey were made necessary to use different modes and technologies, each in the context in which it was more appropriate: archaeological area, monumental buildings, urban fronts, and peripheral areas. Research has thus also been configured as an experiment on the integrated use of techniques and instrumentation for relief, a field laboratory to develop a proven multidimensional and multiscale integrated digital survey methodology.

The obtained data provided a detailed picture of the situation of the entire territory of the municipality of Pompeii, which was compared with the archives and historical flights (from 1945 onwards) to evaluate the evolution and modifications of the 'environment over the years.

These surveys have been complemented by the contribution of the other specific disciplines: for example, historical and archive research, which has allowed to formulate unprecedented hypotheses on the evolution of the territory of Pompeii before the first archaeological excavations were carried out; the monitoring of environmental and acoustic pollution and the design of sound landscapes; Structural surveys on different types of buildings for the definition of environmentally friendly design protocols for the recovery and upgrading of historic buildings; surveys on seismic security levels; the study of an integrated system of sustainable mobility and production of electricity (from greenhouses and photovoltaic parks) for better cultural and tourist enjoyment of the excavation area; and so on (Longobardi, 2002).

The project is innovative already in its premises, considering the entire territory as a living organism and constantly evolving, to be analyzed in every

component, material and immaterial, involving aspects ranging from studying the technical and performance aspects of buildings, to the psychological aspects associated with the enjoyment of cultural goods. This strategic line aims to promote eco-sustainable development of the territory through the protection and enhancement of the natural and cultural resources present in order to combine the improvement of the quality of the environment with the economic growth resulting from the development of tourist activities, productive and cultural, with a view to sustainability. Cultural Heritage must be a resource for the territory, but respecting local identity; for this reason it needs to be analyzed and programmed in all its components to achieve a positive final balance even from the point of view of the reduction of harmful emissions or noise pollution due to poor programming of accessibility and mobility for the enjoyment of sites of interest. The results of these analyzes were allocated to a single technology platform, a georeferred information system capable of organically managing the multi-dimensionality of the environment. This representation system has enabled transferring information on geology, morphology, hydrology, vegetation, history, physics, chemistry, environment, structures, cultural heritage, psycho-perceptual, socio-economic, administrative aspects, and so on, which constitute an open and dynamic system of knowledge (Figure 2).

The information contained in the layers can in fact be linked to each other according to multiple combinations, also providing judgment and evaluation tools, analytical and synthetic of the territorial good, competing with the in vivo representation of reality and its critical description for the exploitation of the territory through choices made based on active, dynamic and multidimensional monitoring (Gambardella et al., 2015).

The experimented model is exportable to other contexts, both from the point of view of the method adopted in the individual segments of the survey at the various scales, as well as a general method of cognitive analysis of a territory in its complexity, as a final product, or as a flexible information system and implementable, designed to be used by all stakeholders in the area: from local administrators, law enforcement, to tourists for a conscious and sustainable planning of their visit.

3. ECOLOGICAL NETWORK AND ENVIRONMENTAL REHABILITATION (Raffaela De Martino)

The uncontrolled growth of cities, with the resulting settlement, infrastructure and production phenomena, have led to profound alterations to the territorial ecological structure by intensively transforming natural and semi-natural spaces: nature is often reduced to isolated fragments, poorly connected and strongly compromised in its ecological functionality. In recent years, the concept of ecological network, referred to as an interconnected system of habitats to safeguard biodiversity, has been proposed for the environmental redevelopment of significantly anthropized territories since it allows to “design” the territory starting from the handling of conflicts between the anthropic and natural flows.

These considerations have been applied to the territorial context of the Sarno River regional park in Campania. The territory under consideration has been significantly compromised by the constant anthropic aggression that has been carried out over the last fifty years: water supplies from springs, the supply of pollutants of agricultural, civil and industrial origin, the illegal dumping of waste, as well as the cementing and rectifying long stretches of the river banks have all led to a drastic reduction in the ecology and ecosystem. Numerous studies have highlighted how river water quality and dynamics are influenced by the conditions of the surrounding area. The river is a living ecosystem not only in itself, but also in the relationships it physically and ecologically establishes with the crossed territories. It is therefore evident that an environmental reclamation of the area, aimed at the realization of a local ecological network capable of "engaging" with the regional level, must aim to reconstruct the balance between territory and the river network in the long term.

The aim of the study is to use the ecological network as a tool for regenerating the territory of the Sarno River Regional Park in order to improve its ecosystem quality.

From a methodological point of view, the study has focused on the construction of an ecological network for the territory under study, according to an approach that, starting from the ecological-environmental analysis, identifies the elements (both aerial and linear) that constitute it, while also evaluating the overall quality level in order to define any strategic actions necessary for its implementation.

The methodological organization for the construction of the ecological network has included several phases:

- ecosystem and ecological analysis;
- identification of the territorial ecological network;
- comparison between the identified ecological network and the results of the analytical phase;
- identification of environmental improvement actions on the elements of the network identified above.

The ecosystem analysis, applied to the environmental system under study, is based on ecological indicators and analytical-descriptive methods present in current literature, that are able to highlight the level of ecosystem equilibrium of a given territory and the level of territorial fragmentation. The scientific study of the functioning of environmental systems is carried out through Landscape Ecology with space models that can quantify the processes by using a set of control indices already known in ecology but applied with appropriate modes to landscapes.

The tool used to analyse the state of the environmental health of the area under study, capable of giving a graphical model that schematically represents the level of ecological connection of the territory is the Ecological Graph. Thanks to this model, it was possible to identify the landscape units and the most ecologically valuable connections to be preserved, the parts of the territory upon which to aim to improve the system as well as the territorial portions characterized by high ecosystem quality and therefore more resistant to possible human intervention.

Upon identifying and quantifying the territorial fragmentation, the ecological analysis made it possible to collect different types of information about the environmental system analysed so as to define and evaluate the initial ecological structure. All the information and data relating to the analysed territory have been collected and standardized through an ecological assessment that can delineate the ecological structure of the territory and provide the "ecological value" of the individual areas.

After the analytical phase (ecosystemic and ecological), the ecological network for the territory under study was developed. This meant identifying the territorial elements capable of assuming the role of core nuclei in the network and the most important ecological connections.

It was possible to identify the elements of the network on the territory through the application of *landscape/structural* and *biological/functional* criteria. The *landscape/structural approach* includes the identification of environmental realities in the territory that, because of their structural and spatial conformation, can belong to the potential ecological network. However, the connectivity of a system is determined not only by the structural parameters, but also by the *biological/functional* parameters that take into account the behavioural differences of the different species present throughout the territory. Nevertheless, it is not possible to hypothesize the modulation of the protection and the uses of the territory on the dynamics of every species. It is therefore necessary to identify some priority species (focal species) in order to guide any interventions on the most at risk elements and optimize the use of the available resources .

Through the composition of the grids of each of the focal species, a single grid was obtained that represents the potential ecological network for the environmental system under study (Figure 3).

The adjective "potential" highlights how the efficiency of the network is subject to an acceptable level of the ecological-environmental quality of the structural elements that constitute it. Since, in the present case, this condition, verified through a comparison with the results of the analytical phase, was not always satisfied, it is necessary to identify for some elements, more appropriate environmental rehabilitation interventions so as to improve the overall level of ecosystemic-ecological quality.

In analogy to the principles that guide the classification of the technological system (UNI 8290), the environmental improvement interventions have been systematized through the identification of *Classes of support units* of the ecological network divided into levels of importance. Subsequently, the *Support unit* for each of them has been defined, capable of housing the works of environmental improvements aimed at optimizing hospitality wildlife and the implementation or enhancement of the ecological role of the network elements. Finally for each support unit, the *Potential intervention* unit was identified.

The network elements for the Sarno river basin belonging to ecologically-environmentally low-quality areas, which therefore need environmental improvements, belong to the following classes of support unit:

- Natural main water courses with clearing bands;

- Main viability;
- Railway lines;
- Secondary viability;
- Agro-ecosystem.

Each potential intervention unit was mapped with exhaustive indications of: purpose, role within the ecological network, interventions to be anticipated, work execution techniques and management aspects.

It is important to point out that the potential ecological network identified is a local level network, built according to the specific needs of the focal species present in the territory. Planning at this scale plays a key role since it allows to defend and use biodiversity sustainably. However, provided that the functionality of this network is guaranteed, it is necessary to co-ordinate it with the supra-local scale: in the interpreting of the territorial organization, the local territorial system is part of a system of wider relationships, representing one of the supra-local network nodes, which connects the different places between them.

This is in accordance with the indications of the Regional Territorial Plan of Campania in which the Regional Ecological Network (RER) identifies it as *the connection in a single system of territorial realities that pursue the centrality of the territory, recover its own integrated vision and play a strategic role in local development processes, ensuring the sustainability and compatibility with the environmental resources and ecological processes.*

In the light of the work that was carried out, possible future developments could be based on the specific design of environmental improvement interventions on the network elements with little or no ecosystem/ecological quality, while on the other hand, on the study of the ways of "joining" the local ecological network as well as the higher levels, so that territorial biological connection is possible, which is a fundamental condition for the proper functioning of the network itself.

4. THE ENVIRONMENTAL NETWORKS SYSTEM (Rossella Franchino)

A problem related to the growing urbanization that took place in the last century is that of protecting the environmental conditions of the territory from the impact of development and anthropisation. To address the development of the urban territory in order to find an alternative to the model that was imposed in the last century, transformation and rebalancing interventions must be addressed with particular attention to the identification of possible interferences between the natural and anthropized aspects, while also dealing with the issues related to the sustainability of urbanization, biodiversity conservation, land use control and territorial fragmentation.

Fragmentation has the immediate consequence of isolating natural environments with an impact on their ecological conditions, causing the reduction, and in some cases, the destruction of the biological populations present. The main causes of the fragmentation process are mainly due to urban growth, land exploitation through intensive agriculture, but above all, the distribution in the territory of infrastructure networks responsible for the flows of matter, energy, etc.

The territorial redevelopment interventions must therefore deal with the ecological conservation of biodiversity in order to safeguard the natural processes underlying the survival of the ecosystems.

Particular attention is therefore given to the system of networks that represent the tool that allows for the redevelopment interventions of the natural space within contexts that have been transformed by man.

In order to improve the capacity to absorb and control the phenomena of urbanization with a sustainable impact on the ecosystem, the role played by the networks system to ensure supplies and services that must be structured in a manner consistent with the sustainable changes from the environment in which they are located is very important.

It is therefore evident how an organic restructuring of the networks system that takes into account not only of the ecological aspects but also other environmental issues related to the water, air and soil subsystems may be important for the sustainable management of the territory with an interest in the conservation of the species present as well as the conservation of biodiversity.

The concept of network traditionally presented in current literature recognizes only network infrastructures (grey infrastructures) which consist of an accessory, albeit useful and necessary, superimposed on the territory, a secondary element to its ecological and environmental transformations. The traditional approach to the problem of network service provision is that of realising infrastructures, merely an engineering operation that measures the network on an established or predictable demand with passive criteria and places it in the territory with a project guided by the criterion of cost effectiveness, tempered only by the duty to observe the reference norms.

A different way of working is to consider networks as a system of networks of integration, consolidation and protection of the anthropic intervention that improves the ecological-environmental quality of the territory, providing it with appropriate and sustainable services.

It is a linking element since the network can realise an interconnection of services as well as of built and natural spaces through optimization processes for the built spaces that they serve as well as the natural environment and ecological context in which they are inserted and which they help to modify.

A network is a stable, programmable and repeatable system of the supply of performances, exchange of information, transfer of products, energy transmission, transport of things and people, arranged and constructed in such a way that, unless due to accidental failures, it is always available upon the user's request (Franchino, 2006). Since the grey infrastructures in a territory are a mesh made of nodes and connections which can lead to changes in the natural system in which they are located, it is important that in the regeneration interventions of the anthropized contexts, they are placed in relation to the ecological networks that in this type of intervention play an essential role.

The ecological networks are a valuable tool to guide any form of intervention to improve the ecosystemic services as well as the state of biodiversity in the regeneration interventions and rebalancing of urban contexts.

Ecological networks also play a strategic role within the multifunctional system of green infrastructures that make it possible to use the principles of nature as a model of sustainable management, stimulating the natural intrinsic potential of the environmental and undeveloped resources due to mass anthropisation. Using the ability of nature is, moreover, more convenient not only environmentally but also economically, since it allows to contain the use of grey infrastructures, that can be costly both from an economic point of view as well as an environmental-landscape one.

The realisation of green infrastructures, in addition to improving the quality of the water, air and soil subsystems, also has positive effects in relation to the control of hydrogeological disasters and the management of climate change. In general, these infrastructures contribute to increasing the resilience of urban areas and can thus provide a sustainable future for the anthropized territories as well as generate numerous environmental, social, cultural and even economic benefits in terms of the implementation of green economy projects .

The issue of compatibility between grey and green infrastructure has orientated the application to the case study under consideration of the Pompei area. Several field restrictions were set in place, which included the intersection of the potential ecological network built according to the procedures set out above and the road and transport infrastructure network (Fig. 4) that among all the grey infrastructures, for the area under study, were the ones with the most impact on the environmental water, air and soil subsystems (De Martino et al., 2016).

The comparison confirmed, as had already emerged in the initial ecosystemic analysis, considerable problems of interaction between the two systems, with it being necessary to intervene with appropriate mitigation strategies as well as improve the ecosystemic characteristics in order to make the grey and green infrastructures compatible, of which the ecological networks are a key element.

5. OPEN URBAN SPACES AND CONNECTION AREAS (Caterina Frettoloso)

The exploration of urban open spaces in this study shares the logic that it is appropriate to reason on networks, at different scales, that carry not only a biological function but are conceived as "[...] systems of bio-cultural connections, networks of networks or with metaphor in some respects bold, an environmental infrastructure: a basic infrastructure, which, placing itself before those currently popular it tends to ensure throughout the territory, the conditions for environmentally sustainable development" (Gambino, 2003).

In fact, "as part of a network, strategically planned throughout the urban area, well-designed urban spaces can help reduce the impact of the urban heat island thanks to the refreshing effect of vegetation; help regulate the water balance and reduce drainage, allowing for more rainwater infiltration; reduce the impact of noise and environmental pollution; constitute an ideal habitat for plants and animals" (Stiles).

The study involved the development of a network model that, based on the considerations set out, works in different ways: it relates noteworthy points to a particular urban context (sites of cultural interest, environmental or strategic areas from a functional point of view); provides an integrated system of connection and relaxing/sharing spaces maximizing accessibility and mobility; increases environmental ecological quality by interfacing (by overlapping or intersecting) with the territorial ecological network.

A urban open space network is characterized not only by the set of isolated spaces but also, by the connective tissue that detects the system of relationships established between them, relationships that influence the users way of enjoying, both physically and perceptually, the city itself. It is therefore possible to read a network through two dimensions that co-exist, the physical and formal, as well as the relational one in terms of connections and interactions (Pinto et al., 2010).

The proven difficulty is in locating in heavily anthropized environments green areas with high environmental valorisation (size that allows for the passage of fauna, floristic continuity, presence of watercourses, etc.), especially in large metropolitan areas, suggested in designing selection criteria that also included elements that could be called urban (Pagano, 2006). Therefore, the methodology developed for the construction of the network contemplates the systemization of both existing spaces characterized by functions such as relaxing, meeting and connection where there is a percentage, even if minimum, of green as well as spaces that express the potential while being, in the current economic-environmental budget, a cost for the city (urban voids, residual spaces, areas for inappropriate use).

In line with the approach adopted for the construction of the ecological network, two network models will be defined: a potential open space system that will only become permanent once the necessary improvement strategies are implemented to answer the expected system performance.

The model will then find different final configurations depending on the specific application contexts and will be closely connected to the data set out by the functional-spatial and ecological-environmental analyses of the intervention area, taking into account both the current state of the elements as well as the increase in quality that they could have on the network.

From a methodological point of view, it was useful, in the phase of identifying the characterizing elements of the model, to hypothesize a starting performance framework that could synthesize the most recurring issues in the urban contexts of the territory under study. The city of Pompeii was a significant example, given the richness and variety of its archaeological and environmental heritage. A wealth that makes it a city under great tourist stress, as highlighted by the numerous types of users present and the variety of ways to enjoy it. This wealth "is opposed by an inadequate supply of tourist facilities and services, such as public transport; park and rides; complementary shops; hotels; a poor relationship between the various resources of archaeological and cultural interest; a modest quality of the central urban environment and services (traffic congestion, degradation, shortage of services) that determines the absence of significant

functional relationships between the archaeological excavations and the urban settlement in a predominant condition of degradation in the peripheral areas and peri-urban agricultural areas. The analysis of the geometric and functional features of the road network that serves the city centre showed that while one part of the city has a lot of pedestrian paths, urbanization has occurred in other parts of the city that has penalized the pedestrians, neglecting to realise pavements walks, that in some cases are do not exist or are not wide enough to make it safe to walk, while others are cannot be used due to the furnishings" (Municipality of Pompei).

The proposed model is characterized by an organized set of functional areas which constitutes the backbone of the network upon which it will be possible to attach, depending on the application context, additional elements. The connectivity of these spaces will characterize the articulation and readability of the network highlighting the possible hierarchy of the elements installed. The pedestrian and bicycle networks will, therefore, be the primary connection system capable of allowing the elements of the network to communicate. Both physically and/or perceptually, thus facilitating the accessibility of the individual areas and increasing the use of the system without

creating barriers, while also promoting compatible ways of use.

Mobility and accessibility are significant parameters with which to select the spaces/elements that may be useful to the network and, at the same time, in terms of conservation of habitats, providing guidance on the predisposition of an area to reach higher levels of ecological quality. In order to create connections between the urban space system and the ecological network, it is worth taking into account the feasibility of the fauna and, in a broader sense, to work on environmental protection, trying to increase the performance of each functional network.

The connection areas, i.e. the parts of the territory in which the overlap is achieved between the functional open spaces network and the territorial ecological network, has a key role in the model and is characterized by a higher naturalness compared to other functional areas. Thinking in macro terms, from a performance point of view, these areas should contribute to a rational water management and, in general, be a place of experimentation of strategies aimed at reducing the environmental impacts resulting from anthropic activities. Maintaining high levels of environmental quality will have the positive effect on the urban quality, creating, first of all, open air living conditions that are more comfortable and appropriate to the needs of the users.

The connecting areas still need to interface with the urban context, a task performed in the model by a buffer zone that is placed at the edge of the connecting areas with a dual purpose: preserve the environmental values of the intercepted ecological network and bring the city and users closer to its use in the perspective of both a responsible use of the environment as well as participation in the exploitation mechanisms that the network should trigger (Fonti, Pagano, 2006).

Figure 1- Natural and built environment in Pompei area

As the network penetrates the city, it is necessary to intervene, with a capillary action, with the natural and artificial systems oriented to regenerating, from a microclimate and energy point of view, the urban fabric and open spaces. These areas, defined as mitigation and adaptation areas, are intended not only to accommodate recreational, relaxation or cultural activities but, in particular, small green spaces which share the functional and environmental principles of pocket parks. The current debate on the challenge that sustainable cities must face in meeting the ambitious carbon neutral goal, orientates the urban and building projects to focus on the issue of mitigation and adaptation to the climate (Roma Capitale, 2014). Thus, the inclusion in the model of such functional areas can help to increase the resilience of the urban environment through the correct balancing of the surfaces that characterize the space reservoirs and implementing strategies for the rational management of the water cycle.

The proposed model, therefore, shares the vision of a city that collects various challenges that reflect a growing interest in the human dimension of public spaces: a vibrant city, secure, sustainable and healthy in which the users are asked

to move around by walking and cycling, while also relaxing, or doing other things in the public spaces (Gehl, 2010).

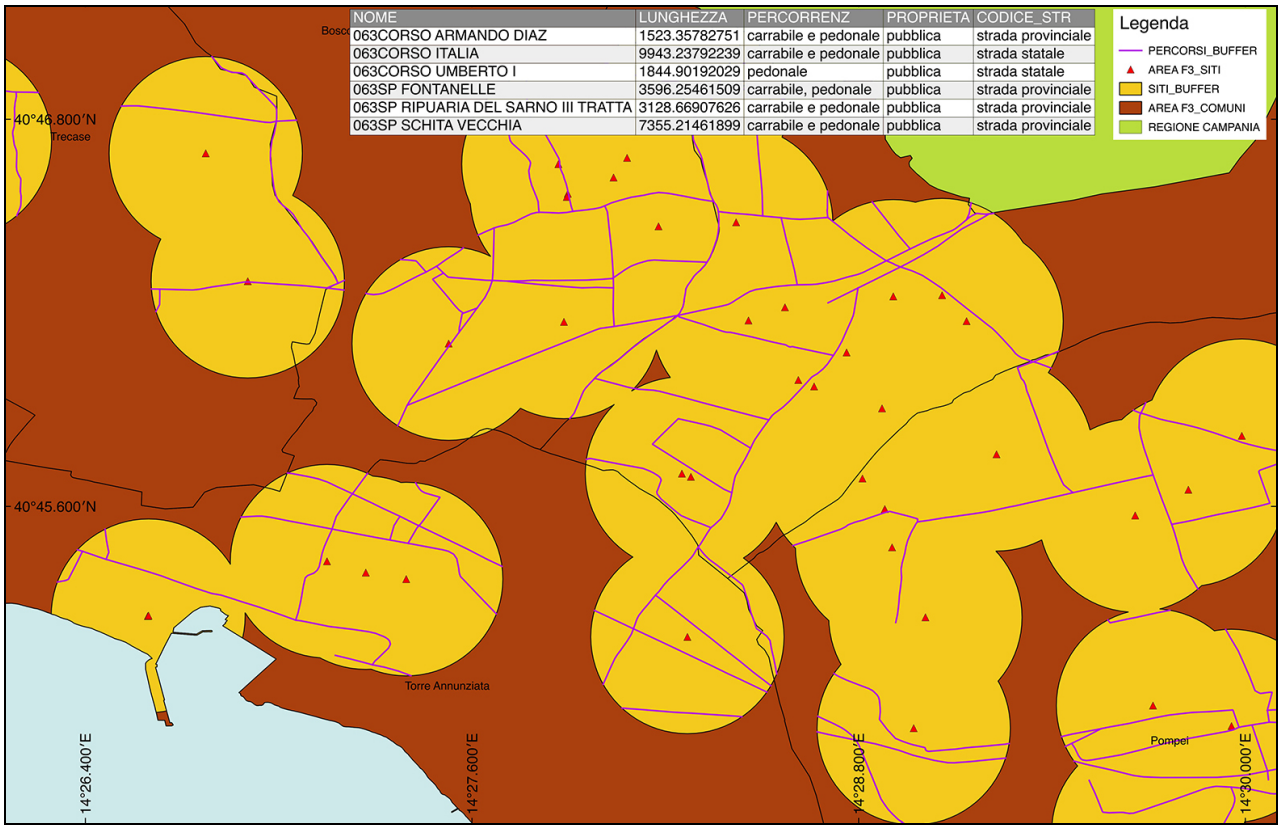

Figure 2 - Geographical Information System of Pompei area. Archeological sites and infrastructures

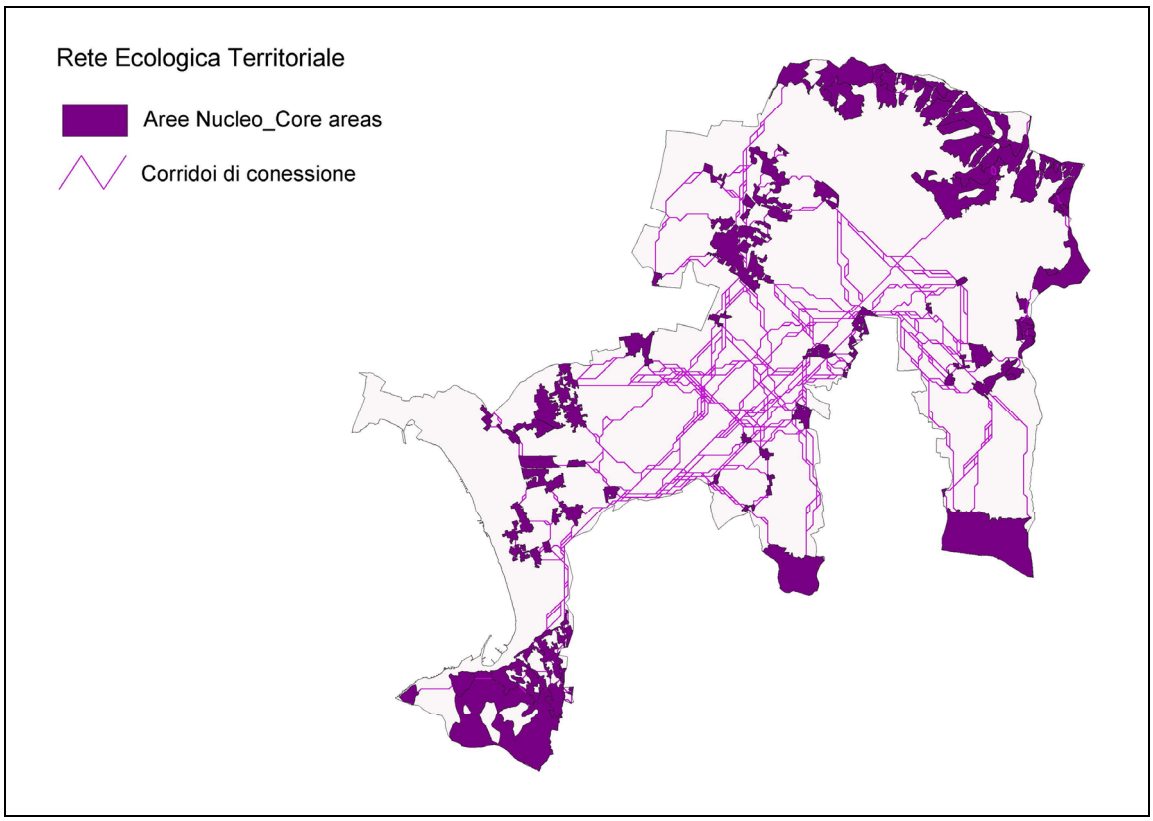

Figure 3 - Identification of potential territorial ecological network

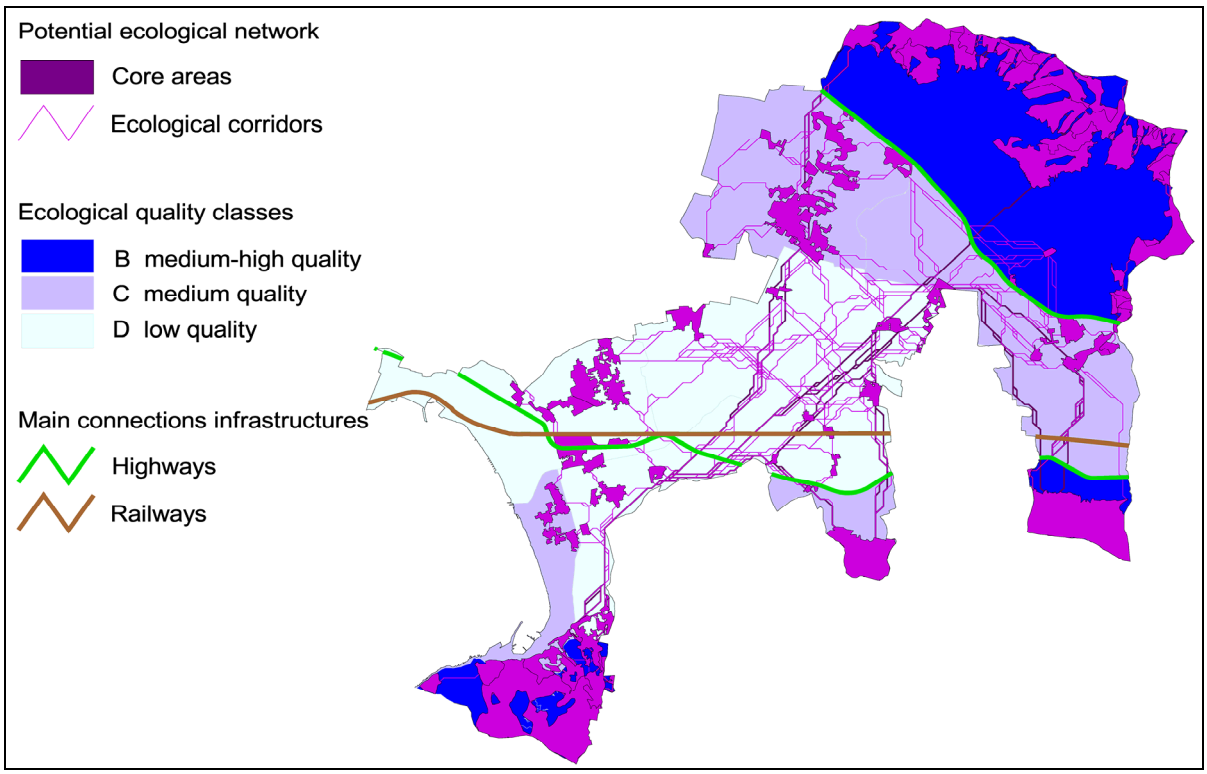

Figure 4 - Intersection between connecting linear infrastructure and potential ecological network

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FORECASTING OF DECREASE IN WATER CONSUMPTION AT THE ENTERPRISE OF THE BEET SUGAR INDUSTRY DUE TO USE OF A METHOD OF WATER BALANCE

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ABSTRACT

The analysis of the existing scheme of water consumption and water disposal of the beet sugar plant with use of a method of water balance is carried out. Water consumption sources at the enterprise are revealed, calculation of water consumption is carried out. The main sources of formation of sewage of the enterprise are revealed, the quantitative and qualitative composition of sewage on three categories is calculated and analyzed. The solution on introduction of local treatment facilities for decrease in water consumption of the beet sugar enterprise due to re-use of the purified waters is proposed. The scheme of local treatment facilities besides mechanical sewage treatment on sand traps, settlers and the mechanical filter, also provides decanters which serve for condensation of a soil sludge which went to fields of filtration earlier. The decanted water after condensation of an earth deposit can be cleaned and returned in the reverse system of water supply. Local treatment facilities will provide sewage treatment of the II category to suitable for use in the reverse system of transport and washing waters. Thus, for sewage treatment of the II category decrease in water consumption of the beet sugar plant with a productivity of 3000 tons on sugar beet on 1400 m^3 of river water a day is possible.

Key words: water balance, sugar beet industry, decrease water consumption.

Modern beet sugar production is resource-intensive production which is characterized by the high level of water consumption on unit of finished goods - sugar sand, and, as a result, high level of water disposal. Earlier authors have

considered a question of resource intensity of sugar production [1]. The question of decrease in water-retaining capacity of beet sugar production is not less important. On average for processing of 1 ton of beet about 18 m^3 of water at the direct-flow scheme of her use are spent and less than 1,8 m^3 of water at the reverse system of water supply [2]. At the same time, the existing Departmental standard requirements of design of the beet sugar plants (VNTP 03-91) order to organize the reverse system of water supply at the enterprise [3].

For forecasting of decrease in water consumption of the beet sugar plant it is necessary to carry out calculations of water balance of the enterprise. It consists of a ratio of water supply (water consumption) and water disposal of the enterprise which include calculation of need for water for the main units and production phases, proceeding from settlement data on a consumption of water [4].

The enterprise with the reverse system of water supply and with a productivity of 3000 tons per day on beet is chosen as an object of a research. Daily productivity on sugar sand about 400 tons is calculated. According to the specified productivity the water consumption is calculated, it will make 3200 m^3 of water a day.

The method of water balance used by authors with the corresponding technical calculations will allow to make a full picture of a problem of sewage of beet sugar production and fields of filtration, defines a possibility of forecasting of decrease in water consumption of the enterprise due to recycling of the purified sewage that also allows to lower load of fields of filtration.

According to VNTP 03-91, the sewage which is formed during a production cycle of the beet sugar plant refers to three categories with different quantitative and qualitative structure.

Water balance water and its possible application in case of water return water management of the enterprise will allow to estimate sources of losses. Such decision will allow to reduce the water consumption of the enterprise. Formation of sewage of three categories with different quantitative and qualitative structure is characteristic of the chosen enterprise.

Assessment of the existing situation on beet sugar production allows to give the characteristic to the following types of sewage:

I category of sewage (conditional and pure waters) is warm water from condensers of evaporating installation, vacuum devices, condensate of return steam, ammoniac water, water from heating an utfel-mixer, coolings of various equipment. Purification of this sewage as a rule isn't required as they are used for cooling and differ in only temperature. In too time other part contains ammonia and insignificant amount of organic substances, such water to be taken away to III category sewage.

II category of sewage is the polluted transport and washing waters, beet-washing, sinks of tests of beet in raw laboratory, straw-traps, stone-traps, beet-pump and a beet elevator. Sewage II of category undergoes cleaning on section settlers and comes back to the reverse system of water supply of transport and washing waters. Remained after settlers the polluted movement-washing waters

mix up with III category sewage on the mud collection of section settlers and arrive on fields of filtration.

III category of sewage is a mix of the high-concentrated drains after various technological and auxiliary operations of beet sugar production. Besides the sewage I and II of categories designated above they include beet-press waters, beet-sour waters, waters from washing of the equipment, a purge of coppers, from washing of scales for beet and a beet-elevator, washing beet-cut installations and the beet-cut of knives, filter cake.

Authors are describing water balance of the enterprise taking into account categories of sewage and data of the enterprise for water supply and water disposal at different stages of a production cycle of beet sugar production. Data are consolidated in table 1.

Table 1 - Quantitative data on water supply and water disposal of the beet sugar plant (m^3/day)

№	**Technological production phase**	**Water supply**			**Water disposal**			**Loss**
		Reverse system	River	Well	Reverse system	Drain-field	Municipal sewerage	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	I category							
1	Cooling of gas laver	440	-	-	440	-	-	-
2	Condensate of evaporating installation (preliminary)	1329	-	-	1329	-	-	-
3	Condensate of evaporating installation (main)	4430	-	-	4430	-	-	-
4	Hydrolocks of vacuum devices	4	-	-	-	-	-	4
5	Cooling of utfel-mixer	330	-	-	330	-	-	-
6	Cooling of the equipment	-	350	-	350	-	-	-
7	Cooling of the service equipment	-	192	-	-	192	-	-
8	Cooling of turbogenerators	-	620	-	620	-	-	-
9	Power supply of boilers of combined heat and power plant	-	800	20	-	191	-	629
10	Oil coolers	-	384	-	384	-	-	-
11	Feed of a pond of the cooler	-	206	-	-	-	-	206
12	Condensate of vacuum filters	1394	-	-	1394	-	-	-

	II category							
13	Hydro-elevator	8400	-	-	7219	1181	-	-
14	Beet-washing office	580	-	-	580	-	-	-
15	Raw laboratory	-	60	-	-	60	-	-
16	Sink of knives and beet-cut	8	-	-	-	-	-	8
17	Sink of floors and equipment	-	10	-	-	-	10	-
18	Station of clarification of water	-	480	-	180	300	-	-
19	Collector of the sampler	-	50	-	50	-	-	-
20	Laboratory of the plant	-	6	4	-	-	10	-
21	Household needs of personnel	-	-	10	-	-	10	-
22	Avtoransport	-	6	-	-	4	-	2
	III category							
23	Sugar beet separation	264	-	-	-	264	-	-
24	Mixer of a filtrational deposit	426	-	-	-	426	-	-
25	Diffusive installation	1200	-	-	-	28	-	1172
26	**TOTAL:**	18805	3167	34	17309	2464	20	2021
27	**SUM:**	22006			22006			

In the first column of table 1 use of water at 25 production phases is presented. For each stage information on water supply, water disposal and losses is provided. In columns from the second on the fourth sources of water supply of production phases are specified, sources are - the reverse system of water supply, river water, deep-well water or water from network of regional water supply. In columns from the fifth on the seventh - the ways of water disposal, that is return to the reverse system of water supply and irrevocable water drainage on fields of filtration and in the regional sewerage are painted. Other article of water drainage is submitted in a column 8, these are irrevocable losses during a production cycle (evaporation, losses with production, etc.). In line 26 total daily values of water consumption and water disposal on all streams are shown. As check of water balance serves the line 27 where the amount of the brought water is equalized by quantity dewatered.

For the further analysis of the movement of water streams at the beet sugar enterprise the simplified scheme of formation of II and III category of sewageis made, which is represented in fig. 1. In the drawing the main sources of formation of sewage of these two categories and stages of their cleaning are visible. Apparently from the scheme, sewage of beet sugar production contains transport and washing, filtration cake in bigger quantity and beet pulp press waters. At them there are also chemical, mechanical and biological pollution.

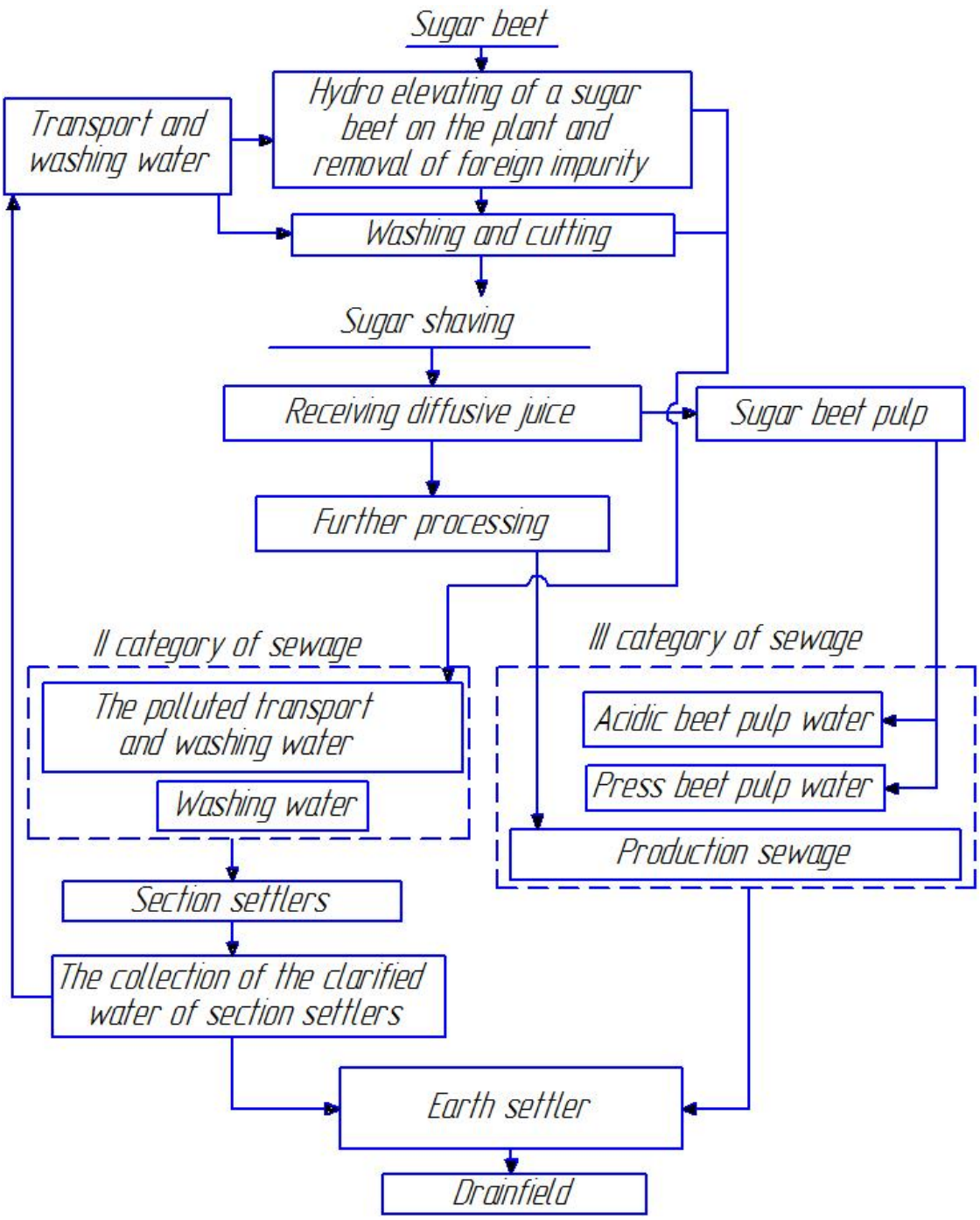

Figure 1 - The scheme of formation of II and III category of sewage on beet sugar production

According to tab. 1 and fig. 1 in a production cycle of the enterprise two main drains are possible: an earth deposit after sewage treatment of the II category (transport and washing), going after section settlers and collections of the clarified water to the mud collection and other III category of sewage.

For decrease in water consumption of the enterprise separate local sewage treatment is offered. It will allow to purify these waters with a mechanical method, it depends biological cleaning is necessary for sewage treatment of the III category.

For assessment of qualitative composition of sewage II of category of the real enterprise and help data authors have made table 2. In the table in columns 2

and 3 the data of the real enterprise received by authors are provided In the table provided concentration for water, arriving on cleaning on section settlers, and concentration of an earth deposit. An earth deposit - water with the concentrated deposit which is formed during purification of transport and washing waters on section settlers and the collection of the clarified water.

Table 2 - Qualitative composition of transport and washing II category of waters

	Indicators	Concentration of indicators in the transport and washing water arriving on section settlers (before cleaning)	Concentration of indicators in an earth deposit (formed after cleaning)
	1	3	4
1	The weighed substances, mg/l	150-300	6000
2	pH	10-12	6,55
3	Dry rest, mg/l	300-2500	2600
4	BOD, mg/l	400-4000	2500
5	COD, mg/l	600-5200	3000
6	General nitrogen, mg/l	10-30	-
7	Ammonia and salts of ammonium, mg/l	2-12	-
8	Sulfates, mg/l	1-100	4,6-256,3
9	Phosphates, mg/l	2-9	0-3
10	Chlorides, mg/l	15-135	4-108,4

For cleaning of an earth deposit to the water suitable for transport and washing needs, cleaning on the weighed substances is necessary. Such cleaning will allow to clean 1181 m^3 of water a day after the hydro conveyor and about 300 m^3 of water a day after the station of clarification. The purified water can be returned to the reverse system of transport and washing waters.

Authors offer the scheme local clearing constructions, capable to purify sewage II of category (fig. 2). Now selection of alternative engineering decisions taking into account technical, ecological and economic parameters is carried out.

The scheme of local treatment facilities provided on the figure 2 besides mechanical sewage treatment on sand traps, settlers and the mechanical filter, also provides decanters which serve for condensation of a soil sludge which went to fields of filtration earlier. The decanted water after condensation of an earth deposit can be cleaned and returned in the reverse system of water supply. Local treatment facilities will provide sewage treatment of the II category to suitable for use in the reverse system of transport and washing waters. Thus, for sewage treatment of the II category decrease in water consumption of the beet sugar plant

with a productivity of 3000 tons on sugar beet on 1400 m^3 of river water a day is possible.

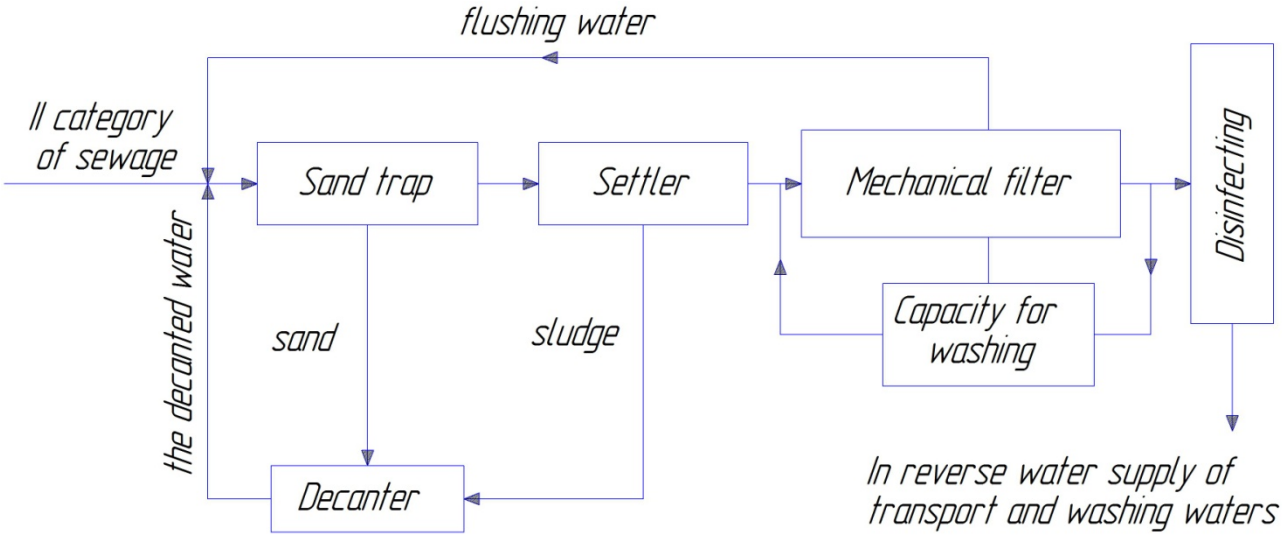

Figure 2 - Scheme of local treatment facilities

In case of introduction of engineering decisions on additional biological sewage treatment of the III category, cleaning there can undergo 718 more m^3 of sewage. Introduction of local treatment facilities for sewage treatment II and III categories for the considered beet sugar plant will allow to reduce irrevocable water drainage on fields of filtration by 2000-2100 m^3 of water a day and to return her to the reverse system of water supply of the enterprise. During it water consumption the enterprise of fresh river water from 3201 m^3 a day will decrease to 1100-1200 m^3 of water a day.

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MENTAL HEALTH AT INDIVIDUAL AND ORGANIZATIONAL LEVEL: THE GHQ-12 IN A SAMPLE OF OVER 2,000 EMPLOYEES

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ABSTRACT

This study aims at measuring mental health in a sample of Italian workers as to evaluate the usability of the 12-item General Health Questionnaire (GHQ-12), both at individual and organizational levels. Indeed, working in unhealthy organizations appears to be particularly risky for workers. A database was built from data collected through a survey of workers in Italian industrial and public firms. The final sample comprised 2,707 employees from 55 Italian organizations. A confirmatory factor analysis (CFA) was conducted in which different competing models were tested. In addition, we measured the degrees of mental health both at individual and organizational levels by using a two-step cluster analysis. The findings of this study indicate that the GHQ has potential not only for measuring mental health at individual level but also at organizational level. In addition, demographic data was associated with mental health and appeared useful for epidemiological purposes. Finally, the use of a two-step cluster analysis illustrates the conceptualization of different degrees of mental health problems. These findings have some important theoretical implications for mental health promotion and also offer several opportunities for more in-depth research. Furthermore, these findings have the potential to help organizations prevent mental health problems at individual and organizational levels concurrently.

Key words: work-related stress, general health questionnaire, mental health, occupational health

1. INTRODUCTION

Nowadays, a greater emphasis is being given to workplace mental health promotion and the implementation of measures to protect and improve well-being at work (Arcangeli et al., 2014). Mental disorders strongly affect individuals and their employment (Poms et al., 2016; Mucci et al., 2014); in turn, individuals with unsupported mental health needs may cause decreased productivity due to increased error rates, poor decision-making, lack of motivation, or high tension and conflicts between colleagues (Sobocki et al., 2006). Furthermore, these negative consequences might increase absenteeism and incidents at work, as well as foster a culture of early retirement (Poms et al., 2016; Sobocki et al., 2006; Arcangeli and Mucci, 2009). Thus, it is important to address the existence and causes of poor mental health and well-being in order to deal with these problems at work and promote healthy employees in healthy working environments (Graziani et al., 2012; Montalti et al., 2012).

In that sense, the General Health questionnaire (GHQ) (Goldberg, 1972) is commonly used instrument for assessing mental health and detecting various sources of distress for workers, such as depression, anxiety, somatic symptoms and social withdrawal. The GHQ is a self-report measure initially developed as a screening instrument to detect psychiatric disorders in non-clinical population (Goldberg, 1972). There are also diverse versions available ranging from 12 to 60 items, in this study focused on the shortest version (GHQ-12) because is the most frequent in the literature (Fryers et al., 2004) and was validated in Italy by Fraccaroli et al. (1991) in a sample of young unemployed participants. However, research on its psychometric properties among workers in Italy is still scarce for proper scientific comparisons with an actual normative sample. Consequently, the first aim of this study is to update the validation of the GHQ-12 in Italy in a sample of employed people.

The second aim is to explore the capacity of the GHQ-12 for evaluating mental health at an organizational level rather than at an individual level. Giorgi (2012) states that an individual's health might be aggregated into organizational health since in organizations there are unhealthy contagious cycles involving individual agents and groups. In other words, in those organizations where there are many workers with mental health problems or who are particularly stressed, there might be a contagious effect, as individuals can affect their colleagues' mental health and mood (Arcangeli et al., 2013; Giorgi et al., 2016; Rosenquist et al., 2011). Thus, in this paper we take a broader look at organizational health, going beyond the focus on individual health that is commonly found in the literature. We discuss methodological issues and theoretical approaches that allow us considering mental health at an organizational level and its implications for evaluating psychosocial risk factors and promoting mental health at work. Validation of the GHQ-12: The validation of a GHQ-12 version in the organizational context may have important implications for occupational epidemiology and for monitoring employees' health and well-being. The GHQ-12 has shown a good internal consistency in a wide variety of studies from diverse

cultural settings (Goldberg et al., 1997), including a validation study in the Italian context in a sample of young unemployed people (Fraccaroli et al., 1991). However, there is still an important controversy about its factorial composition (Rocha et al., 2011; Wang and Lin, 2012; Campbell et al., 2003) and a lack of evidence of its use in the Italian work-related context. In response, this study assesses the factor structure of the GHQ-12 in a sample of workers employed in different Italian organizations. We also explore the internal consistency of the GHQ-12 and its criterion validity by correlating scores on the GHQ-12 with socio-demographical variables and working conditions measures (Psychosocial factors at work). Regarding socio-demographical variables, we expect to find different GHQ-12 scores depending on gender and job position/status. Particularly, we expect women would score higher than men since a meta-analysis of 19 epidemiological survey studies conducted in Europe revealed that women had higher prevalence rates of psychological distress than men according to their scores on the GHQ-12 (Fryers et al., 2004). In light of previous findings, we also expect that blue-collar employees in low-skilled jobs (e.g., transportation, construction or manufacturing) would score higher than both blue-collar employees in high-skilled jobs (e.g., sales, accounting or administration) and white-collars employees (e.g., managers). In this regard, Batinic et al. (2010) argued that blue-collar employees in low-skilled jobs are committed to work that generally involves more physical exertion in less than optimal work environments, increasing the risk of psychological problems.

In addition, although antecedents of health and well-being at work are composite and multifaceted, researchers agree that there is a clear association between working conditions and employee mental health. For example, results from work-related studies conducted in United Kingdom suggest that poor working conditions, such as lack of social support, low decision authority, high job demands and role conflict predict psychological morbidity and distress measured with the GHQ-12 in representative samples of civil servants and healthcare professionals (Wilhelm et al., 2004). Indeed, Rau et al. (2010) found a positive association between working demands and depression. Similarly, recent meta-analyses of longitudinal studies indicated that being exposed to stressful working conditions has negative consequences on employee physical and mental health (Stansfeld and Candy, 2006). Thus, we expect a positive correlation between several job stressors (such as role conflict, job demands and lack of job control and social support) and mental health.

We consider both traditional notions of workplace mental health focusing on the individual and recent comprehensive approaches that emphasize assessing the mental health of the organization itself (Leka et al., 2011). Thus, using the GHQ-12 in organizational settings can be useful not only in monitoring the possible negative consequences of being exposed to poor working conditions (Individual level) or in estimating psychiatric morbidity in a specific population (Society level), but also in identifying specific unhealthy organizations, workplaces, departments or units in which there is a high risk of deteriorate mental health (Group or organizational level).

Considering mental health at an organizational level needs to be approached both from a theoretical and a methodological point of view. In that sense, although aggregations of lower-level variables request caution and continue to remain a focal theme in multilevel organizational methods research (Bliese, 2000; Judge and Kammeyer-Mueller, 2012), one type of emergence of higher-level constructs is the composition model, which emphasizes the shared collective properties of an organization with the assumption of isomorphism between manifestations of constructs at different levels (Kozlowsky and Klein, 2000).

As Kozlowski and Klein describe "a phenomenon [As] emergent when it originates in the cognition, affect, behaviors, or other characteristics of individuals, is amplified by their interactions and manifests as a higher-level, collective phenomenon" (Kozlowsky and Klein, 2000). According to these considerations and based on a multilevel comprehensive approach, organizational mental health can be defined as an organization-level construct that is created from the emergence of individuals' mental health and psychological well-being at work and is amplified by the interactions of the individuals, as people tend to converge in their emotions to those around them, a process that Hatfield et al. (1994) defined as emotion contagion, suggesting that moods and emotions spread among individuals much like viruses. Recent studies have shown that both positive emotions and common mental disorders (Depressive symptoms) can also 'spread' person-to-person (Rosenquist et al., 2011; Eisemberg et al., 2013).

Consequently, the current research design tried to overcome previous limitations by using a cluster analysis technique in order to categorize persons with mental disorders (Or different degrees of mental health) instead of examining total scores. Using a cluster analysis technique might allow us to differentiate different gradations of mental health and not only establishing dichotomy categories (Healthy/non healthy or healthy/mental disorders). Such technique will be also applied at an organizational level, allowing us to differentiate between healthy and unhealthy organizations. Identifying gradations of mental health at both individual and organizational level is important from a managerial and occupational health preventive approach since it allows to establish specific measures depending on the situation (e.g., level of distress: healthy employees/organizations, employees/organizations at risk of experiencing mental problems and employees/organizations with mental problems).

2. MATERIALS AND METHODS

Data was collected between 2009 and 2012 from various companies that were asked to participate in a study investigating stress and mental health at work. The organizations were selected out of convenience. Specifically, 55 out approximately 100 organizations contacted agreed to voluntarily participate in this survey study. Companies were widespread around Italy, although the majority was established in the center of Italy. Furthermore, the sample comprised of only 5 public organizations, whereas 50 organizations belonged to the private sector. Depending on the organization size, in some companies all employees were

involved whereas a stratified sampling technique was followed in others. Overall, the rationale was to achieve a representative sample of the various organizational functions and hierarchies of all organizations.

Participants were tested in their workplace by psychologists and doctors during working hours in rooms provided by the organizations. No payment was provided to participants. They were informed that their responses were anonymous and that completing the questionnaires would take about 30 minutes, although no time limit was imposed.

The questionnaire packages consisted of:

(a) demographic questions;
(b) GHQ-12;
(c) the Stress Questionnaire (SQ).

A subgroup of the total sample was used for criterion validity testing. Thus, the entire sample completed the GHQ-12, whereas employees belonging to a reduced number of private companies (N = 20) also completed the stress questionnaire, SQ. The organizations belonging to the sub-sample were selected out of convenience.

Response rate was high, ranging from 65% to 96% across companies. The latter may be attributed to regulation introduced in 2008 that obliges organizations to assess psychosocial risk factors and their impact on workers' mental health, resulting in a more favorable attitude of companies towards organizational diagnostic activities. Despite the latter privacy and confidentiality have to be taken into account by researchers since results might have strong managerial implications. For that reason, only few demographics (Gender and job position) were collected in order to ensure confidentiality.

The final sample of this study was comprised of 2,707 employees from 55 different Italian organizations. Gender was balanced since 55.2% of the participants were men and 44.8% women. Regarding job position, 70.1% of the participants were blue-collar employees in high-skilled jobs, 25.4% were blue-collar employees in low-skilled jobs and 4.5% of participants were white-collar employees. Finally, regarding professional activity, 43.5% were employed in sales and service areas, 34.5% in technical jobs and 22% in administration.

The sub-sample was comprised of 1550 employees.

After limited demographic questions (E.g., gender and job position), participants completed the following questionnaires in their Italian version:

- The Italian version of the GHQ-12 (Fraccaroli et al., 1991). Participants have to report whether they have experienced a particular symptom of mental distress recently according to a four-point scale (Typically: 'less than usual', 'no more than usual', 'rather more than usual' and 'much more than usual'). The customary scoring methods follow either a bimodal scale (0-0-1-1 with the two least symptomatic answers scoring 0 and the two most symptomatic answers scoring 1), or a 4-point Likert-type scale (0-1-2-3 according to the above mentioned four possible responses). However, there is evidence that suggests that the latter allows better discrimination between competing models in confirmatory factor analysis since "produces a more acceptable distribution of scores for

parametric analysis" (Graetz, 1991). Thus, after recoding negative items (Six of the items are positively worded; the other six are negatively worded), this second scoring method was used in this study. Hence, the questionnaire gives a total score ranging from 0 to 36 points, in which a higher score indicates a 'worse degree' of mental well-being.

- The Stress Questionnaire (SQ) (Giorgi et al., 2013; Giorgi et al., 2015; Mucci et al., 2015). This questionnaire was completed only by a subgroup of the sample (Subsample, n = 1,550) for criterion validity testing. It is composed by 25-item assessing five job stressors or psychosocial factors at work in a 5 point Likert scale (From 1 = "strongly agree" to 5 = "strongly disagree"): (a) role conflict (5 item; e.g., "I have a clear idea about what is expected of me at work"), or lack of awareness regarding your roles and responsibilities at work (α = .76); (b) colleague support (5 item; e.g., "I get support I need from colleagues"), which assess the extent to which employees perceive collaboration and support from their colleagues (α = .76); (c) supervisors' support (4 item; e.g., " My supervisor energizes me at work"), which measures the extent to which employees experience support and understanding from their supervisors or leaders (= .80); (d) job demands (6 item; e.g., "I have unrealistic deadlines"), which measures the perception of quantitative demanding aspects of the job (α = .75) and (e) job control (5 item; e.g., "I can plan my work"), which assess the autonomy and decision-making capabilities that employees have to perform their tasks (α = .75). The factorial structure of this questionnaire has been supported in previous studies (Kalliath et al., 2004).

Regarding statistical analysis we first explored the factorial structure and internal consistency (Cronbach's alpha) of the GHQ-12. According to the solutions found in previous studies (Rocka et al., 2011; Wang and Lin, 2012; Kalliath et al., 2004), this study tests different competing models through Confirmatory Factor Analysis (CFA) to determine the factorial structure of the GHQ-12 among Italian workers: one-dimension model or mental well-being; two-factor model based on how items are presented in the questionnaire (e.g., positive and negative worded); and the three factor model identified by Graetz (1991) that differentiates between anxiety/depression, social dysfunction and loss of confidence.

We then addressed the criterion validity of the GHQ-12 by calculating the correlation coefficients between scores in the GHQ -12 and its dimensions and the scores in the dimensions of the stress questionnaire (SQ). In addition, one-way ANOVAs and t-tests were conducted to explore differences in mental health among target variables (e.g., demographics). Target variables were introduced as factors and both the total score of the GHQ-12 and the score in each dimension were introduced as dependent variables.

Finally, a two-step cluster analysis procedure was used in order to reveal natural groups (Or clusters) within the data set, without having pre-arranged clusters. Cluster analysis encompasses a number of different algorithms and methods for grouping participants of similar kinds into respective categories (Clusters). This method was preferred to using existing cut off points, as the latter can create bias in the definition of categories of people based on whether or not

they suffer from mental health problems (Fraccaroli et al., 1991; Sánchez-López and Dresch, 2008). In sum, a two-step cluster analysis was performed to measure the prevalence of mental health issues and obtain scores to differentiate healthy from unhealthy employees and organizations. In that sense, it is necessary to notice that the Intraclass Correlation Coefficients (ICC) were calculated to test the validity of aggregating mental health to the organizational level. Significant F statistics from a one-way analysis of variance as parameter for ICC (1) and ICC(2) values of more than 0.60 were used as a standard (Bliese, 2000).

3. RESULTS

Three different models were tested by using maximum likelihood estimations to determine the factorial structural of the GHQ-12 in our sample. Results revealed that a three-factor model, where the dimensions were allowed to correlate between them (Anxiety and depression, social dysfunction and loss of confidence), achieved the best fit to the data (Table 1).

Table 1 - Confirmatory factor analysis for the GHQ-12 (n = 2,707)

	χ^2	df	GFI	CFI	RMSEA	RMR	IFI
One-Factor	1,954	54	.88	.81	.118	.038	.81
Two-Factors	1,344	53	.91	.87	.092	.031	.87
Three-Factors	813	51	.95	.92	.074	.026	.92

Whereas both the one-factor model (in which all items were predicted to load onto a single factor, reflecting a general mental health factor) and the two-factor model (Positive and negative worded items where factors were allowed to inter-correlate) presented poor fit indices and both the RMR and RMSEA values were within the accepted range (Brown, 2006; Kline, 2015). According to these results, the GHQ-12 internal consistency was assessed. Cronbach's alpha for the GHQ-12 total scale was .85 and for each dimension/factor ranged from .73 to .82, suggesting the good reliability of the instrument (Table 2).

As it was expected, women (M = 11.1; SD = 5.7) scored significantly higher than men (M = 9.8; SD = 4.9) on the GHQ-12 total scale (T (2576) = 6.3; $p < .001$). Identical results were found when scores on the subscales anxiety and depression, social dysfunction and loss of confidence, were considered instead of the total score. Regarding the job position, blue-collar employees in low-skilled jobs (M = 9.5; SD = 4.8) reported fewer mental health problems (F (2, 2509) = 11.9; $p < .001$) than those in high-skilled jobs (M = 10.7; SD = 5.6) or white-collar employees (M = 10.2; SD = 4.3). Again, identical significant differences were found on the subscales anxiety and depression and social dysfunction; however, the difference for loss of confidence was not significant. Furthermore, the GHQ-12 total scale and each of its dimensions were significantly associated with several job

stressors, with Pearson's correlations ranging from .20 to .47 (Table 2), which supports the criterion validity of the questionnaire.

Table 2 - Descriptive statistics (n = 2,707) and correlations between the GHQ-12 and the SQ (n = 1,550)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1 GHQ12-. Total	10.43	5.42	(.85)	.91**	.89**	.69**	.38**	.34**	.35**	.40**	.35**
2 GHQ12-. AD	4.12	3.63		(.81)	.96**	.72**	.47**	.34**	.35**	.42**	.34*
3 GHQ12-. SD	3.51	2.92			(.78)	.50**	.31**	.29**	.35**	.44**	.33**
4. GHQ12-LC	.60	1.11				(.73)	.29**	.20**	.22**	.21**	.23**
5. SQ-RC	2.00	.68					(.76)	.45**	.39**	.36**	.50**
6. SQ-SS	2.51	.90						(.80)	.42**	.37**	.40**
7. SQ-CS	2.53	.74							(.76)	.37**	.39**
8. SQ-JD	2.74	.73								(.75)	.34**
9. SQ-JC	2.52	.72									(.75)

Note: GHQ12-Total = Total score on the General Health Questionnaire (GHQ-12); GHQ12-AD = Dimension "Anxiety and Depression"; GHQ12-SD = "Social Dysfunction"; GHQ12-LC = "Loss of confidence"; SQ-RC = Score on the dimension "Role Conflict" of the Stress Questionnaire (SQ); SQ-SS = "Supervisor Support"; SQ-CS = "Colleague Support"; SQ-JD = "Job Demands"; SQ-JC = "Job Control"; **$p < .01$ (2-tailed); *$p < .05$ (2-tailed). Cronbach's alpha is reported in the diagonal between parentheses.

A cluster analysis was performed in order to find further evidence of the GHQ-12 sensitivity in light of the different degrees of mental health problems at individual and organizational levels. Sores in the GHQ-12 total scale were considered as a variable in the cluster analysis. At an individual level, results suggested four clusters: the first comprised 44.6% of the cases or employees that participated in our study (M = 6.1; SD = 1.5); the second cluster made up 28.7% of the cases (M =10.3; SD = 1.1); the third cluster comprised 21% of the cases (M =15.5; SD = 2.2); and the fourth cluster 5.7% of the cases (M = 25.1; SD = 3.8). At an organizational level, we first conducted analysis to test if aggregation into an organizational level was feasible or not. Results from one-way ANOVAs tests revealed differences in mental health among target companies when scores in both the total scale ($F (54, 2652) = 3.25$; $p < .001$) and in each dimension were considered: social dysfunction ($F (54, 2652) = 2.74$; $p < .001$), anxiety and depression ($F (54, 2652) = 3.1$; $p < .001$) and loss of confidence ($F (54, 2652) = 2$; $p < .001$). The statistic ICC [2] was thereafter calculated, showing values of 0.60

for the mental health total score and for the dimensions, with the exception of loss of confidence (.48). These results reflect sufficient within-organization consistency and support aggregation at an organizational level. Thus, scores in the GHQ-12 total scale for each company were considered as variables in the cluster analysis. Results revealed two clusters; the first comprised 14.5% of the cases or organizations involved in our study (M = 42.68; SD = 10.51) and the second cluster included the remaining 85.5% of the organizations (M = 22.93; SD = 10.51).

4. DISCUSSION

A comprehensive approach to workplace health management needs to consider the mental health of the employees as well as should explore possibilities for assessing health-related constructs at higher levels.

Our results suggest that the structure of the GHQ-12 in the current sample fits with three factors: anxiety/depression, social dysfunction and loss of confidence. This result is in line with the original purpose of the GHQ of covering diverse common mental health problems or psychiatric disorders, suggesting that the GHQ-12 can be considered a multidimensional instrument. However, as the three proposed factors exhibit high correlations between them, it is also possible to argue that the questionnaire is a screening tool that provides a total score or general measure of mental well-being. In that sense, future studies should explore whether a second-order factor (E.g., psychological well-being) can be obtained from the correlations of these factors (E.g., first-order factors: anxiety/depression, social dysfunction and loss of confidence).

Regarding demographic variables, our results indicate that demographics might play an important role in mental health. The fact that women seem to be more affected by psychological distress than men is congruent with previous findings on psychological well-being (Fryers et al., 2004; Sánchez-López and Dresch, 2008; Malik and Farooqi, 2014), particularly considering that women exceed men in internalizing disorders such as depression and anxiety (Jimenez et al., 2017), which are core dimensions of the GHQ-12. On the other hand, contrary to our expectations, blue-collar employees in low-skilled jobs reported better psychological well-being than their colleagues in high-skilled jobs and white-collar employees (Guest and Clinton, 2006; Von Bonsdorff et al., 2012).

The GHQ-12 also shows a high internal consistency and criterion validity since it was associated to different job stressors that have been identified as precursors of mental problems (Rau et al., 2010; Stansfeld and Candy, 2006). In addition, mental health is a complex phenomenon that might be conceptualized on gradations. Our results suggest that it is possible to construct gradations or degrees for mental health problems by exploring the intensity of mental health with a cluster analysis rather than by using a cut-off point (which may be of interest in clinical settings). The current study provides statistical evidence that 44.6% of the sample did not report mental health problems while 28.7% of our sample indicated low levels of mental health that, whilst it may cause problems over time, are

common and potentially superficial. Indeed experiencing some negative feelings or anxiety now and then appears to be normal at workplace. However, 21% of participants pointed out a potential mental problem that might require professional treatment or intervention. The remaining 5.4% of participants reported important potential problems relating to mental health that could result in permanent problems such as psychological disorders, increased risk of heart disease, and even suicide (Fraccaroli et al., 1991; Kalliath et al., 2004; Cupelli and Mucci, 2010; Mucci et al., 2012).

Finally, our results also suggest that the GHQ-12 can be used at an organizational level to discriminate healthy organizations from unhealthy ones, suggesting its practical use in organizational diagnosis. 14.5% of organizations might be defined unhealthy because they comprise several workers with mental health problems or/and some serious cases. Mentally unhealthy organizations might be hazardous for workers since some psychological problems might not be properly treated and employees with mental disorders can be stigmatized (Harnois and Gabriel, 2000; Martin, 2010; Esmaeili et al., 2014). This might stimulate the conceptualization of mental health problems as "taboo subjects" in the organizations (Amagasa et al., 2005), which, in turn, can trigger that employees who suffer stress or of some kind of mental health problem might not cope with their health status constructively, experiencing a higher risk of developing more serious psychological problems as well as of spreading negativities to the other employees.

We believe that in these organizations negative emotional cycles might be present and mental health problems may spread to multiple people (through contagion effects) (Hatfield et al., 1994; Barsade, 2002; Sial et al., 2011). It may also be that different types of emotion cycles emerge in mentally unhealthy or healthy organizations. For example, people working in unhealthy organizations are likely to pick up on others' negative emotions and tend to focus on negative aspects of their working lives and organizational surroundings (Rosenquist et al., 2011; Larsen and Ketelaar, 1989). In contrast, individuals working in healthy organizations are more self-confident and tend to focus on positive aspects of their social surroundings [32, 50]. Thus, considering that both positive emotions (Happiness) (Eisemberg et al., 2013; Fowler and Christakis, 2008) and common mental disorders can also spread person-to-person (Depressive symptoms) (Rosenquist et al., 2011; Eisemberg et al., 2013), different reinforcing emotional contagion cycles may occur in unhealthy and healthy organizations.

Moreover, as Cooper et al. (2009) pointed out, employment provides psychological experiences that promote mental well-being through time structure (An absence of time structure can be a major psychological burden), social contact (employment offers a social context outside the family) and social identity (Employment is an important element in self-definition). Thus, interventions should aim at both preventing mental disorders (E.g., activities aimed at avoiding illness) and promoting mental health by supporting employees in changing their lifestyle to move toward a state of optimal health (E.g., activities aimed at mental health flourishing and happiness). In this case, the GHQ-12 can be used together

with other measures (E.g., psychological strengths) to assess what mental health needs of the employees are and, in turn, setting priorities before implementation of mental health promotion activities. In other words, the GHQ-12 can be included in the current health risk assessments (HRA), which usually underestimates mental health and focuses more on lifestyle (E.g., exercise, alcohol intake and diet) and physiological data (E.g., weight, height and blood pressure).

Also at individual level, it's worthwhile to note that the GHQ-12 can be used to identify specific employees with mental problems that may need immediate counseling and psychological treatment (Jimenez et al., 2017; Harnois and Gabriel, 2000).

Last, regarding the use of the GHQ-12 at organizational level, from the above findings, it also seems that the GHQ-12 can be used together with other aggregated indicators recorded by HR managers or occupational health professionals (E.g., absenteeism, turnover rates, sick leaves) as part of the psychosocial risk management cycle either to identify departments or units with high risk of mental health problems (E.g., before taking action as part of the psychosocial factors and health surveillance in the company) or to establish the effectiveness of health promotion programs and personnel policies that incorporate health targets (E.g., by comparing mental health levels before and after introducing interventions).

There are also limitations to generalize the results of this study. First, although the study has a significant number of participants from 55 organizations, our sample was convenient and is not representative of the working population in Italy. Second, our measures were assessed via self-report; therefore, the significant relationships found in this study are not immune to inflation due to common method bias. Thus, the GHQ-12 should be used in longitudinal studies in order to provide scientific information about mental health problems in representative samples from the working population in Italy. Moreover, data from epidemiological research at work and from occupational health physicians' daily activities needs to be added to self-report measures in order to confront these findings on mental health problems with related physiological mechanisms.

There are, despite the limitations inherent in the study design, various contributions in our study: (a) the validity and the reliability of the GHQ-12 in our Italian sample of workers; (b) that gender and job position may potentially contribute to mental health at work; (c) that different degrees of mental health exist both across organizations and individuals and (d) that the GHQ-12 is capable of providing a valuable indicator of unhealthy organizations. Consequently, we can conclude that antecedents of mental health problems might be found within the context and structure of the organization, rather than solely in the mind of the individual. This highlights the importance of conducting interventions to promote healthy organizations through the measurement of health also at organizational level (Leka et al., 2011). Thus, measuring mental health at an organizational level appears useful and necessary for promoting healthy organizations and planning a complete intervention on well-being at work.

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SIXTH INTERNATIONAL ENVIRONMENTAL CONGRESS ELPIT-2017

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ENERGY SAVINGS IN INDUSTRIAL FACILITIES

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ABSTRACT

Energy savings are a lever of competitiveness for industrial companies. They are more and more needed to comply with national and international regulations in terms of energy usage and greenhouse gas emissions, and they also are a way to optimize production costs and improve industrial performance. First steps – define an organization and a methodology, according to the size and resources of the company, and carry out an audit of the current energy consumers throughout the production process. Action plans are framed by the most efficient drivers, assuming low investment and a quick payback - we highlight some examples and share experiences. As for the future, digital systems and connectivity can improve energy savings through the development of Energy Management Systems, and their connection to the building dynamic models known as Building Information Modeling.

Key words: greenhouse gas emissions, energy savings, energy management systems

1. INTRODUCTION

The latest decade has seen a growing attention paid to the reduction of the global greenhouse gas emissions and energy consumption. Industry is the major energy user with roughly 40% of final energy use[i], and participates to the global emissions for around 25%, as much as transportation. It stands therefore as a field where energy savings can lead to a profitable result – for environmental sustainability as well as companies' benefits.

The objective of the article is to show that a well driven energy saving policy is accessible to all sizes of business and bring benefits to all of them. An important part of the possible actions can be considered as quick wins, asking for no or low investments yet showing a fast and consequent impact on the energy bill.

On a longer run, the further development of the Energy Management System can systemize those first actions and optimize results through real-time monitoring and adjustment.

2. WHY: DRIVERS OF ENERGY SAVINGS

Regulations

Since Kyoto protocol in 1997 to the Paris agreement in 2016, the strong global acts that framed energy efficiency targets have settled goals for their signatory States to perform a drastic reduction of their energy usage.

European Union translated those global objectives into the 2012 Energy Efficiency Directive (2012/27/EU), setting up the goal of a 20% energy efficiency increase by 2020. Updated in 2016, the EED now targets a 30% efficiency increase by 2030 [2]. According to the countries and the size of the companies, these targets are pursued through a set of regulations, tax systems and incentives. In France, for instance, the energy efficiency audit is now mandatory every 4 years for all companies counting more than 250 employees, while incentives are developed for smaller businesses. Nowadays, deploying an energy saving policy is therefore not only a plus: complying with these rules that always getting stricter – and will follow this tendency in the upcoming years – requires a precise and strong governance.

Competitiveness

Let's go straight to it: energy saving means cost saving. That is probably the most interesting driver to convince any industry to work on its energy footprint, especially in the modern context where the energy price continuously rises. The rough savings of such policies can start with a 15% cut into the energy bill only by "housekeeping", and reach nearly 50% of yearly economies with a fully integrated and real-time managed approach. Those figures make paybacks realistic: if we do consider the weight of energy being near 10% of a product's cost price, a 20% cutback will increase the margin by 2 points [3]. Moreover, tracking energy waste can spawn associated lean production progress, quality improvements and productivity innovations that may boost the result and increase benefits.

Finally, communication and reporting about environmental targets and action plans have an increasing power in terms of brand image, and can actively contribute to the global goals of the company in terms of social responsibility and transparency, and have a positive impact on its financial value.

3. HOW: ORGANIZATION AND METHODOLOGY

Organization

An efficient energy saving policy starts with a simple fact: awareness. At the beginning is the consideration of energy as an integrated inbound of the production chain, and the understanding of its value and cost within transformation process. From this starting point, setting up the framework is based on the company's size and culture. Whereas big groups can have the resources to appoint an energy director and establish an energy team, which will lead to better results but requires more funds, smaller businesses can rely on their existing steering structure and continuous progress groups, and include energy savings within lean manufacturing or kaizen workshops. The agility and mindset of these groups, their multi-disciplinarity as well as their former results in production economies, are to increase support of the top management, facilitate the implementation of the first steps, accelerate the process and generate a sensible and visible promotion of the results. Cross-function is a key feature of the team, which should include production, maintenance, building & utilities as well as purchasing.

The EnergyStar program freely provides helpful matrix [4] (available in three versions - corporate, plants and small companies) to acknowledge the maturity of your company, set up the basis and build the first steps, or even calculate cash flow opportunities of an energy saving project. These files can be downloaded for free on the EnergyStar website (www.energystar.gov).

Methodology

Whether you target an energy bill reduction or a full certification, first steps can be guided by specific project management tools that present the advantage to structure the actions from the very beginning into a systemic vision – making them ready for future improvements and connections. The common methodology for energy savings in industry is a PDCA (Plan Do Check Act) workflow, applied to energy management following the ISO 50001 international standard.

- Plan: Acknowledge the company's managerial and technical status;
- Do: Implement first actions;
- Check: Track and promote the results;
- Act: Adjust actions to improve the results.

Check and Act phases are then meant to repeat endlessly, defining energy saving policy as a continuous improvement effort.

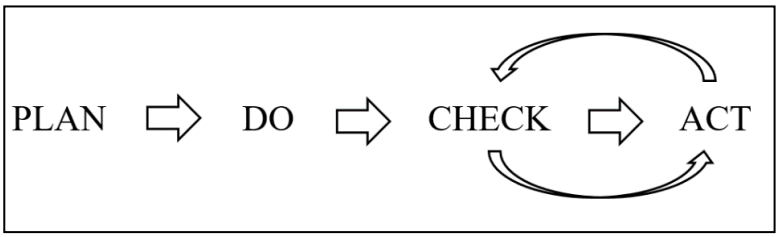


Figure 1 - Energy saving policy as a continuous improvement effort

Where to start

The first step consists in gathering all the energy data that the company already has: energy bills, measurements, results of existing meters, technical data of installed equipment. This will increase efficiency of the audit, which is the second step to identify the origins of energy expenses and highlight potential savings. This exhaustive audit can be carried out after having established the baselines, benchmarked companies that are already more advanced. It will allow to have an overview and dashboard of energy consumption and spending, which means "*to determine where, how and how much energy is being used at the plant*" [5]. Therefore, energy audits should classify the consumptions and expenses by energy type, but also by utilities and by type of process in the transformation scheme. To carry on a successful audit and optimize its cost and time (dynamic data being audited for at least one week, usually several weeks), it is necessary to have a precise expectation, to prepare in advance all the available data, which will save time, money and avoid classical and decontextualized solutions.

EXAMPLE OF ENERGY AUDIT SUMMARY

1. Synthesis of savings opportunities

2. Plant presentation
    1. General presentation
    2. Process presentation
    3. Main energy consumers
    4. Reference situation

3. Energy audit and recommendations
    1. Electricity
    2. Gaz
    3. Hot water
    4. Steam

4. Utilities audit and recommendations
    1. Compressed Air
    2. Boilers
    3. Cold
    4. Lighting

5. Repartition by process
    1. Process 1
    2. Process 2
    3. Process 3
    4. Process 4

Figure 2 – Example of energy audit summary

To reach the expected level of information, the technical task can require a precise summary – for instance, the one above, which integrates different approaches for a better overview.

The result of the audit will highlight the main fields of savings and put the company on the track for first actions.

4. WHERE: MAIN ENERGY SAVING FIELDS

Fields of savings

For industrial facilities, the main identified fields of savings are commonly an echo of the main energy consumers – process and utilities. Most of the time, the main identified fields of savings are the following ones (in the order of potential):

- **Process**: engine drives, heaters, furnaces, handling… This will vary for each business, and that is why having a breakdown of consumption according to the production scheme has a strong added value to find the points to focus on. Anyway, marginal investment leaded by newer and energy efficient process can be very profitable on the short run.
- **Boilers/Coolers, pumps and networks**: overheated water networks or cooling networks can be a draught if not well maintained and regularly renewed. An audit will show its extent and causes (that are most of the time simple – for instance clogging and leakages, insulation, and more rarely obsolescence).
- **HVAC**: Big industrial buildings are difficult to heat or cool and often not so well isolated, leading to a loss of energy in heating and cooling. But an overuse of heating system can hide very simple solutions: as a start, close industrial doors that are broken or kept opened.

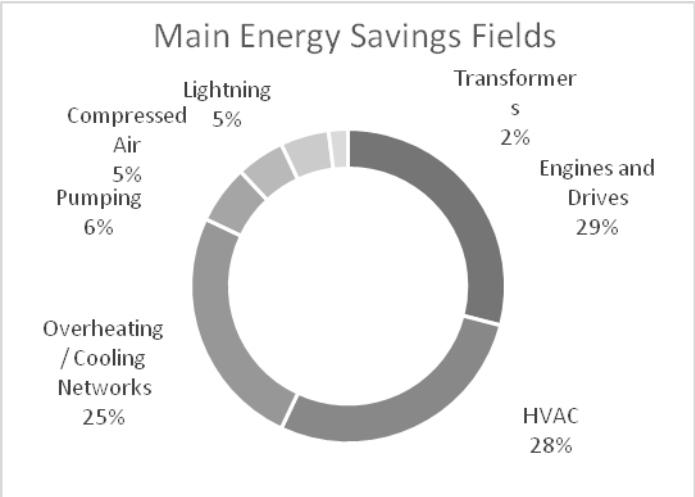


Figure 3 – Main energy saving fields

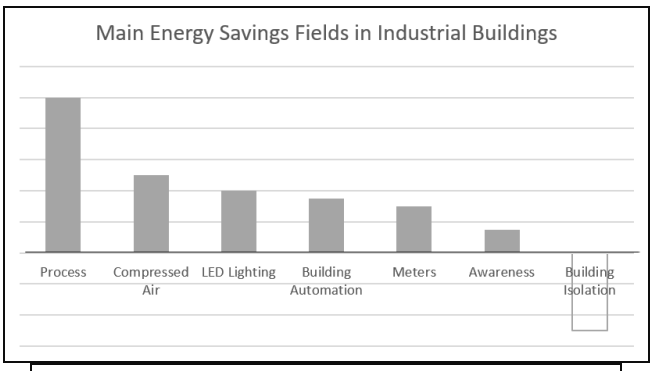
- **Compressed air**: often considered as a cheap energy, compressed air happens to be neglected, and therefore turns to be a big consumer. "*A one-quarter inch leak at 10 psi, at 7 cents per kWh for instance, could cost you $11,735 per year. On the other hand, if you reduce compressed air pressure by just 2 psi, you can cut your electrical use by 1% overall.*" Stopping the compressors outside working hours, checking and adjusting output pressure, adding variable compressors to the fleet or simply tracking leakages in the network can have a big financial gain even on the short run. For instance, in Brauerei Haus Cramer in Germany, a 62500€ compressed air network optimization generated a yearly

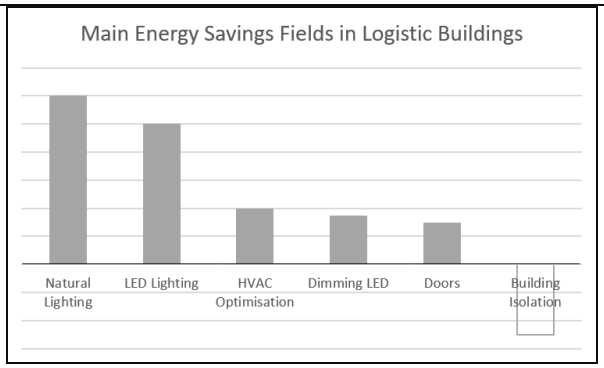
55000€ economy – a 1,1-year payback with a 775MWh saving on the bill and 300t CO^2 emissions avoided [6].

- **Lighting - LED & automation**: LED lighting is popular these days, whether it's for your home or in the factories. They can indeed have a strong saving potential (50-60% compared to fluorescent tubes), and can be coupled with presence detection and automation for better results up to 80%. A point of attention – LED light tubes do not necessarily have the same lighting potential than fluorescent tubes; a review of the lighting layout can be useful to improve the results and preserve the comfort.

As a case study, the audit done by Renault adds the following points for industrial and logistic buildings [7]:

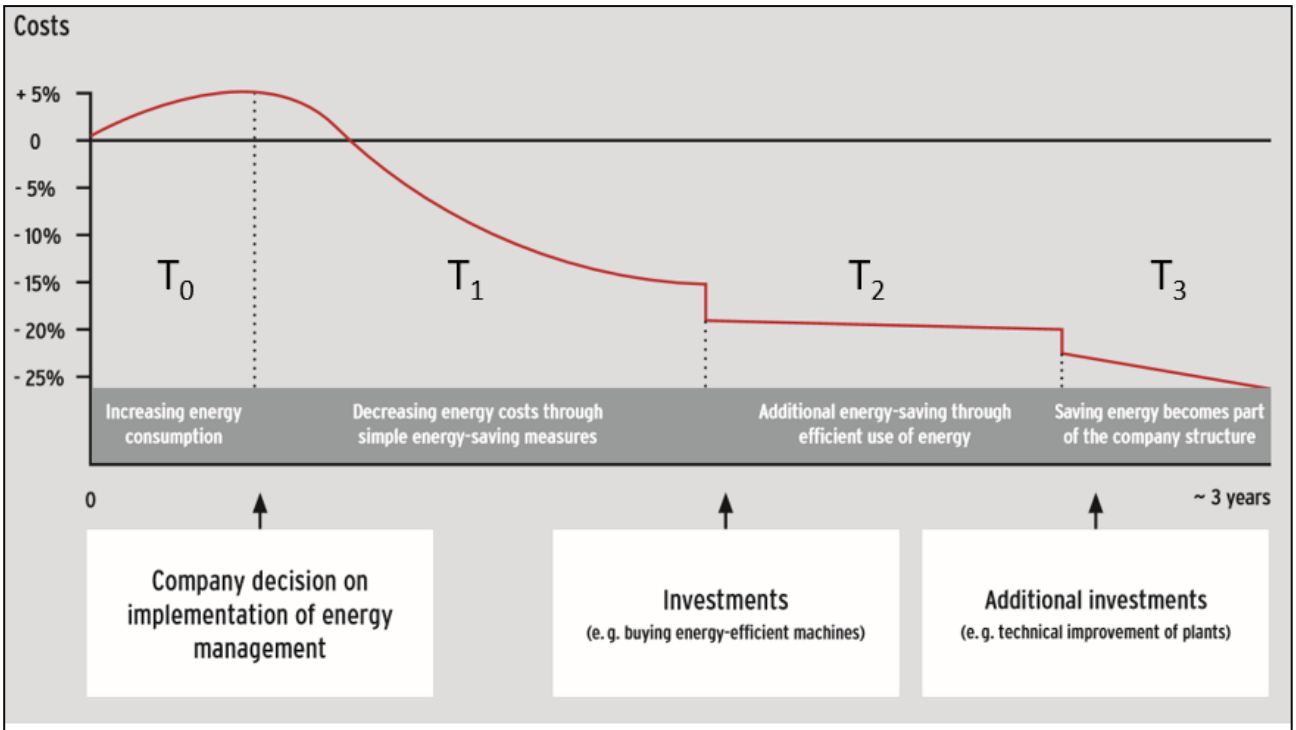
- **Natural lighting** (cleaning skydomes, adding windows to the façades) can reduce artificial light usage during daylight. The optimization of natural lighting position (skydomes close to the operators or main process areas, or between the racks - rather than over the racks - in logistics buildings) can have a strong effect too. The use of natural lighting can reduce the electricity bill to more than 40%. The drawback is that it can become obsolete in case of modifications of the building layout, making this solution more durable in logistic buildings than in the industrial lines that change over the years with new products and new processes.
- **Doors**: Doors are often opened and their proper maintenance (to avoid an "always opened" position) do not cost a lot and, as well as their opening/closing speed, has a drastic impact on energy consumption.
- **Building automation**: switching off lighting and utilities, reducing heating out of production time has nearly no cost and generates a quick feedback. First automation step is the on/off switcher, the second one (more expensive but more efficient) is the real-time automatic adjustment: "*The electric lighting energy saving potential was about 39.4% by using On/Off control integrated with daylighting. […] The largest potential could be 43.1% by using dimming control integrated with daylighting. The dimming control has an even greater energy saving potential than On/Off control"* [8].
- **Add meters**: having a better understanding helps discovering energy waste and implementing focused actions.
- **Awareness**: what seems to be the simplest action is not to be neglected anyway. Switching off the light when you leave a room or informing technical support about a local leakage are small acts that, at the scale of a factory, can have a significant impact. Carrying information campaigns about energy saving is cheap, quick, and can cover different saving fields.





On the other hand, huge building investments like additional insulation are well advertised, but have a very long payback (more than a decade), which can generate a misunderstanding of what an energy policy is, and be counterproductive for the healthy development of a step-by-step kaizen improvement.

Savings typology



Source : KAHLENBORN Walter, KABISCH Sibylle, KLEIN Johanna, RICHTER Ina, SCHURMANN Silas, *DIN EN 16001: Energy Management Systems in Practice,* Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany, 2010

Figure 4 – Energy saving steps

Table 1 - Action examples for each step in the different fields

Field of Savings	**T_1** **Short-term actions "Housekeeping Targets"** **ROI < 6 months**	**T_2** **Mid-term actions "Investment Targets"** **ROI < 1 - 2 years**	**T_3** **Long-term actions "Innovation Targets"** **ROI < 3 - 5 years**
Lighting	- Increase Awareness - Measure lighting - Adjust lighting to necessary conditions - Switch off if natural daylight is enough - Switch off outside production hours	- Implement LED Lighting - Switch automation for daylight and production hours - Adjust skydomes to the layout to optimize natural lighting	- Install intelligent real-time light dimming according to ambient light
Compressed Air	- Increase Awareness - Repair audible leaks - Check pressure and adjust pressure to the precise necessary - Switch off compressors outside production hours	- Install automatic leakage detection - Identify and prevent leakages causes	- Implement variable speed compressors - Increase regulation automation
HVAC	- Switch off or reduce power outside working hours - Implement "neutral band" (no heating or cooling between 18 and 24° outside temperature) - Close and maintain doors	- Install global regulation linked to building automation	- Implement real-time continuous variation
Process	- Increase Awareness	- Prefer new or recent new equipment than used one	- Implement energy efficient motors / pumps - Install variable speed drives

Once the fields of economy are identified, the actions to be deployed can be classified in three categories.

- While current situation is considered as T_0 – energy consumption is rising at the same speed or faster than the growth of the company;
- Short-term simple energy saving measures, are considered T_1. These actions should be focused on at the start, as they require no or very small investment and present a quick payback. They can lead up to a 15% cut off the energy bill.
- Mid-term actions that require investment are considered T_2. They require additional and more consequent investments, and their payback is longer – but they increase savings and they prepare the company for the integration of energy savings within its industrial structure.
- Finally, long-term actions that require deployment of a system and involve innovation and new technologies are considered T_3.

Here is a table 1 of action examples for each step in the different fields.

5. TOWARDS AN ENERGY MANAGEMENT SYSTEM

Energy Management System

Finally, the aforementioned methodology and actions are the first steps to build an Energy Management System. An Energy Management System stands for "*a technical system for gathering, analyzing, documenting, and visualizing energy data, as well as for regulating and monitoring energy consumption in plants and buildings*." [9]

The ENMS aims at converting the energy management approach from static (audits and checks) to dynamic (real-time and centralized monitoring) through dedicated systemized software.

Based on an electronic architecture of sensors and commands, "check" and "act" are made real-time and virtually automated, with a constant monitoring energy efficiency and a real-time correction of deviations, in order to continuously optimize the energy spending of the facility.

According to the size of the company and the defined level of expectations, the cost of implementing ENMS can vary from 50000 to 500000 € for a production unit [10]. Electronic equipment represents around 10% of this amount, the most important expenses being needed for project management resources, audit and certification, and technical assistance. Still, the payback is realistic, as demonstrates Michel Da Silva, Energy Manager of GSK (pharmaceuticals): "*Our ENMS allowed us to take a further leap in the rhythm of realized economies, that already doubled the first year after its implementation and stayed in constant progress over the next years"*[11].

Building Information Modeling

The further step to improve the overall performance is the compatibility of ENMS software with Building Information Modeling platforms. Already mandatory in several countries over the world, dynamic digital models of buildings present many uses and advantages for energy savings.

Prior to construction, the dynamic 3D model allows to optimize all the energy flows within the building and to enhance engineering towards the best energy efficiency results.

During building life, the BIM 3D model provides real-time information about the building and, if connected to an ENMS, can improve the overall efficiency by binding real-time data from process, utilities and building.

Plus, all the information processed by the BIM system is stored and can be provided at any time for an audit, which will accelerate its realization, improve its precision and downsize its costs.

One of the rising solutions to improve interface between energy and building management systems is the OpenBIM cooperation program, based on Building SMART open data model and IFC file format (Industry Foundation Classes, ISO16739:2013). This object-oriented file format targets compatibility and interoperability of building and engineering management data [12], through collaborative design and open standards.

6. CONCLUSIONS

Building an Energy Management system is not a one-shot investment. It starts with simple awareness and housekeeping, with easy and cheap actions (T_1) that have a big effect. Nevertheless, it is important to think from the beginning about the global procedure, to implement coherent actions and, as soon as investments are concerned (T_2), to ensure compatibility and upgradability of the chosen platforms as an innovative system (T_3). As in a lot of fields, the quickly developing digital solutions and automations will transverse the approach and optimize the results.

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CATALYSTS FOR WATER TREATMENT: METHOD OF PRODUCTION, STRUCTURE AND CATALYTIC PROPERTIES

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ABSTRACT

Household and industrial waste water contain toxic substances, which pose a threat to the life of humans. Therefore the problem of waste water treatment is relevant. The solution of this problem are promising technologies, including the catalytic post-treatment of waste water. To implement them, the creation of fundamentally new catalytically active materials is required. Such materials must have high thermal conductivity, good adhesion strength of the base with the active metal, as well as high catalytic activity to the destruction of toxic contaminants.
It is proposed to increase the thermal conductivity and adhesion of the supported catalysts by using a metal base in the form of microscreens, and increasing the catalytic activity by creating in the active metals a high concentration of defects of growth origin that contribute to the formation of a special morphology of the catalyst surface.
The article describes the procedure for obtaining all-metal copper catalysts, the surface of which consists of defective crystals having structural features in the form of a pentagonal symmetry, growth steps, and certain highly active crystallographic facets. Such catalysts showed good activity in the decomposition of formic acid in water.

Key words: waste water, water treatment, toxic impurities, all-metal catalysts

At present, humanity consumes 4000 km^3 of fresh water annually, half of which is converted to wastewater. In Russia in 2014, the volume of water intake from natural sources for all needs amounted to 70 billion m^3, and the volume of wastewater discharged into the water bodies is about 50 billion m^3, and about 15

billion m^3 of them are not sufficiently purified and about 3 billion $m^3$of wastewater are not purified at all [1]. Household and industrial wastewater contain microorganisms, solvents, phenols, petroleum products, toxic substances, heavy metals, etc., which pose a threat to the life of plants, animals and humans [1-3]. Therefore, today the problem of wastewater treatment is particularly relevant.

The solution of this problem are promising technologies, including the catalytic post-treatment of wastewater. Catalytic methods of wastewater treatment are destructive and do not create secondary waste [4]. To implement them, the creation of fundamentally new catalytically active materials is required. Such materials must have good physical and chemical characteristics, in particular, high thermal conductivity and good adhesion strength of the base with the active metal, as well as high catalytic activity towards the destruction of organic, toxic contaminants.

It was shown in [5, 6] that the cutting of microcrystals, the presence of certain crystallographic planes, edges, vertices, and surface defects in crystals significantly affect the catalytic activity of the substance. In particular, it was noted in [5, pp. 38-39] that the {111} face of copper crystals is more active than the {100} face for the decomposition of ammonia by 10^5 times. We used this fact to create catalysts based on copper.

In particular, we propose to increase the thermal conductivity and adhesion of the supported catalysts by using a metal base in the form of micro-grids, and the increase in the catalytic activity can be achieved by creating a high concentration of defects of growth origin in the metals deposited on the base. The defects contribute to the formation of a special morphology of the surface of the catalyst in the form of certain crystallographic facets, steps of growth, vertices and edges.

This approach is based on the idea that the catalytic activity of metallic materials is determined not only by the specific surface, but also strongly depends on the defective structure and the specific faceting of the crystals.

The present work is devoted not only to the solution of material science problems associated with the creation of all-metal catalysts having an unusual defect structure, developed surface and high catalytic activity to the decomposition of toxic contaminants in water, but also their testing in laboratory conditions. In particular, the examples are developed our catalysts designed to purify water from formic acid dissolved in it.

In this paper, for the decomposition of formic acid, we recommend to use catalysts made of defective copper micro crystals (Figure 1a), grown on a mesh carrier. For their production, the author's technique was used – electric deposition with mechanical activation of the cathode and copper crystals growing on it [7-9]. It is the method that makes it possible to grow highly defective crystals having a certain shape, size, pentagonal symmetry, developed surface and a specific facet (Fig. 1).

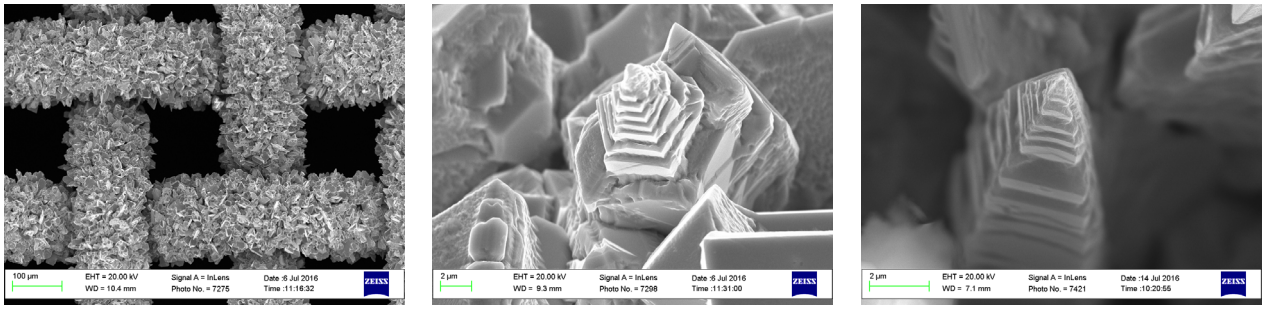
The technique is as follows. Electric deposition is carried out onto micro-nets (in this case) made of stainless steel AISI 304 or AISI 321 with a wire diameter (30.0 ± 0.5) – (100.0 ± 0.5) μm and a cell size (40.0 ± 0.5) μm– (230.0 ± 0.5) μm, in the sulfurous electrolyte for copper plating. For the preparation of the

electrolyte, reagents of grade "Purum" (H_2SO_4, $CuSO_4 \cdot 5H_2O$) and distilled water are used. To carry out mechanical activation, activator powders made of abrasive particles of metal oxides (silica, alumina, titanium dioxide, etc.) with sizes of 5 to 20 μ mare used. It is important that the activator particles are inert with respect to the electrolyte. The concentration of the activator in the electrolyte varies depending on the dispersion of its particles and ranges from 30 g/l to 70 g/l.

The abrasive particles are stirred together with the electrolyte by a rotating stir bar in the magnetic field of a PE-6110M agitator or a mechanical mixer US-2000A in a specialized unit developed in the laboratory "Nanocatalysts and functional materials".

Electric deposition is carried out in potentiostatic or galvanostatic deposition regimes, using a three-electrode cell and potentiostats-galvanostats. Optimal deposition regimes are indicated in [8-10].

Studies of the morphology of the surface of copper coatings on micro-grids (grown by this method) after electric deposition, carried out by electron microscopy (Carl Zeiss Sigma and JEOL JCM 6000), and it showed that they consist of 60-70% of crystals with pentagonal symmetry (Fig. 1b) and high stages of growth (Figure 1b, c).

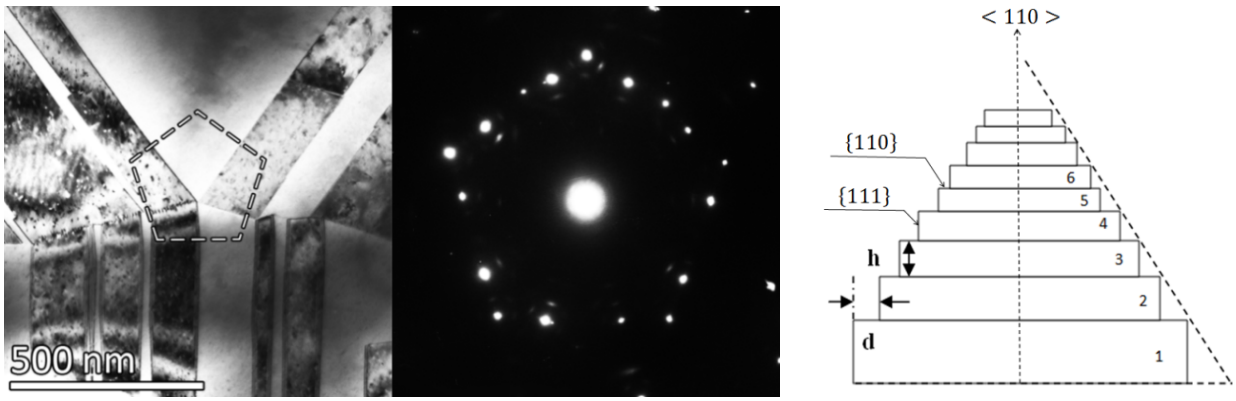


a b c

Figure 1 - All-metal catalysts (a) consisting of pentagonal micro crystals of copper (b) and crystals having a defect structure and a developed surface (c)

Translucent electron microscopy (JEOL 2100F) was used to study the structural features of copper crystals formed due to cathode activation.

A detailed structural-crystallographic analysis showed that pyramids having a pentagonal symmetry (Fig. 1a) grow mainly in the crystallographic direction <110> and contain a partial seven-degree disclination in the center [11,12], on which the twin boundaries break (Fig. 2a). The developed surface of the pentagonal pyramids (Figure 1b) is formed during the layer-helical growth of the crystal around the disclination axis and consists of growth terrains in the form of vertical {111} and horizontal steps {110} (Fig. 2b). The height and width of the steps correlates with the dimensions of the twin inter-layers (Fig. 1c). The size of the growth terraces and the conical shape of the crystals (Figure 2) are due to the specific features of the supply of the building material (copper ions) to the growing crystal, namely, the electrolyte mixing, which, in our case, ceases at the initial stages of electric crystallization.



a b

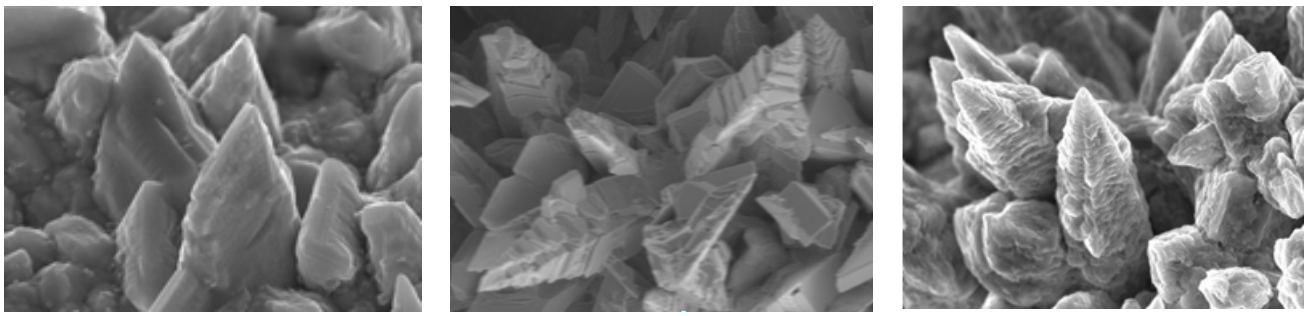
Figure 2 - Peculiarities of the structure of the pentagonal pyramids: the section of the pyramid and the electron diffraction pattern from it (a), the profile diagram of the pyramid (b)

It is important to note here that terraces on the surface of the crystal, consisting of special catalytically active crystallographic faces, as well as incoming angles at the twin boundaries and yields of disclinations at the top of the crystals (Fig. 2) and surface defects are the centers of catalytic activity of the material, and they provide high reactivity.

Further, to determine the activity of the obtained material based on copper, the process of catalytic decomposition of formic acid was studied. For this purpose, using the described author's technique and using a method of electric deposition of a metal with simultaneous mechanical activation of cathode and growing crystals on it, two types of copper coatings of the same mass, but with significantly different morphologies, were grown on a reticulated metal carrier. The first consisted of cone-shaped crystals having a smooth lateral surface (Figure 3a) and the second of the pentagonal pyramids and cone-shaped crystals with a developed stepped surface (Fig. 3b).

Then, these copper layers were used as catalysts for the decomposition of formic acid, Figure 4 (curves 1, 2, 3).

Tests of the catalyst samples were carried out in a quartz tube with an internal diameter of 6 mm and a length of 40 cm, placed in a tubular furnace SUOL-0,25.1/12-I1. To do this, the copper-coated micro-grids were cut into discs 6 mm diameter and placed in a reactor: 10 pieces parallel to each other. Determination of the composition of the initial and reaction mixture was carried out by a gas chromatograph Kristal luks 4000M with a TCD. For the decomposition of formic acid, the initial mixture of HCOOH 2% in helium was feed at a rate of 10 ml / min. The concentration of formic acid and its decomposition products (CO/CO_2, H_2, H_2O) was determined by the absolute calibration method, on a HyeSep Q column 2 m in length.



a b c

Figure 3 - Copper coatings: a) cone-shaped crystals with a smooth lateral surface, b) pentagonal pyramids and cone-shaped crystals with a developed stepped surface, c) the same crystals after the reaction

The influence of the internal structure of the crystals and the features of the surface morphology on the catalytic activity of defective copper crystals with a developed surface during the decomposition of formic acid is shown in Fig. 4.

The decisive role of terraces and growth stages, consisting of active atomic planes {110} and {111} copper crystals, in various catalytic reactions was confirmed by us in the original experiment.

Sample 2 - with a developed surface in the form of terraces and growth steps (Fig. 3b), showed a high conversion in the temperature range 210-280°C (in comparison with sample 1 having a smooth surface) in the decomposition of formic acid. However, at temperatures of the order of 280°C, their catalytic activities were equal. In repeated experiments (curve 3), the activity of samples with a developed surface also decreased. Electron microscopic studies have shown that such temperatures (280-300°C) lead to clear-cut losses in crystals, melting of the steps (Fig. 3c) and, accordingly, to equalization of the catalytic activity of samples 1 and 2 (Fig. 4, graph 3).

Thus, the presence on the surface of the catalyst crystals of a high concentration of polyatomic growth stages, consisting of active atomic planes, provides a high catalytic activity even at a small specific surface area. Especially, this effect is noticeable at relatively low test temperatures (up to 250°C). At elevated temperatures, due to the activation of diffusion processes, the stages drift, the clear-cut disappears and the reactivity of the material decreases.

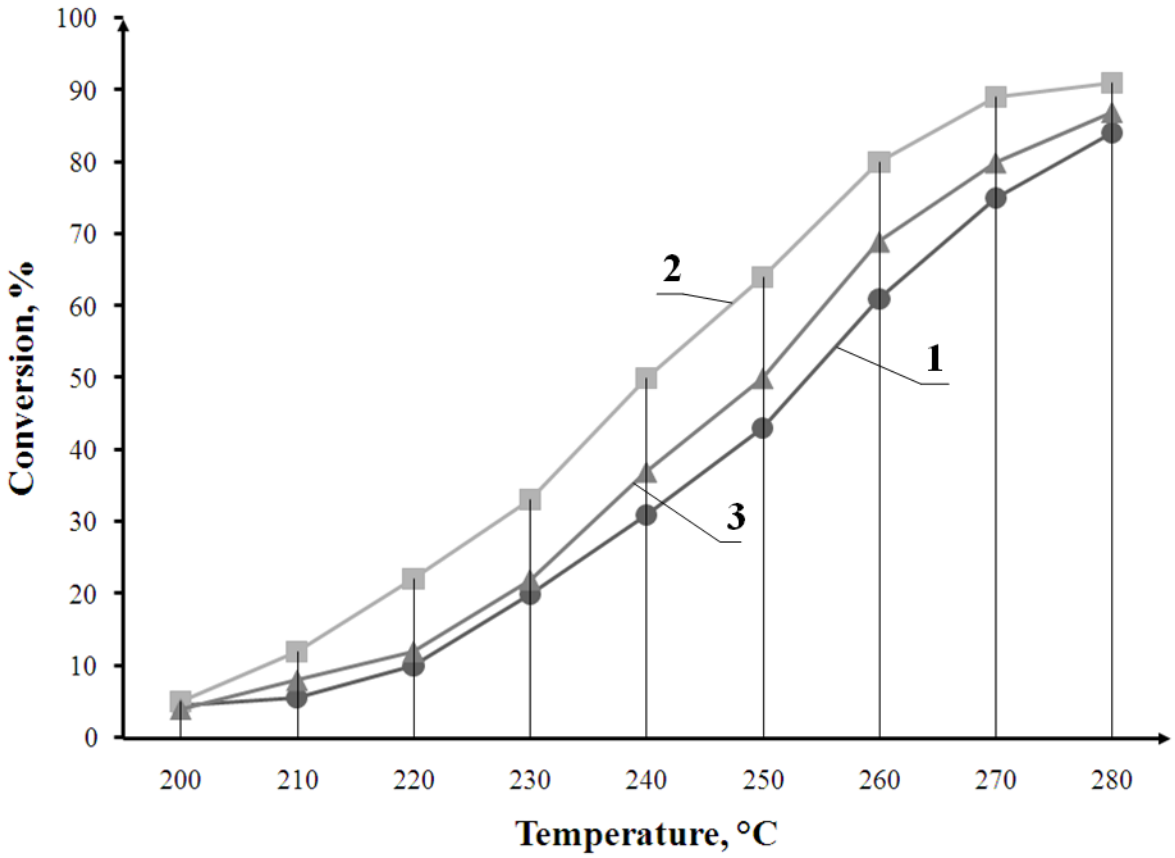


Figure 4 - Catalytic activity of copper catalysts in the decomposition reaction of formic acid: 1 - crystals with a smooth surface, 2 - crystals with a developed surface, 3 - the same crystals after the reaction

In conclusion, it can be said that by electric deposition of a metal with mechanical activation it is possible to create all-metal catalysts consisting of crystals that have a developed surface (Figures 1 and 3) in the form of steps and terraces from active crystallographic planes such as {111} and {110}. The carried out experiments make it possible to conclude that in such all-metal catalysts, consisting of defective crystals having a developed surface in the form of certain crystallographic growth stages, the catalytic activity depends strongly on the characteristics of their faceting, the presence and total area of the catalytically active atomic planes, the presence and concentration of the edges, vertices and surface defects, which are the active catalytic centers of the crystals. However, copper crystals with a developed surface, because of thermal instability, are recommended to be used as catalysts in catalytic reactions that occur at relatively low temperatures not exceeding 200-250°C.

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EFFECT OF TEMPERATURE AND HYDRODYNAMIC CONDITIONS ON ADSORPTION OF AROMATIC AMINO COMPOUNDS BY MODIFIED BENTONITES

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ABSTRACT

We studied the effect of temperature and hydrodynamic conditions on sorption of o-phenylenediamine and o-toluidine by several variants of modified bentonite. The sorbents differed by both modification method and granulometric composition (grain size). Our results revealed that both factors affected the sorption ability of bentonite, as well as changes in sorption intensity with increasing temperature and stirring frequency. We discovered that the intensity of o-toluidine adsorption on these modifications increased with rising temperatures, indicating possible chemisorption. The stirring regimen affected the sorption activity of bentonite variants modified by carbon nanotubes alone, which implied the process limitation by external mass transfer. In sorbents, modified by glycerol, such dependence was not detected, which could mean that the process was limited by internal mass transfer. The results of our study proposed the sorbent variants that are of interest for wastewater treatment from aromatic amine compounds.

Key words: adsorption, bentonite, aromatic amine compounds, hydrodynamic conditions

1. INTRODUCTION

Aromatic aminecompounds (AAC) are common and highly toxic water pollutants. Their wide prevalence is associated with active industrial application [1]. Frequent use of these substances is explained by their high reactivity, which makes them indispensable in the synthesis of important chemicals [2]. They are

especially dangerous when occurring in water reservoirs used for drinking water supply. Their reactivity with respect to chlorine is very high. Thus, in the course of chlorinating water, a variety of highly toxic chlorine-substituted substances are formed [1].

AAC are especially common in industrial wastewaters of dyes and pharmaceutical drugs production. These industries are associated with significant water expenditures and use of diverse range of to77xic organic compounds [3, 4]. Such wastewaters should be subject to thorough cleaning prior to their discharge in order to avoid contamination of natural reservoirs with harmful impurities.

Adsorption is among common and widely used methods of water purification. In recent years, the use of inexpensive and effective sorbents based on natural mineral raw materials, such as clay rocks, is of particular interest.

Natural sorbents for water purification from harmful impurities are often used after a certain treatment (modification) rather than in their natural condition in order to increase their adsorption capacity. Some studies [5, 6] have investigated the sorption effectiveness of bentonites modified by firing, carbon nanotubes and/or glycerol towards AAC. It was found that the modification of bentonite with organic components generally increased its sorption activity. However, it is noteworthy that simultaneous modification of bentonites by carbon nanotubes and glycerol is substantially inferior to the method of its modification by carbon nanotubes alone. Among the factors influencing the ability of bentonite to absorb AAC, the firing regimen should also be considered.

Conducted studies suggested a comparison of the sorbents under certain fixed conditions. However, adsorption processes are complex and diverse. They depend on a variety of factors associated with the properties of sorbents and adsorbents, along with many external conditions [7]. Among the factors that have significant influence on the adsorption process, temperature and hydrodynamic conditions are of special interest. Studying the details of temperature effect on adsorption facilitates predicting the type of adsorption (physical or chemical) of a given substance on a given sorbent. The study of adsorption dependence on the hydrodynamic process could reveal whether the intensity of adsorption is limited by external or internal mass transfer, which is also important for choosing the appropriate type of sorbent modification.

The goal of our study was to investigate the specifics of AAC adsorption on modified bentonite sunder varying hydrodynamic conditions and temperatures.

2. METHODS

The objects of our study were modified bentonite sorbents of the Sarigyukhsky deposit. The modification of bentonite included thermal treatment at 550° C, as well as the simultaneous or separate inclusion of various organic components (carbon nanotubes, further referred to as CNT, and glycerol).

Besides, some of the sorbents also differed in grain size: fine, medium and coarse fractions were obtained by sifting the product through sieves with different cell sizes. Modification of bentonite was conducted by the employees of LISSKON

LLC (Saratov). Here goes the full list of the sorbents used in our study: sorbent 1 bentonite modified with CNT, firing at 550° C, fine fraction; sorbent 2 bentonite modified with CNT, firing at 550° C, medium fraction; sorbent 3 bentonite modified with CNT, firing at 550° C, coarse fraction; sorbent 4 bentonite modified with CNT and glycerol, firing at 550° C, fine fraction; sorbent 5 bentonite modified with CNT and glycerol, firing at 550° C, medium fraction; sorbent 6 bentonite modified with CNT and glycerol, firing at 550° C, coarse fraction; sorbent 7 bentonite modified with glycerol, firing at 550° C, medium fraction.

We used the qualitative method of spot test analysis in the study of adsorption processes. This group of analytical reactions with respect to organic substances has been described in detail and systematized by F. Feigl [8]. While the main area of spot analysis application is identification of unknown substances, we considered the possibility of using it for studying the adsorption process on solid materials.

The algorithm of our experimental study was the following: (1)the sorbents were charged in containers of identical volume and design, (2) followed by addition of a solution of the substance under study in a certain concentration; (3) the mixtures were kept intact for a fixed period of time with strict maintenance of experimental parameters being investigated; (4)solution samples were taken after this fixed time interval for conducting chemical tests; (5) test results led to the conclusion, whether a negative reaction was established under the chosen parameters, or not.

The experiment was repeated with different concentrations of the test substance, while the step between the consecutive concentrations was exactly the same. Concentrations of the substance were increased by the value of this step until some extreme concentration was established, at which the reaction on the substance presence in the solution under the given conditions was negative. It was taken for the response. The more negative concentrations were obtained in the chosen concentration interval, the more intensive adsorption on this sorbent at a given value of the studied factor was took place. Actually, the reaction itself was carried out according to the procedure [8], based on the azo coupling reaction, typical for aromatic amines. Schematically, the sequence of the reaction is shown in Fig. 1.

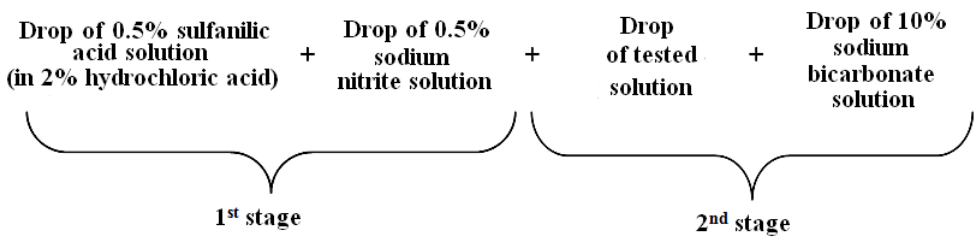

Figure1 – Step sequence of conducting qualitative reaction to aromatic amine compounds

The experiments on the intensity of o-phenylenediamine adsorption under various hydrodynamic conditions and of o-toluidine adsorption under varying temperatures were conducted as follows: (1) 10 g of tested sorbent variant were placed in tubes of the same design; (2) 5 ml of the test substance solution were added, and from that moment time was controlled; (3) test tubes with sorbents and solution were kept under certain conditions for 60 min: in case of o-phenylenediamine, three variants of hydrodynamic regimen were maintained by different stirring frequency (every 5, 6, or 7 min), while in case of o-toluidine, three temperature regimens were maintained by keeping tubes in a thermostat at 20, 30, or 40° C, with tube content stirred every 5 min for 1 minute by continuous over turning of the tube; (4)after 60 min, the solution was separated from the sorbent by pouring it into a separate tube; (5) spot test analysis of the resulting sample was conducted. The step between the concentrations was 1 mg/l, and the lowest concentration was 1 mg/l.

3. RESULTS AND DISCUSSION

Fig. 2 presents the curves showing the dependence of o-phenylenediamine adsorption by seven sorbent variants on the stirring regimen. The latter is quantitatively expressed by the number of stirring incidents performed during 60 min of the experiment.

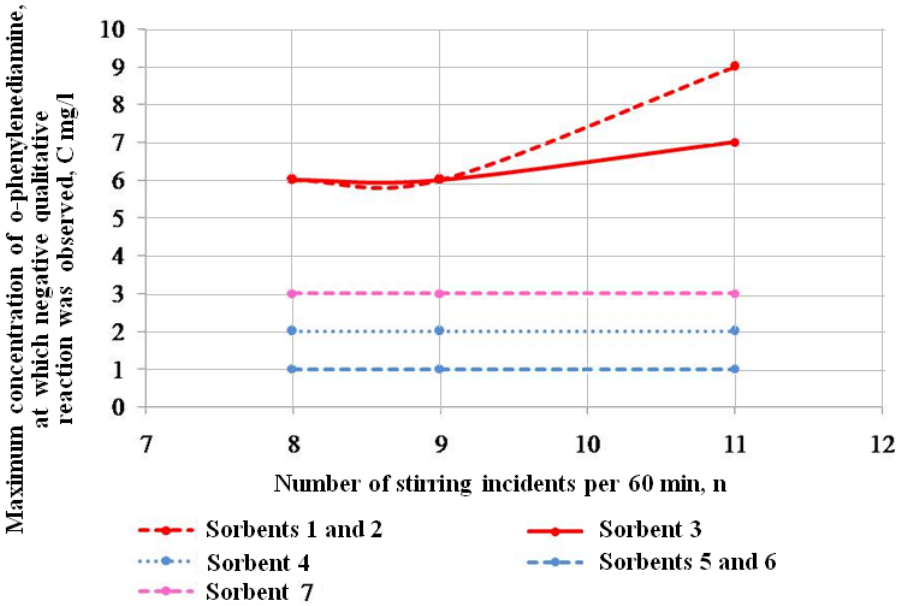

Figure 2 – Adsorption intensity of o-phenylenediamine vs. stirring regimen

To interpret this graph, it should be noted that the closer the curve is to the abscissa axis, the sorption activity of the sorbent is lower. Various modifications of bentonite showed different levels of the sorption activity with respect to o-phenylenediamine. Thus, the sorbents can be arranged in the following order along the gradient of their sorption activity: sorbents1 and 2 > sorbent 3 > sorbent 7 >

sorbent 4 > sorbents 5 and 6.It is also worth noting that, depending on the stirring frequency, the intensity of adsorption is fundamentally different for different forms of sorbents.

Bentonite modified with CNT (various fractions). All three fractions of this bentonite modification differed fromothersorbents by their higher sorption ability. The curves depicting the dependence of the adsorption intensity of o-phenylenediamine on the stirring regimencoincided for fine and medium fractions. The coarse fraction was somewhat weaker in its sorption capacity. Analysis of specific features of adsorption dependence on the stirring frequency showed that with increasing stirring frequency, the sorption capacity of these sorbents was also increasing. This fact implies that under given conditions, the adsorption intensity was limited by external diffusion, i.e. the sorbent capacity was most fully used in a well-chosen hydrodynamic regimen. The general regularity for considered sorbent variants demostrated that under the stirring regimens once every 6 or 7 min, the intensity of o-phenylenediamine absorption did not change, and its increase was observed under the highest stirring frequency (once every 5 min).

Bentonite modified with CNT and glycerol (various fractions). This modification variant was characterized by the absence of adsorption intensity dependence on hydrodynamic regimen. The best adsorption properties were shown by the fine fraction of the sorbent. The curves for medium and coarse fractions coincided.

Bentonite modified with glycerol (medium fraction). This sorbent manifested weaker sorption activity than bentonite, modified with CNT alone, but superior to the bentonite with complex modification. It therefore held an intermediate position between these modification variants. This fact suggests that glycerol and CNT inhibit each other's action, and simultaneous modification of bentonite with CNT and glycerol is not feasible.

The dependence of o-toluidine adsorption on temperature is shown in Fig. 3.Sorbents showed a complex and ambiguous nature of the change in their adsorption intensity with increasing temperatures. It is obvious, that at different temperatures, sorbent variant distribution along the sorption capacity gradient was different. In this regard, let us consider three individual temperature regimens.

At 20° C, fine fraction of bentonite modified with CNT and glycerol had the highest sorption activity. The rest of the sorbents exhibited equally weak sorption ability with respect to o-toluidine. At 30° C, the differences between the sorbents became most pronounced. They could be arranged in the following sequence in order of decreasing sorption activity: Sorbent 7> 1 and 3>6> 2 and 5>4. At 40° C, the distribution of sorbents in descending sorption capacity order was as follows: 4 and 6>1 > 2 and 7> 3 and 5.Thus, the best sorbent of all studied was bentonite modified with glycerol, since at 30º C it exhibited the highest sorption activity. Bentonites of fine and coarse fractions modified with CNT and glycerol can also be considered promising, because at 40º C these sorbents had an obvious advantage. Therefore, they could be used treatment of wastewaters, having such temperature, for from AAC.

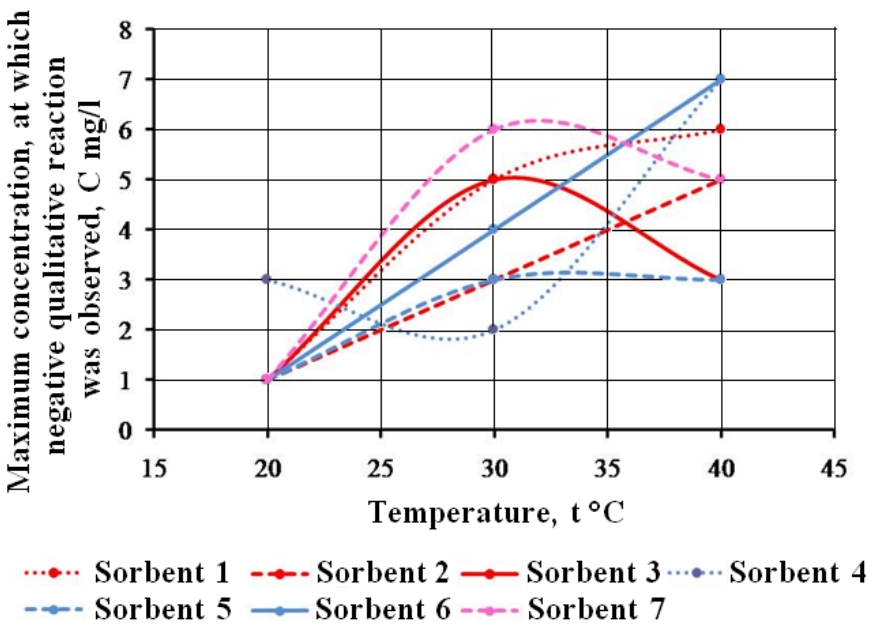

Figure 3 –Dependence of o-toluidine adsorption intensity on the stirring regimen

All studied sorbents were characterized by the fact that, with temperature increase, their adsorption intensity increase was also observed, which suggested that adsorption on these sorbents was predominantly of chemical nature. However, for each sorbent, this increase occurred at different rates, as well as at different temperatures. This could be explained in terms of the following logic: bentonite is a polar material, and the polar character of adsorption, specifically cation exchange as a special case of chemisorptions, is more typical for it [9]. Also, aromatic amines belong to organic basic electrolytes, i.e. in aqueous solutions they are partially ionized, exhibiting the properties of cations. This could cause an interaction of AAC and bentonite by means of polar adsorption [10].

The only sorbent with a sharp increase in sorption activity, but at a higher temperature than in others, was fine fraction bentonite modified with glycerol and CNT. In order to compare how intensively the increase in sorption activity occurred (without taking into account the fact that this process occurred at different temperatures), we have identified the regionson the graphs, where the sharpest increase was noted, and presented our findings in Fig. 4.

In order to assess resulting line slopes, we computed the equations of the resulting lines using Microsoft Excel software and from those identified angular coefficients. These were: 0.2 for sorbents 2 and 5, 0.3 for sorbent 6, 0.4 for sorbents 1 and 3, and 0.5 for sorbents 4 and 7.

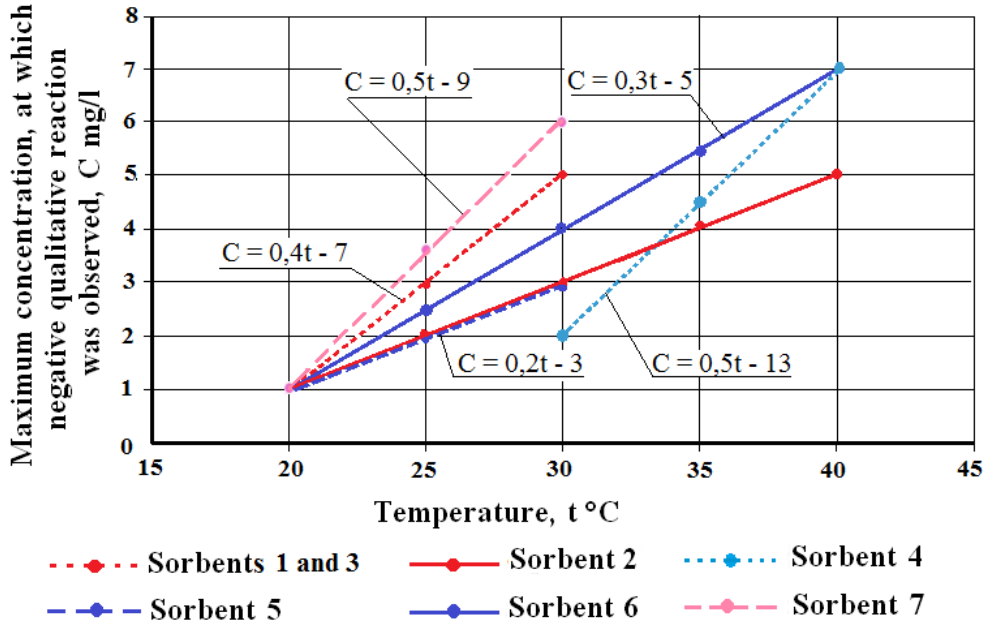

Figure 4 – Regions of steep increase of adsorption

The obtained values of angular coefficients indicate that increase in sorption activity for sorbents 4 and 7 occurred with the same intensity, no matter that it began manifesting itself at different temperatures. It is also important to note that, of all studied sorbents, variants 4 and 7 showed the steepest increase in adsorption with increasing temperature.

4. CONCLUSIONS

The results of our experimental study led us to the following conclusions:
(1) both the granulometric composition and the modification method of bentonite affect the sorption activity in general as well as the nature of its change under varying external parameters;
(2) the intensity of o-toluidine adsorption on these bentonite modifications tends to increase with increasing temperature, which implies the presence of chemisorption;
(3) the stirring regime has an effect on the sorption activity of bentonite variants modified by CNT alone, which indicates the process limitation by external mass transfer; for sorbents with glycerolintroduced in their structure, such dependence is absent; hence, the process is limited by internal mass transfer;
(4) the most promising sorbent variants for AAC extraction from wastewater are fine to medium fractions of bentonite modified with CNT, as well asbentonite modified with glycerol alone;
(5) the properties offine and coarse fractions of bentonite modified with glycerol and CNT deserve further study in more detail;
(6) taking into account the established complex and ambiguous influence of external factors on the course of AAC adsorption, it is desirable to conduct a multifactorial experiment to determine relative significance of each factor under consideration in the context of their combined effect.

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SET UP OF A TEST FACILITY AND THE PRELIMINARY RESULTS FOR THE VISUAL AND ENERGETIC PERFORMANCES ASSESSMENT OF SMART WINDOWS

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ABSTRACT

The use of large smart windows can help to improve the visual and thermal comfort inside rooms, as well as reduce the energy consumption of buildings. However, for the correct use of these new devices, their comprehensive characterization aimed at understanding their real performances from visual and energetic points of view is fundamental. For this reason, an experimental multi-activity test room was set-up for the visual and energetic on-site characterization of smart windows.
Preliminary experimental measurements were performed with conventional double low-emittance glazings, with the aim of testing the acquisition system as well as validating and calibrating a virtual model of the test room realized in the dynamic simulation software TRNSYS 17. The TypeDLT, that allows for the direct interaction between TRNSYS and RADIANCE, was used and the reliability of the daylight simulation results was evaluated.
The results show a good agreement between the simulated and experimental data. In terms of average daylight illuminances, values of the relative mean bias error equal to -0.7% and relative root mean square error equal to 16.6% were observed.

Keywords: daylight; TRNSYS; experimental measurements; smart windows; energy saving; visual comfort.

1. INTRODUCTION

Considering the increase in the cost of oil as well as pollution due to carbon dioxide emissions, the design and construction of more efficient buildings from an energetic point of view and comfortable for visual tasks, has become the main objective of many researchers and politicians [1,2]. Consequently, numerous research projects are currently in progress focusing on the design and commercialization of new devices and energy saving strategies aimed at reducing CO_2 emissions, as well as increasing occupant comfort [3,4]. In this perspective, it is necessary to improve the performances of all the building components, both active (heating, cooling, lighting…) and passive (building envelope). Among the components of the building envelope, windows represent the element through which the greatest heat exchange between inside and outside occurs. In fact, about 4% of the total energy consumption in Europe [5] can be ascribed to heat loss and gain across windows. In this scenario, smart windows, in particular electrically driven window, can play an important role in the control of the visual and thermal conditions inside a room. A recent report estimates that the worldwide market of glass and electrochromic (EC) films will reach about €580 million by 2024, while the contribution of all other smart window solutions was estimated to be about €70 million by the same year [5]. In contrast to conventional glazing, the visual and thermal conditions inside a room can be controlled by adjusting the characteristics of smart devices. Overviewing the field of smart materials (electrochromic, electrotropic, liquid crystal…), it is worth noting how there is a large discrepancy between the high number of new smart materials that are continuously realized and studied at laboratory scale and the low number of them that are actually scaled up. The materials used, the building technology as well as the size strongly affect the characteristics and operation modes of the large area electrically driven windows. For this reason, many studies have been performed, and will have to be performed, in order to examine the behaviour of large smart windows under real operating conditions aimed at analysing the actual ability to guarantee visual and thermal comfort to the occupants, along with evaluating their impact on the reduction of energy consumption of a whole building. For the experimental characterization of full scale smart windows as well as to assess their on-site performances, an experimental station was realised at the Department of Engineering of the University of Sannio.

The measurement set-up was described and the preliminary experimental data were presented. The experimental set-up allowed to acquire the external global and diffuse horizontal illuminance values as well as the daylight illuminance distribution inside the experimental station. With the aim of characterizing the experimental laboratory from the optical point of view, while also validating the measurement set-up, the preliminary experimental measurements were carried out using a conventional double low-emittance glazing. At the same time, a virtual model of the experimental station was built in the simulation software TRNSYS 17 [6] and the daylight analysis was performed by using the TypeDLT. Finally, the simulation results were compared with

experimental data so as to validate and calibrate the model of the facility as well as assess the reliability of the direct interaction between TRNSYS and RADIANCE.

2. TEST FACILITY DESCRIPTION

At the Department of Engineering of the University of Sannio, an experimental multi activity test room, named MATRIX, was built (latitude 41°07'N, longitude 14°47'E, site elevation 156 m). The station has an internal size of 5.00 m x 4.74 m and height of 2.98 m. In order to allow for the characterization of different types of opaque components and windows, three of the four vertical walls as well as the related window can be easily replaced. The whole structure is placed on a turntable to adjust its orientation. The experimental station already used for the thermal characterization of materials and HVAC systems as described in [7], in the present research is used for daylight analysis. In order to allow for the future evaluation of the real performances of smart windows, a starting characterization of the station, from the photometric point of view, was performed.

The preliminary measurements were performed considering a wood window with a total size of 2.000 m x 1.200 m and equipped with two conventional double low-emitting glazing filled with Argon. The two glasses have a size of 0.785 m x 0.900 m each and were manufactured by Saint-Gobain [8]. The ratio between the glass area and the total window area was equal to 0.59 and the distance between the middle point of the window and the ground was equal to 2.750 m. According to the technical data declared by the manufacturer, the glass was characterized by a visible solar transmittance (T_{vis}) equal to 80 %, a thermal transmittance (U_g) equal to 1.1 W/m^{2}K and a solar factor (SF) equal to 0.63.

3. PHOTOMETRIC CHARACTERIZATION OF THE INTERNAL SURFACES

For the photometric characterization of the internal side of the station, the reflectance values of all the internal surfaces were experimentally measured by means of the spectrophotometer Konica Minolta CM – 2600d (size of integrating sphere: ø52 mm, wavelength range: from 360 nm to 740 nm, spectral reflectance: standard deviation within 0.1 %). For each surface, the measurements were performed on three different points; for each measurement point, three acquisitions were recorded. The reflectance value assigned to each surface was calculated as the average value of the reflectances recorded on the three measurement points. With the purpose of characterizing the behaviour of the surfaces under daylight, the reflectances were evaluated using the standard illuminant D65 [9] considering the Specular Component Included (SCI) and Specular Component Excluded (SCE). In Table 1, the experimental SCI and SCE values of the reflectance, acquired for the main surfaces inside the experimental station, were listed.

Table 1- Experimental reflectance values of the main internal surfaces

Surface	Values of D65 reflectance SCE (%)	Values of D65 reflectance SCI (%)
Floor	55.1	53.0
Walls	86.8	86.7
Window frame	17.2	15.2
Door	54.6	53.0
Ceiling	79.2	78.8

4. EVALUATION OF THE REAL EXTERNAL DAYLIGHT AVAILABILITY

With the aim of knowing the real external weather conditions, the horizontal global and diffuse illuminance values were measured. The external illuminances were acquired by using two illuminance-meters LP PHOT 03 (manufactured by Delta OHM, with cosine correction, measuring a range from 0 lx to 150,000 lx, relative spectral response (f1') < 6 % and accuracy < 4 %). The sensors were placed on the roof of the laboratory in a position relatively without external obstructions; the obstructions angles are less than 10°.

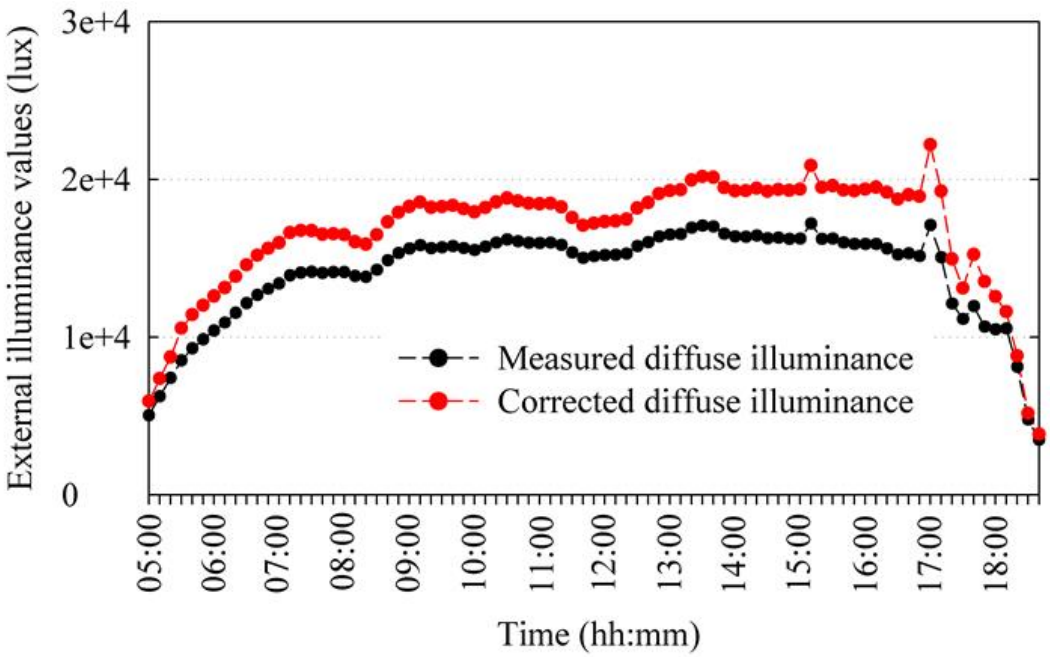


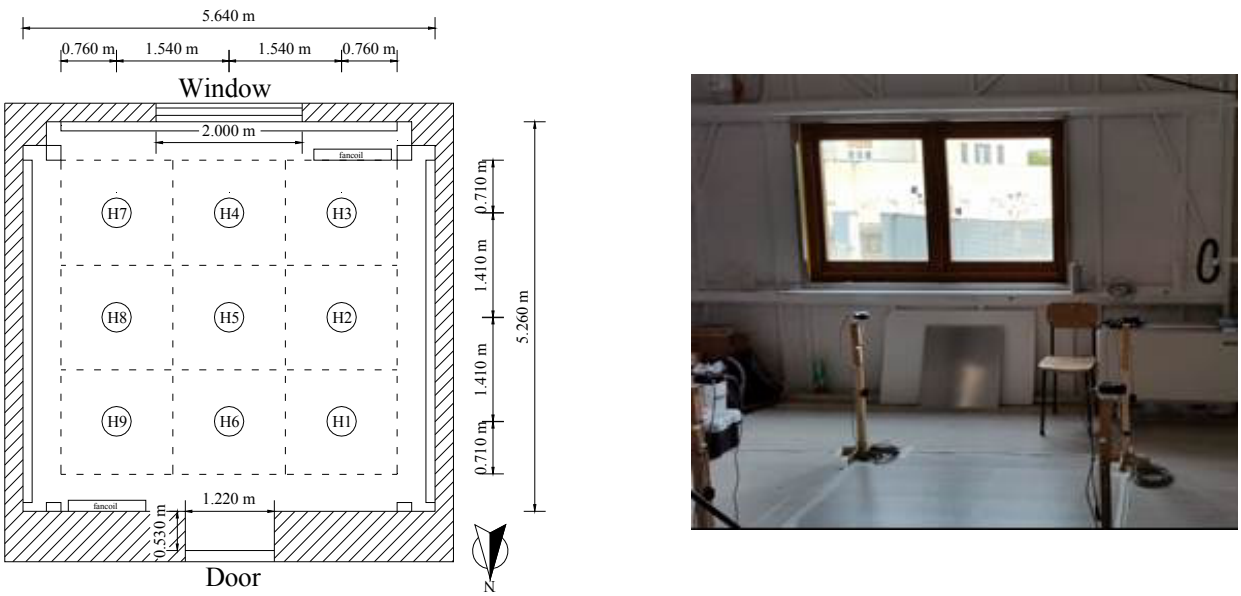
Figure 1- Comparison between measured and corrected external horizontal diffuse illuminance, for data recorded on June 18th 2016

The horizontal diffuse illuminances were acquired using a shadow ring with a diameter of 0.574 m and thickness equal to 0.052 m. In order to take into account both the isotropic and anisotropic conditions, the data were corrected following the methodology proposed in [10]. The authors indicated that the proposed correction model allows to predict the hourly real values of horizontal diffuse irradiance with values of MBE equal to -0.9 W/m^2 and RMSE equal to 17.3 W/m^2; the MBE is the

mean bias error (calculated as average value of the sum of differences between real and corrected values) and the RMSE is the root mean square error (calculated as the square root of the mean bias error). Figure 1 shows the comparison between the measured external horizontal diffuse illuminance and the corrected values, for the data recorded on June 18th 2016.

5. EVALUATION OF THE INTERNAL DAYLIGHT DISTRIBUTION

The internal daylight distribution was measured through nine lux-meters placed inside the experimental station with the window south oriented. The nine Konica Minolta T-10 lux-meters (with cosine correction, measuring range from 0.01 lx to 300,000 lx and accuracy of ± 2 %) were placed at 0.85 m from the floor level in a horizontal position by means of suitable support structures; all the illuminance values were recorded simultaneously. The measurement points were identified considering a grid subdivision of the total area in a 3 x 3 array with a single cell 1.410 m x 1.540 m each; the sensors were placed at the centre of each small area. In Figure 2a, the layout of the laboratory, the position of the window as well as the position of the lux-meters (indicated with a number from H1 to H9) are reported. Figure 2b shows an internal view of the station.



a) b)

Figure 2- Layout of the experimental station as well as the position of illuminance-meters, from H1 to H9 (a), and the internal view of the station (b)

6. PRELIMINARY EXPERIMENTAL RESULTS AND NUMERICAL MODEL

In order to verify the performances of the measurement methodologies and characteristics of the room from the photometric point of view, preliminary acquisitions of data with a standard configuration of the laboratory were

performed. The preliminary data were recorded considering a conventional window with the aim of: (1) verifying the operation of the different instruments and their correct positioning, (2) obtaining information that can be compared with those widely reported in current literature and (3) defining a reference point for the future evaluation of the real performances of smart windows.

7. DAYLIGHT ANALYSIS

The sky conditions were evaluated acquiring at the same time both the diffuse and global external horizontal illuminances. With the purpose of taking into account the variation of the sky condition with a reasonable time step, experimental data were recorded every 10 minutes. Simultaneously, the daylight distribution inside the laboratory was investigated acquiring the daylight illuminance distribution with the same time step. The measurements were acquired in local time, starting from 25th May. The experimental illuminance values were filtered to remove spurious data; in particular:

1) the recorded diffuse horizontal illuminance values were corrected according to the methodology proposed in [10];
2) all the data recorded for a solar altitude lower than 5° were removed;
3) all the recorded diffuse illuminance values greater than the global values were removed;
4) all the global data greater than the extraterrestrial data were removed;
5) all the diffuse data greater than half of the extraterrestrial data were removed.

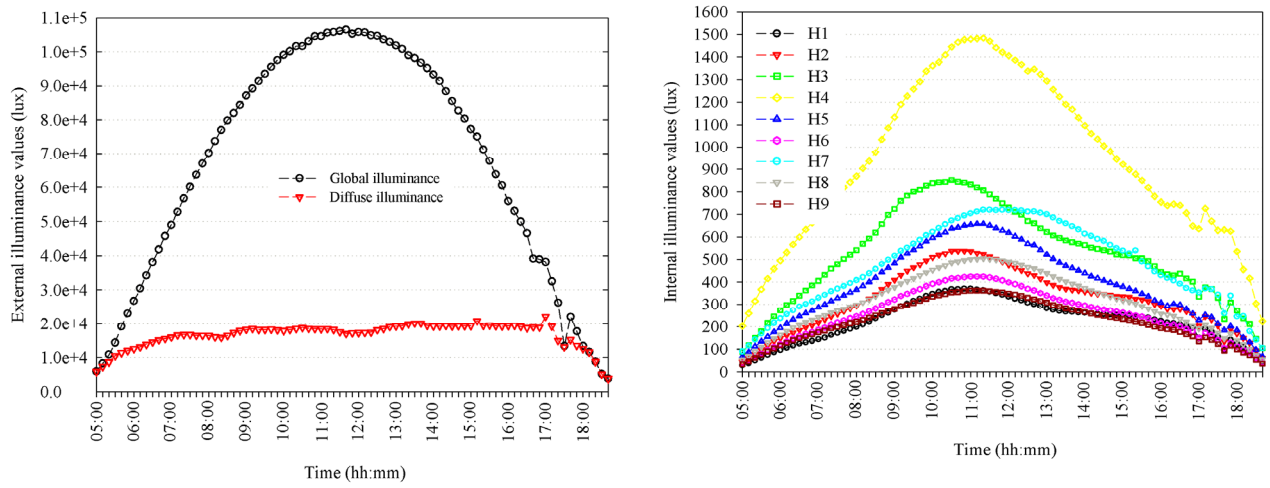
In Figure 3a, the external diffuse and global horizontal daylight illuminance values for a typical sunny day are reported, while, with reference to the measurement layout are reported in Figure 2, Figure 3b shows the daylight illuminance values acquired inside the test facility. Both the figures display the data recorded on June 18th 2016. The connecting lines between the dots in the figure are only guidelines for the eye to connect data points belonging to the diffuse and global external illuminance values. Analysing the daylight illuminance values reported in Figure 3b, it can be seen that:

1) the highest illuminance values were observed for the sensors close to the window (H3, H4 and H7). In particular, the sensor placed in front of the middle point of the window (measurement position H4) detected the maximum illuminance values;
2) the internal daylight illuminance distribution values decrease upon the distance from the window increasing;
3) the greatest internal daylight illuminance values were detected by the sensors placed in front of the window (H4, H5 and H6);
4) the internal daylight distribution follows the typical illuminance distribution that can be expected for a side-lit office room.

8. VALIDATION OF NUMERICAL MODEL

A virtual model of the test facility was realized in the dynamic simulation software TRNSYS 17 [6]. This software is widely used in literature to evaluate the energy performance of buildings upon varying the operating scenarios [11-13].

The daylight analysis was conducted by means of the TypeDLT [14]. The TypeDLT is a climate-based tool that allows to perform the daylight analysis of Complex Fenestration Systems (CFS) inside TRNSYS. Through the TypeDLT, it is possible to perform daylight analysis by means of the so called RADIANCE Three-Phase Method (3PM) [15], using the information reported in weather data files: 1) latitude and longitude of the site, 2) month, day of the month, hour of the day, 3) direct normal illuminance values and 4) diffuse horizontal illuminance values. The experimental reflectance values, reported in Table 1, were used to characterize the internal surfaces of the laboratory from the photometric point of view. In order to increase the accuracy of the simulation, also the external buildings and obstructions were modelled in the virtual model. The Bidirectional Scattering Distribution Function of the conventional double low-emitting glazing was created by using the modelling software WINDOW 7.3 [16].



a) b)

Figure 3 - External diffuse and global horizontal illuminance values (a) and internal daylight illuminance values (b), both acquired on 18th June

From the external experimental data acquired every 10 minutes, the values of the diffuse and global horizontal illuminance as well as the direct normal illuminance with a time step of 1 hour were deduced. These data were then integrated into a weather file, with the purpose of creating a file representative of the real sky conditions and under which the daylight distribution inside the test room was recorded. A comparison between the simulation and experimental data was performed in terms of instantaneous values of both the point daylight illuminance values, acquired on each of the nine measurement points (Figure 2a) and spatial average daylight illuminance values. The spatial average daylight illuminance values were calculated, for each time step, as the average value of the illuminance values recorded in every of the nine internal measurement points. For

the comparison, a total of 361 one hour time step values, acquired from 25th May to 30th June under different sky conditions, were considered.

For each time step, the assessment was based on statistical indices and regression analysis, evaluating the regression line, the resulting coefficient of determination R^2, the mean bias error (MBE), the relative mean bias error (rMBE), the root mean square error (RMSE) and the relative root mean square error (rRMSE). The statistical indices were calculated as follows:

$$MBE = \frac{1}{N}\sum_{i=1}^{N}\left(E_{sim,i} - E_{\exp,i}\right) \tag{2}$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(E_{sim,i} - E_{\exp,i}\right)^2} \tag{3}$$

$$rMBE = \frac{1}{N}\sum_{i=1}^{N}\left(E_{sim,i} - E_{\exp,i}\right) \Big/ \frac{1}{N}\sum_{i=1}^{N}E_{\exp,i} \tag{4}$$

$$rRMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(E_{sim,i} - E_{\exp,i}\right)^2} \Big/ \frac{1}{N}\sum_{i=1}^{N}E_{\exp} \tag{5}$$

where $E_{sim,i}$ is the simulated point/spatial average illuminance value in the time step i, $E_{exp,i}$ is the experimental point/average illuminance value in the time step i and N is the number of the time steps considered. In Table 2, the results of the comparison analysis between the simulation results and experimental data are listed.

Table 2 - Results of the statistical comparison between the simulated and experimental data

Total number of time steps considered	Parameter	R^2	MBE (lx)	RMSE (lx)	rMBE (%)	rRMSE (%)
361	H1	0.901	2.1	42.8	0.9	18.6
	H2	0.909	-1.9	57.6	-0.6	17.4
	H3	0.890	2.8	108.8	0.5	18.8
	H4	0.871	-12.1	235.8	-1.1	21.1
	H5	0.914	1.1	72.3	0.3	17.3
	H6	0.901	0.3	49.6	0.1	18.3
	H7	0.879	-16.3	103.9	-3.2	20.1
	H8	0.927	-3.1	49.7	-0.9	15.1
	H9	0.918	-2.8	37.5	-1.2	16.0
	Average illuminance	0.912	-3.3	74.1	-0.7	16.6

9. MEASUREMENT POINTS ANALYSIS

With reference to the measurement layout shown in Figure 2, the values reported in the table show that:

- the MBE (rMBE) values for the nine measurement points range from -16.3 lx (-3.2%) for the point H7 to 2.8 lx (0.5%) for the point H3;
- the RMSE (rRMSE) values for the nine measurement points range from 37.5 lx (16.0%) for the point H9 to 235 lx (21.1%) for the point H4;
- the greatest differences between the simulated and experimental data can be noted for the points closest to the window:
  - H3 (R2 = 0.890; rMBE = 0.5%, rRMSE = 18.8%);
  - H4 (R2 = 0.871; rMBE = -1.1%, rRMSE = 21.1%);
  - H7 (R2 = 0.879; rMBE = -3.2%, rRMSE = 20.1%).

Considering the spatial average illuminance values, the simulated values slightly underestimate the experimental one with a value of MBE = -3.3 lx and rMBE = -0.7%. Figure 4a shows the comparison between the simulated and experimental illuminance values in the point H5, while Figure 4b shows the comparison between the simulated and experimental spatial average illuminance values. In the figures, the black dotted lines are the 1:1 line that represents the condition of perfect matching between the simulation and experimental results, while the red solid lines represent the best fit line of the points. In the figures, the equations of the best fit line as well as the resulting coefficient of determination R^2 are reported too. Observing the data reported in Figures 4a and 4b, it can be noted that:

- for low illuminance values, the points show a small dispersion, tending to be close to the 1:1 line;
- the dispersion of the points increase upon the illuminance values increasing;
- generally, the simulated point values tend to slightly underestimate the experimental ones.

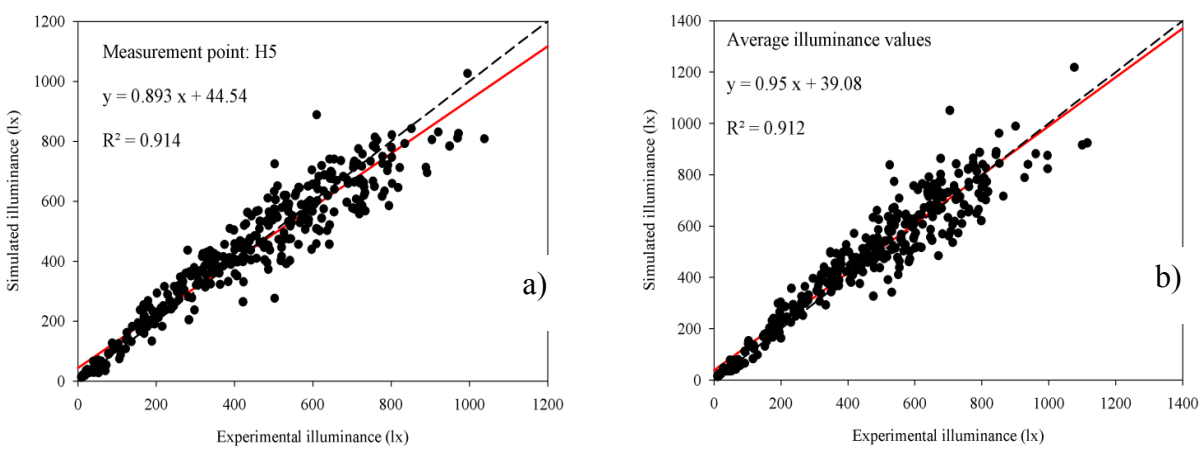


Figure 4 - Comparison between the simulated and experimental data for the measurement points H5 (a) and the spatial average illuminance values (b)

Considering the results reported in [17,18], the simulation results were considered in good agreement with the experimental ones if the rMBE was less than ±15% and the rRMSE was less than +35%.

In order to identify the sky conditions (input data of the simulation software) with the highest differences between the simulated and experimental data, the distribution of the relative percentage error □% evaluated for the spatial average illuminance values was reported as a function of the ratio between the diffuse and global external illuminance and the solar altitude in Figure 5. Low values of the ratio between the diffuse and global external illuminance are representative of clear sky conditions, while values close to 1 are representative of cloudy sky conditions.

The percentage relative error was evaluated as follows:

$$\varepsilon\% = \frac{E_{sim,i} - E_{\exp,i}}{E_{\exp,i}} \times 100 \qquad (6)$$

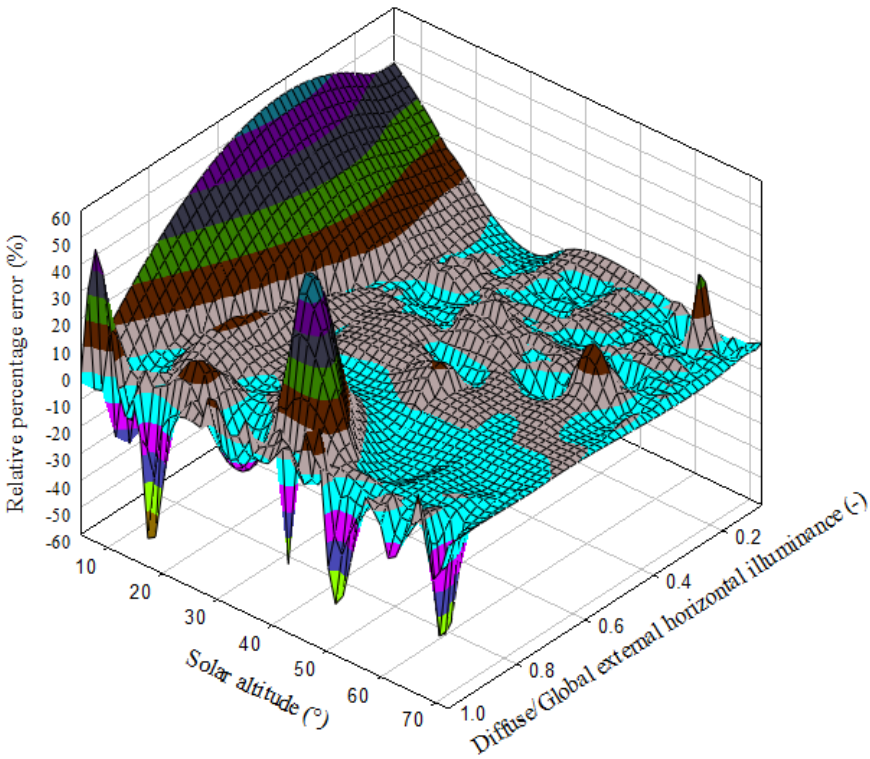


Figure 5- Relative percentage error % as a function of the diffuse/global illuminance ratio and the solar altitude

Figure 5 shows that:

- the greatest error values occur for values of the solar altitude lower than about 12°, whatever the value of the diffuse/global illuminance ratio is;
- for low values of the solar altitude, the errors become more pronounced in presence of direct sun radiation (clear sky condition); the simulated data overestimate the experimental ones in clear sky conditions, while they underestimate them in cloudy sky conditions;

- the variability of the error values between the simulated and experimental data increase upon the diffuse/global ratio increasing from about 0.85 to 1;
- for values of the diffuse/global ratio greater than about 0.85, generally the simulated data underestimate the experimental ones, except for the data evaluated with a value of the diffuse/global ratio of about 0.86 and solar altitude of about 40°.

Figure 6 displays the relative error distribution calculated for the spatial average daylight illuminance values. For a better reading of the figure, the values of the rMBE and the rRMSE were repeated. As can be seen, the percentage relative error values evaluated for each time step :(i) about 50% range from -10 % to 10 %, (ii) about 92 % range from -30 % to 30%, (iii) there are not values lower than -50 % and (iv) only 1.7 % are greater than 50 %.

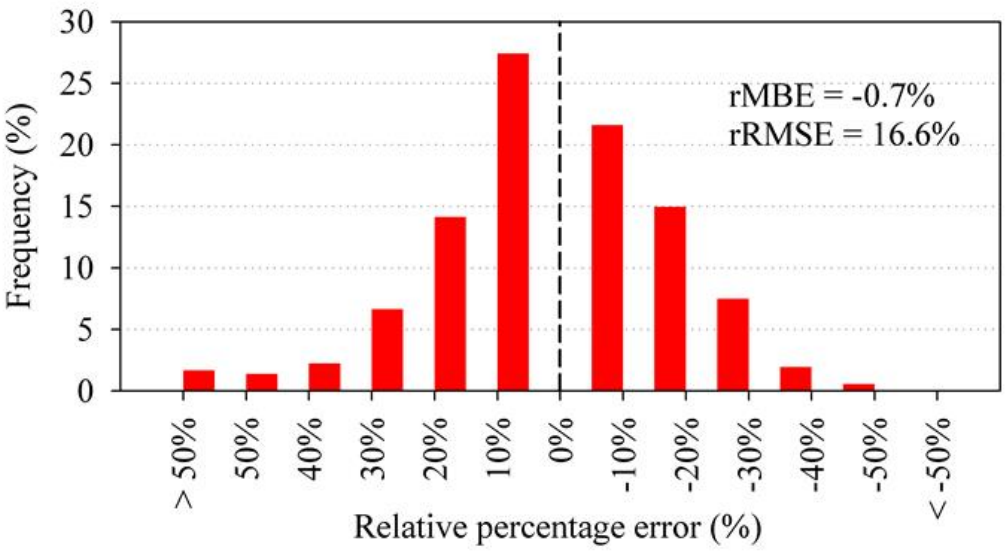


Figure 6 - Relative error for average daylight illuminance values distributions

10. CONCLUSIONS

The market analysis highlights that a great deal of effort still has to be made to improve the performance of smart windows and support their widespread diffusion. In order to increase the diffusion of these emerging technologies, their on-site assessment and characterization upon varying internal and external conditions is necessary. For this reason, an experimental multi-activity test room, named MATRIX, was set up to allow for the on site characterization of smart windows. With the purpose of characterising the experimental facility and validating the measurement methodology of internal and external physical quantities, preliminary experimental measurements were performed with a conventional double low-emittance glazing. The internal daylight illuminance distributions were simulated by means of the dynamic simulation software TRNSYS 17 and compared with those recorded experimentally. The comparison

highlighted that the simulated spatial average daylight illuminance values agree with the experimental ones, showing values of rMBE = -0.7% and rRMSE = 16.6%.

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ANALYSIS OF AVIATION EFFICIENCY AND INTERRELATION WITH AIRPORT ENVIRONMENTAL CAPACITY ACCORDING TO NOISE CONDITIONS

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ABSTRACT

The paper presents analysis of efficiency of air transport systems related to environmental characteristics, first, to noise condition. The effects of operational characteristics on airport environmental capacity are investigated. Current methodology allows estimation of airport environmental capacity taking into account operational conditions and flight safety requirements, which ensure environmental safety and reducing noise impact on airport personnel, passengers and people living in airport vicinity. It is ascertain that for airports in Ukraine aircraft noise constraints become dominant among environmental factors and significantly impact of the total capacity of civil airports. For the short and mid-term prediction of airport operational conditions it is recommended to implement operational measures for noise control, such as optimization of routes for landing and take-off, architectural and constructional methods, specific flight techniques, operational restrictions during night time.

Keywords: aviation efficiency, airport capacity, airport environmental performances, noise control

1. INTRODUCTION

Despite the current economic context, air traffic in most of European countries, USA, Australia and Ukraine is trended to grow, as it has done over the past 50 years.

The European Organisation for the Safety of Air Navigation, commonly known as EUROCONTROL, forecasts the most recent medium-term grows equal to 16% to 2018 and the number of flights in Europe increasing up to 2,2 times to 2030 [1].

According to the International Air Transport Association (IATA) forecasts for the next 20 years, global demand for the air transport will be doubled to 2034 and will reach 7 billion passengers [2]. Previously, IATA forecast 7.4 billion passengers in 2034 based on a 4.1% average annual growth rate. The revised result reflects negative developments in the global economy that are expected to dampen demand for air transport.

Table 1 - Flight Movements at top 7 European airports from 2010 to 2015, thousand of units

№	Airport (Location)	Code (IATA/ ICAO)	2010	2011	2012	2013	2014	2015
1.	Paris-Charles de Gaulle Airport (Seine-et-Marne, Seine-Saint-Denis, Val-d'Oise, Île-de-France, France)	CDG/LFPG	500	514	498	478	471	476
2.	Frankfurt Airport (Frankfurt, Hessen, Germany)	FRA/EDDF	464	487	482	473	469	468
3.	London Heathrow Airport (Hayes, Hillingdon, Greater London, United Kingdom)	LHR/EGLL	455	481	475	472	473	474
4.	Barajas Airport (Barajas, Madrid, Madrid, Spain)	MAD/LEMD	434	429	373			
5.	Amsterdam Airport Schiphol (Haarlemmermeer, Netherlands)	AMS/EHAM	402	437	438	440	453	466
6.	Munich Airport (Munich, Bavaria, Germany)	MUC/EDDM	390	410	398	382	377	
7.	Istanbul Atatürk Airport (Istanbul, Turkey)	IST/LTBA			364	406	440	465

Active recovery of air traffic volumes in Ukraine which had started in 2010 and converted into rapid increase of demand for air traffic in 2011. Passenger flows through Ukrainian airports during 2011 increased by 21.7%, reached 12.5 million passengers, and had a peak in 2012 due to holding of the 2012 UEFA European Championship. Under statistic data, cargo flows through Ukrainian airports during 2011 increased by 11% and reached 47.2 thousand tons of cargo and mail. In general, according to the data of the State Civil Aviation Administration of Ukraine (CAA), 9 Ukrainian airlines operated regular passenger flights to 48 countries worldwide, while 56 foreign airlines operated regular flights from 33 countries. 26 Ukrainian airports and aerodromes handled commercial

flights of domestic and foreign airlines. Is should be mentioned that according to CAA report 2015 Ukrainian air transport showed reduction in passenger traffic in comparison with 2014 for 2.7%. Nevertheless, the volume of passenger air transportation grows now. During 2016, the volume of passenger air transportation has grown by 25.5%.

2. ANALYSIS OF TRENDS IN AIRCRAFT MOVEMENTS IN MAJOR WORLD AIRPORTS

If we consider this grows in terms of aircraft movements (which is related to airport environmental issues - noise conditions first – more directly than passengers flow), we get the following trends. For Europe, (see table 1 for the top 7 European airports). USA (see table 2 for the top 10 USA airports). Australia (see table 3 for top 10 Australian airports).

Table 2 - Flight Movements at top 10 USA airports from 2010 to 2015, thousand of units

№	Airport (Location)	Code (IATA/ ICAO)	2010	2011	2012	2013	2014	2015
1)	Hartsfield–Jackson Atlanta International Airport (Atlanta, Georgia)	ATL/KATL	950	883	879	878	883	868
2)	O'Hare International Airport (Chicago, llinois)	ORD/KORD	883	667	703	650	911	680
3)	Los Angeles International Airport (Los Angeles, California)	LAX/KLAX	667	652	540	605	615	566
4)	Dallas/Fort Worth International Airport (Coppell, Euless, Grapevine, and Irving, Texas)	DFW/KDFW	652	630	647	613	678	637
5)	Denver International Airport (Denver, Colorado)	DEN/KDEN	630	531	629	552	583	545
6)	George Bush Intercontinental Airport (Houston, Texas)	IAH/KIAH	531	461	462	450	497	432
7)	Charlotte/Douglas International Airport Charlotte, North Carolina	CLT/KCLT	529	531	532	528	558	522
8)	McCarran International Airport Paradise, Nevada	LAS/KLAS	506	506	517	510	521	509
9)	Philadelphia International Airport Eastwick, Philadelphia, Pennsylvania	PHL/KPHL	461	0	0	0	522	466
10)	Phoenix Sky Harbor International Airport Phoenix, Arizona, United States	PHX/KPHX	455	924	428	911	582	439

Turning to Ukraine, we finalise that the main share of total passenger movements (more than 90%) is concentrated in 5 strategic international airports of Ukraine: Boryspil, Dnipropetrovsk, Odessa, Lviv, Kharkiv and Kyiv (Zhuliany Airport).

Statistic data starting from the year 2011 and later clearly evidenced Boryspil International Airport shared more than 60% of the total volume of air passenger

handling, more than 70% of the total volume of cargo and mail handling among the airports of Ukraine (see table 4 and fig. 1-2).

Table 3 - Flight Movements at top 10 Australian airports from 2010 to 2015, thousand of units

№	Airport (Location)	Code (IATA/ICAO)	2010	2011	2012	2013	2014	2015
1	Sydney Kingsford Smith International Airport Sydney, Australia	SYD/YSSY	304,9	310,9	314,9	326,7	329,6	337,0
2	Melbourne Moorabbin Airport Melbourne, Australia	MBW/YMMB	252,2	274,1	235,2	220,8	235,5	242,5
3	Adelaide Parafield Airport Adelaide, Australia	YPPF	228,3	207,0	239,4	182,2	197,5	235,4
4	Melbourne International Airport Melbourne, Australia	MEL/YMML	205,2	206,3	211,8	220,8	228,3	235,3
5	Perth Jandakot Airport Perth, Australia	JAD/YPJT	295,5	265,8	257,3	246,1	253,1	222,9
6	Sydney Bankstown Airport Sydney, Australia	BWU/YSBK	276,0	243,1	236,0	215,8	227,5	220,2
7	Brisbane International Airport Brisbane, Australia	BNE/YBBN	188,0	199,0	209,5	223,0	226,6	220,2
8	Perth International Airport Perth, Australia	PER/YPPH	124,6	136,5	149,2	150,9	149,9	138,7
9	Brisbane Archerfield Airport Brisbane, Australia	ACF/YBAF	118,4	119,3	130,1	124,2	137,3	133,9
10	Adelaide International Airport Adelaide, Australia	ADL/YPAD	101,6	101,5	101,1	104,0	107,6	106,6

Nevertheless, at the earlier 2016 CAA developed and adopted the new State target Programme for Airports Development in Ukraine for the period to 2023 (Order of the Cabinet of Ministry №126 dated 24/2/2016). According to this Program, aerodromes became the property of the airport operators as state enterprises, which also got the necessary land plots in the permanent use.

Table 4 - Flight movements at Borispol airport from 2009 to 2011, thousand of units

Airport / Year	2009	2010	2011
Borispol	86	97	107

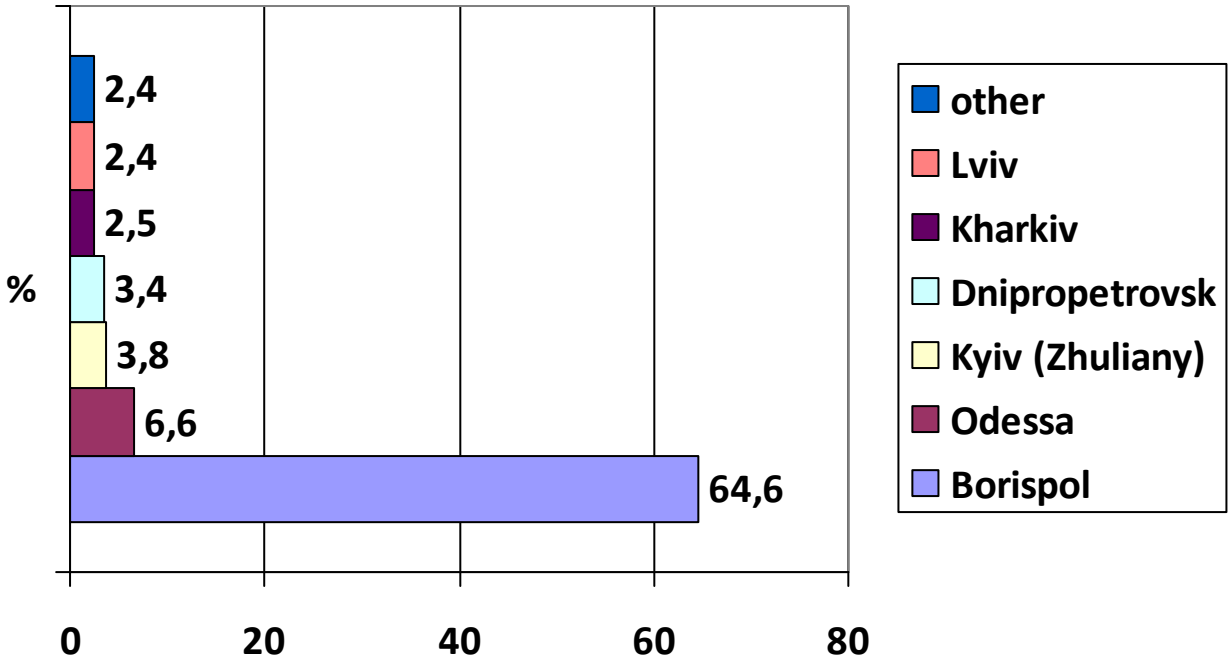

Figure 1 - Share of Ukrainian Airports in Passenger Transportation

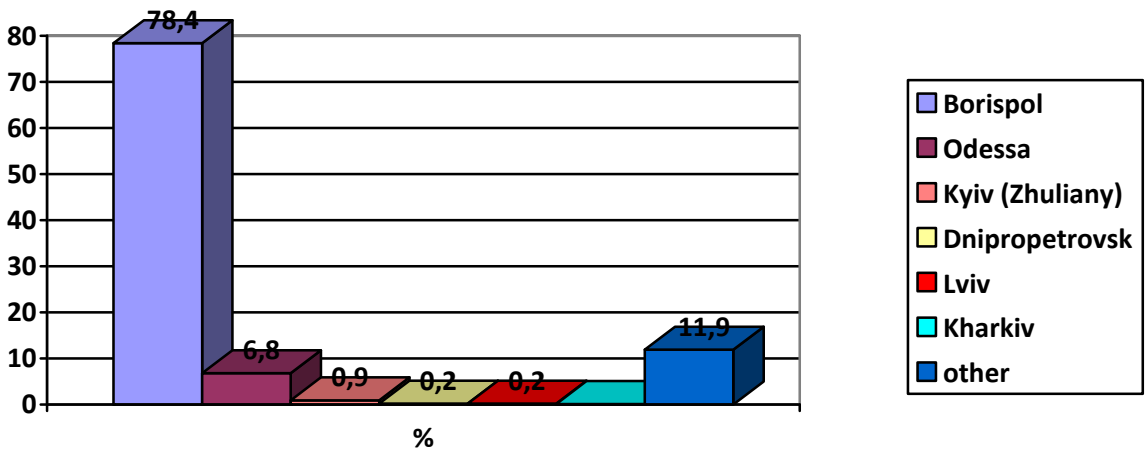

Figure 2 - Share of Ukrainian Airports in Cargo and Mail Transportation

3. ANALYSIS OF EFFICIENCY IN AVIATION

In ACARE (Advisory Council for Aviation Research and Innovation in Europe) Strategic Research Agenda efficiency of the Air Transport System is defined as "rising traffic should not exacerbate the downsides of congestion, delay and lost opportunities". Which means that the efficiency of the whole system must be substantially improved according to economic conditions and needs and maintaining a level of comfort for customers (passengers first, then customers of goods and mail transportation). On the other hand, the definition of aviation environmental issues again contains economic conditions as determinant factor.

Environment – the challenge of meeting continually rising demand while reducing the environmental impact of manufacturing, operating, maintaining and disposing of aircraft and associated systems.

Aviation experts assess the effectiveness of aviation addressing to capital productivity. That is, at the air travel industry level, measured in two ways:

- The simplest measure is the average aggregate load factor of the airline.
- A more adequate method is to evaluate efficiency by analyzing and comparing the outputs of the decision unit to its inputs. Each output and each input is assigned accordingly a weight and the ratio of weighted outputs to weighted inputs yields a global measure of efficiency in given environmental conditions. Outputs include total passengers transported and total passenger-kilometers. Inputs include total personnel, capacity, fleet, fuel and average stage length.

The farther and more often cargo or passengers are carried – the higher the indicator is.

According to air transport efficiency the Annual report of the International Civil Aviation Organisation (ICAO) asserts the 61 place for Ukraine – for regular freight traffic and 57 place – on regular passenger transportations. The full list contains 101 country including only ones presenting traffic more than 100 billion tonnes-kilometers.

At the route level, standard measures of efficiency are load factors and fares. Load factors express the efficiency in the use of aircrafts on each route.

4. PROBLEM STATEMENT AND PROPOSED CALCULATION SCENARIOS

Investigations made by experts of the Center of Environmental Problems of Airports (CEPA) at National Aviation University confirmed that nowadays most of Ukrainian airports such as Borispol, Kiev (Zhulyany), Odessa, Dnipropetrovsk, Kharkiv, Ivano-Frankovsk, Cherkasy, Rivne and Gostomel, have zones with high noise levels, which partially overlay residential areas. Those airports consider potential constraints of air traffic according to environmental requirements. At present day, aircraft noise is the most negative factor among the other environmental factors of airport operation.

Aircraft noise impacts not only on aviation personnel, but also on residents – people living in an airport vicinity. However, aviation is responsibly reducing its environmental impact.

In 2001, the ICAO Assembly endorsed the concept of a "balanced approach" to aircraft noise management [3]. This consists of identifying the noise problem at an airport and then analyzing the various measures available to reduce noise through the exploration of four principal elements, namely reduction at source (quieter aircraft), land-use planning and management, noise abatement operational procedures and operating restrictions, with the goal of addressing the noise problem in the most cost-effective manner.

For land use management around civil airports the State Sanitary Norms are in force and the Regulations for determination of zones of construction restrictions

around airports according to aircraft noise impact (below – the Regulations) are developed. In accordance with the Regulations territory around an airport is divided into three zones of construction restrictions (table 5). The normative criteria of noise contamination are equivalent noise levels L_{Aeq} *(dBA)* and maximum noise levels L_{Amax} *(dBA)* during daytime (from 7:00 till 23:00) and night time (from 23:00 till 7:00).

Table 5 - Regulation of construction restrictions around civil airports

Type of restriction in a zone	**Daytime**		**Nightime**	
	L_{AeqD}, **dBA**	L_{AmaxD}, **dBA**	L_{AeqN}, **dBA**	L_{AmaxN}, **dBA**
Unsuitable for construction	≥75	≥90	≥65	≥80
Protection against noise	<75 ≥65	<90 ≥80	<65 ≥55	<80 ≥70
Limitations for residential construction	<65 ≥55	<80 ≥70	<55 ≥45	<70 ≥60

For calculation of acoustical loading for the specified airport the timetable of air traffic during a week is used, at which the maximum intensity of aircraft movements is reached. Noise contours and accordingly zones of construction restrictions are estimated for current and perspective (5-10 years predictions) operational conditions and also the scenario of airport operation at the level of maximum operational runway capacity.

Experts of the CEPA have made the complex of investigations and, as a result, the zones of aircraft noise impact for the most of civil airports in Ukraine. Thus, for Borispol international airport three operational scenarios were evaluated:

1. For the first calculated scenario (fleet and intensity of aircraft movements for the year of 2011) the noise level equal to L_{AeqD}=75 dBA that according to the Regulations determines zone unsuitable for construction does not cover any residential area for both runway ends.
2. For the second scenario (redoubled intensity of aircraft movements for the year of 2011) the fleet is changed in accordance with Chapter 3 of ICAO Annex 16 Volume 1 and Directive 20002/49/EC [4, 5]. Because of fleet change, contours of the noise levels 55, 65 and 75 dBA are very close by their characteristics to the respective contours of the first calculation variant.
3. For the third calculation scenario (intensity of aircraft movements equal to the maximum runway capacity, and fleet according to the Chapters 3 and 4 of ICAO Annex 16 Volume 1) [4].

In accordance with ICAO and EU requirements for sustainable developments of civil airports it is necessary to step-by-step replacement of noisy aircraft types by the modern aircrafts with better noise characteristics which correspond to the Chapter 3.

The problem of noise contamination around civil airports in Europe and also in Ukraine becomes more acute because most of airports are located close by

inhabited localities and thus, as a result causes high environmental loading on those residential areas. For Ukraine this problem became of current importance visa free regime because of sharp increase in intensity of aircraft movements when acoustical capacity can be a limiting factor for airport development.

This is why the aim of current investigation is the method of evaluation of environmental capacity of civil airports taking into account operational characteristics and flight safety requirements.

5. CONCLUSIONS

Sustainable development of an airport is significantly affected by airport environmental capacity. Environmental capacity, in addition to emission of air pollutant and electromagnetic contamination, significantly depends on acoustic loading on environment in airport vicinity.

Current methodology allows estimation of airport environmental capacity taking into account operational conditions and flight safety requirements, which ensure environmental safety and reducing noise impact on airport personnel, passengers and people living in airport vicinity.

Hence, for the short and mid-term prediction of airport operational conditions (f. e., for the period of 5-10 years, when intensity of aircraft movements doubles in comparison to the years 2010-2011) it is recommended to implement operational measures for noise control, such as optimization of routes for landing and take-off, architectural and constructional methods, specific flight techniques, operational restrictions during night time.

As advanced research, estimation of population within zones of impact and estimation of density of population is considered.

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THE METHOD OF PROJECTS AS A MEANS OF FORMING AN ECOLOGICAL OUTLOOK IN THE FRAMEWORK OF STUDIES IN HIGHER EDUCATION

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ABSTRACT

The process of forming an ecological outlook is a difficult task. We came to the understanding that it is necessary to conduct project activities in the technical university for the effective formation of an ecological outlook in the course of implementation of the universal competencies in the educational process. Within the framework of the CDIO approach to training, projects have been implemented aimed at obtaining hydrogen fuel from algae and eliminating hunger by obtaining protein from insects. Experience has shown that the implementation of the project contributes to the formation of a culture of thinking, communication skills, increases the scientific interest stimulates their independent research activities. The method of projects as developing innovative technology contributes to the formation of students not only competencies, but also to expand their outlook, form an active life position and in the case of an environmental focus of the project – an ecological outlook.

Key words: ecological worldview, project activity, CDIO approach, competence-based approach, integration in education, innovations.

Formation of ecological culture, development of ecological education and upbringing are the main tasks of the state policy in the field of environmental development of the Russian Federation, set out in the Fundamentals of State Policy in the Field of Ecological Development of Russia for the period until 2030.

The main task in environmental education and upbringing is to improve the ecological culture, educational level and professional skills and knowledge in the

field of ecology, as well as develop the initiative and active life position that are required to solve environmental problems.

The process of forming an ecological outlook is a difficult task. The essence of environmental education can be defined by the following categories: world view – values – attitude – behavior, which are the main components of the whole system. Each link is presented in sequence and performs a certain function, but all of them are interrelated and interact in the process of organizing environmental education and upbringing. As a result of environmental education, an ecological outlook based on scientific knowledge, reflecting the person's deep conviction in understanding the unity of man and nature, determining the system of values and the corresponding relation to nature, man and society should be formed [1].

We came to the understanding that in a technical university for effective formation of an ecological outlook in the course of implementation of the universal competence in the educational process, it is necessary to conduct project activities.

Modern pedagogy treats the method of projects as a pedagogical technology, oriented not to the integration of actual knowledge, but to their application and the acquisition of new ones. The use of interdisciplinary connections contributes to the formation of a scientific worldview of students.

An important place in the study takes the opinion of the famous researcher of Russian culture Yu.M. Lotman, «the modern stage of scientific thinking is increasingly characterized by the desire to consider not separate, isolated phenomena of life, but vast unity» [2]. In our opinion, one of the reasons for the emergence of integration in science is the blurring of boundaries between fields of scientific knowledge, which appeared at the end of the XIX century, when the same phenomena began to attract scientists of different fields of knowledge, and became the most stable trend in the second half of XX century.

The principles of the project activity form the basis of the international CDIO approach in education according to which the main task of engineering education is defined as the training of graduates who are able to conceive, design, implement, operate (CDIO) complex engineering facilities, processes and systems with high added value [3]. Such skills can be formed only by modeling task solutions or through the implementation of real projects led by professional engineers. However, any number of analyzed examples can not replace the real practice, in particular, on the implementation of the project. The case method can be useful, but it is not enough to train a qualified engineer [4].

This approach is aimed at strengthening the practical orientation of training future engineers, as well as introducing a system of problematic and project training [3, 5].

We emphasize that project activities need to be trained, and it is advisable to implement this through the integration of theory and practice. Formation of a specialist will not be complete if it relies solely on audit activity. Mastering the skills of design is possible only in practical activities, while the design method of training becomes an effective tool. Under the conditions of innovative tendencies in higher education, it is expedient to speak about project teaching as a didactic reception in educational activity [6].

Here are some examples of some of our students' projects in the field of ecology. The first project for obtaining hydrogen fuel is aimed at reducing the level of atmospheric pollution by greenhouse gases and solving the energy problem.

Reducing the harmful impact of transport on the environment in the form of greenhouse gas emissions is in line with the United Nations Framework Convention on Climate Change (1992), the Kyoto Protocol (1997), the Paris Climate Agreement (2016). The transport strategy of Russia until 2030 envisages the transfer of vehicles to environmentally friendly fuels, encouraging the use of vehicles operating on alternative sources (non-oil origin) of fuel and energy resources.

Every year our cadets, future pilots, burn a considerable amount of fuel in training flights. Aviation kerosene is used for aircraft.

The project proposes to replace kerosene with hydrogen produced by seaweed. The idea is based on an innovative method of obtaining hydrogen under conditions of lack of oxygen and sulfur, in which photosynthesis in algae is sharply weakened and rapid development of hydrogen begins [7]. In this way, hydrogen can produce different kinds of green algae – chlamydomonas (Chlamydomonas). The plants for the production process are considered, the working platform is chosen, the economic costs are calculated, the need to re-equip the aircraft is taken into account, the payback of the project was 10 years. The project is a complete technical proposal.

The project in the event «Weekend of technological entrepreneurship on the Volga» in 2017 was awarded a diploma for the best development of innovation in the field of ecology, and also passed a competitive selection for the youth forum of the Volga Federal District «iVolga-2017».

Another project of students is aimed at eliminating hunger by obtaining protein from insects and applying it in the food industry. It is known that in the world about a third of all manufactured agricultural products are thrown away, goes into waste. If these waste are bred insects, it will yield a valuable, protein-rich product. The project is consistent with the work of the World Food Organization at the United Nations, which promotes the concept of replacing cows, sheep and pigs with insects. When growing insects, the production of greenhouse gases is less than in the cultivation of common types of livestock. It does not require large areas of land, as in the case of livestock, specifically allocated for grazing and feeding. The level of ammonia emissions associated with insect breeding is also much lower than in cases with farm animals.

Innovative development of trainees is the device of the farm itself, representing a complex of isolated, sealed heated boxes with constant optimum temperature and humidity, and also sufficient food for insect breeding. As a culture, the cricket of the house (Acheta domesticus), rapidly multiplying, having a high growth rate of individuals, an extensive diet and a large protein content was selected. Each generation of insects is separated by cells (Figure 1). The next generation appears in the underlying cells. This makes it possible to control the generation of insects.

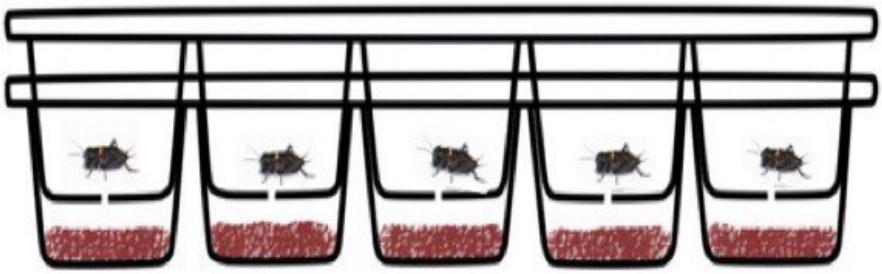

Figure 1 – The idea of dividing the generation of insects into sections

The well-known thesis «Insects – the food of the future» is already widely spread in the world's largest organizations. Such farms will spread throughout the world in the future. As a result, the tendency of insect breeding as a food will reach such a scale that the project will eventually be able to solve the problem of reducing the number of hungry people in the world and even will «swing» the idea of feeding the whole world.

In the work, economic costs and profits are calculated. The project is also a complete technical proposal. Integration today is one of the most significant innovative phenomena in education, it surpasses all other phenomena «in the breadth of the experimental incarnation, the depth of the creative design, the duration and dialectic of historical development» [8]. The main function of integration processes is to achieve a synergetic effect based on cooperation that prevail over differentiation and isolation. Integration leads to the formation of new elements, changing, transforming the current into more effective ones.

The method of projects, being a universal method of training, contributes to the formation of the entire range of competences required for future engineers. In this method, many common and special disciplines are integrated, ensuring the «tangibility» of the results of the project. Unlike the traditional knowledge approach, the team form of work is used in the framework of project and independent work. The instructors are given sufficient freedom of action when performing tasks: there is no hard algorithm of work, only stages and terms of work are established. Responsibility rests with the team members, and the responsibilities of each participant are distributed by the team in dependently [5].

In conclusion, we emphasize that the creation of a project that provides for the final product, contributes to the formation of communicative skills among its participants (teamwork with other students, interaction between the teacher and the creators of the project); Teaches the solution of problem situations arising as a result of the phased implementation of tasks; Serves as a means of developing creative activity, thinking, the ability to analyze situations, setting tasks and abilities to solve the problem in non-standard way; Provides interdisciplinary integration (from many areas) of knowledge, skills and abilities; Develops a high degree of independence, initiative, cognitive motivation; Purposefulness, ingenuity, perseverance; Forms skills in the organization and use of working space and time, the ability to assess their capabilities.

Indeed, the project activity was always carried out in higher education in the framework of course and diploma design, but this design was carried out individually, according to the template, the content was strictly regulated, the topics were given by the leader, the result was predetermined [9].

At present, the project form of training, popular in world universities, has so far become part of the programs only in some educational institutions in Russia. The Higher School of Economics (2014) has adopted new educational standards for bachelor's degree (the university has the right to set its own standards, other than federal ones). One of the peculiarities of the standards is that within the educational programs considerable time is devoted to the design work. In accordance with educational standards, the design and research work is at least 20 % of the total labor intensity of the bachelor's educational program. In our opinion, the project method is a promising innovative educational technology that has all the prerequisites for growth and development not only in the leading universities of our country.

Thus, the method of projects – as developing innovative technology, contributes to the formation of students not only competences, but also broadening their outlook, forming an active life position, and in the case of an environmental focus of the project – an ecological outlook.

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CALCULATION AND REDUCTION OF RAILWAY NOISE

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ABSTRACT

The scope of acoustical pollution from the railway transport and its impact on population are shown. Noise sources of railway transport are evaluated and analysed, the on-site measurements are held and train characteristics are given. Processes of formation and propagation of noise emitted by trains of different categories that are exploited in Russia are examined. On the basis of measurements and literature search a classification of rail noise reduction measures was developed and their effectiveness was evaluated. For the new rolling stock the biggest attention should be paid for the noise reduction in source. The approaches to the rail noise reduction at source and on the way of propagation are investigated and the complex of noise protection measures is elaborated. The most effective measures to reduce the noise of existing train lines are measures applied on the way of noise propagation.

Keywords: railway noise, calculation, noise reduction

The problem of protection from increased noise is a serious problem, the solution of which is being searched all over the world. It is one of the most important environmental problems. Hundreds thousands of people are under the influence of increased noise, causing discomfort, hearing loss and even serious pathologies of the cardiovascular, nervous and other human systems. UNESCO has formulated the current situation as follows: "Noise is a disaster of the modern world and an undesirable product of its technical civilization". According to data provided by the chief sanitary doctor of the city of Moscow increased long-acting noise affects life expectancy.

Train passage causes an increase in the noise level by an average of 10-20 dBA over background noise values in the adjacent residential area that leads to a large number of complaints from residents for the increased noise. Russian trains are 7-10 dBA noisier than European models [1].

The noise in the residential area near the railways reaches 70-75 dBA that significantly exceeds the sanitary limit accepted in Russia (55 dBA in the daytime and 45 dBA in the nighttime, the bonus for the rail noise is not applied). As the distance from the railway line increases, the noise gradually decreases, but in most cases the noise exceeds the norms even at distances of 1 km or more.

According to expert opinion in the Russian Federation, the number of residents exposed to the excessive impact of railway noise reaches 8-10 million people. Railway transport is one of the main sources of public complaints along with road and aviation noise.

For a long time a sound method to calculate rail noise was absent in Russia. Since the sound levels of Russian trains were higher than noise of rolling stock functioning abroad, it was necessary to create a national method of evaluation taking into account the specific of noise sources of Russian trains.

The main categories of trains functioning at Russian railroads can be classified as follows: passenger, cargo, electric and high-speed trains. The parameters of the different train categories functioning in Russia at the moment are represented in table 1. After launching of the high-speed line from Moscow to Kazan a new category of high-speed trains with the speeds up to 400 km/h will be added to the existing classification.

Table 1 - Train classification

Category	Train type	Maximum speed, km/h
1	Passenger	200
2	Cargo	90
3	Electric	160
4	Speed	250

In general, the process of noise generation of a train is contributed by two main components: the rolling stock (body, traction motors, wheel pairs, etc.) and the track (rails, sleepers). Analysing the noise generation of trains, we should take into account three main groups of noise sources:

- equipment noise;
- rolling noise;
- aerodynamic noise.

Equipment noise (compressors, traction motors, etc.) prevails at speeds up to 50-60 km/h. Rolling noise is a process of interaction of the "wheel-rail" system. It is determined by the dependence of 30lgV, where V is the speed of train movement, km/h. This type of noise prevails in the speed range from 60 to 300 km/h. The aerodynamic noise formed by the air flow of the body, rolling stock,

pantograph, etc. is determined by the dependence of 60lgV and prevails at speeds above 300 km/h. The aerodynamic noise from the high-speed trains is not considered in this paper.

A certain contribution to the processes of noise generation is provided by such processes as “rattling” of the train body (body noise), the “squeal” of the wheel in the curves, the sound of the brake pads and wheels during braking (braking noise), collision of wagons (coupling noise), sound reflection generated at the installation of rails on the concrete slabs, impacts at the joints of rails, etc.

Analysis of the processes of formation and propagation of vibration has shown that vibration is formed as a result of the interaction of the wheel and rail, it is transmitted to the rolling stock, and through the elements of the upper structure of the track it is transferred to the environment. Vibration takes part in noise generation processes in the source. But when transmitted to elements of approximate structures, it can serve as a secondary source of sound. Reducing vibration in most cases leads to a reduction of noise.

The rolling noise is prevalent. Studies have shown that the type of train, the state of the working surface of the rails and the speed of movement are the most important parameter influencing this type of noise. The lowest noise is in cars with disc brakes, because the slide-block, causing the greatest noise when driving, is not formed on the wheel brace at braking. The level of wave-like wear of rails is an important factor also [2, 3].

When the roughness is doubled, the sound level increases by more than 6 dBA, and with an increase in roughness by 3 times the sound level increases by 10 dBA.

The screech occurs when the rolling stock passes the curves with a small radius. This screech is caused by the interaction of the edge of the wheel brace with the rail, where the main noise is generated by the wheel. This noise can exceed by 10 or more dBA the rolling noise from the same train on the straight section of the track under the same conditions. Usually, when the train passes the curves a discrete tone prevails in the screech and the frequency composition is in the range of 500-8000 Hz, i.e. the noise has a strong high-frequency character.

The noise of braking is different for different types of brakes. The most low-noise cars are equipped with disc brakes. The noisiest ones are cars equipped with block brakes with cast-iron pads. Here, the noise is radiated by the wheel and the braking system, but additional noise arises from the slide-blocks formed on the rolling surface of the wheel. If the braking noise has a short-term nature, the wheel damages lead to a long-term increase in rolling noise. The noise of a car with disc brakes is 5-10 dBA lower in the high-frequency range than noise of a car with block brakes.

At speeds above 300 km/h, the rolling noise is supplemented by the aerodynamic noise. At speeds more than 350 km/h, the noise of a train is completely determined by aerodynamic noise.

The experimental studies were performed in order to establish the dependencies of equivalent and maximum sound levels on the type of train, speed, length, and other factors. The sample was obtained from linear regression

calculations using the results of noise measurements performed for passenger, cargo, electric and speed trains. The parameters of the trains are presented in Table 2.

Table 2 - Results of measurements for different train categories

# category	Train category	Speed, km/h	Length of trains, m	Equivalent sound level, dBA	Maximum sound level, dBA	Number of trains
1	Passenger	40-130	175-500	76-88	81-93	100
2	Cargo	40-90	506-1188	78-88	86-91	120
3	Electric	40-120	176-264	78-90	81-94	150
4	Speed	100-220	250	68-86	72-88	50

78% of passenger trains, 74% of freight trains, 71% of electric trains and 98% of high-speed trains fall into the specified sound level ranges at given speeds.

Comparison of the noise characteristics of trains has shown:

- cargo trains are the noisiest trains, the noise of electric trains is 2 dBA lower and noise of the passenger trains is 5 dBA lower at the same speed;

- speed trains were developed using new low-noise technologies, the noise of speed trains is lower than, for example, noise of passenger trains by 16 dBA. The noise characteristics of speed train at a speed of 220 km/h are approximately the same as for the passenger train at a speed of 110 km/h.

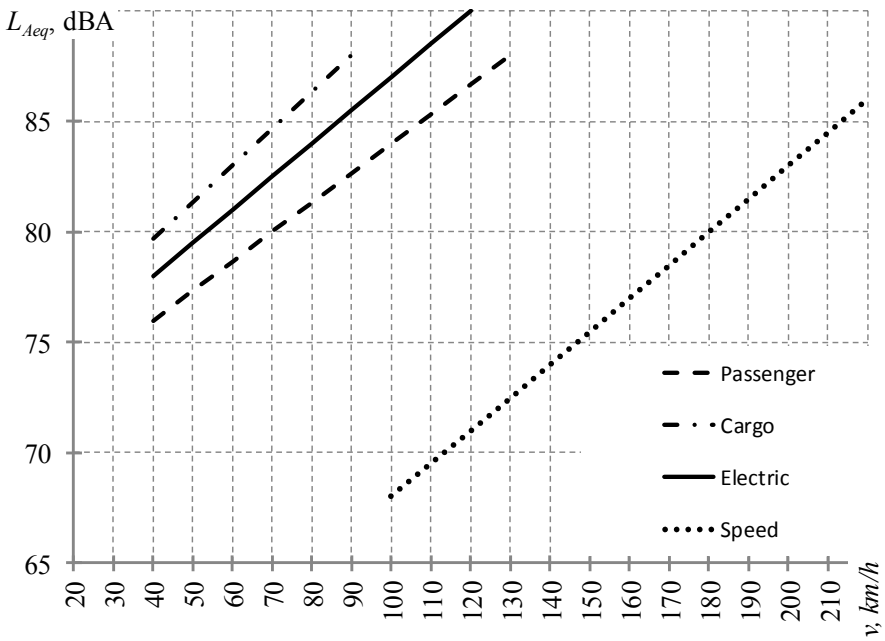

Figure 1- Experimental dependencies of equivalent sound levels on speed for different train categories

The dependencies of equivalent sound levels on the speed for different categories of trains are shown on figure 1.

The analysis of the measured data let us to propose the formulae to evaluate noise characteristics of different train categories. It is suggested to calculate the equivalent sound level (L_{Aeq25}, dBA), created by individual trains of the i-th category (1-passenger, 2-cargo, 3-electric, 4-speed trains) at a distance of 25 m from the axis of the nearest main railway track using the formulas:

Passenger trains (category 1):

$$L^{1}_{Aeq25} = 25\lg v_1 + 10\lg\left\{arctg\left(\frac{l_1}{25}\right)\right\} + 33, \quad (1)$$

Cargo trains (category 2):

$$L^{2}_{Aeq25} = 20\lg v_2 + 10\lg\left\{arctg\left(\frac{l_2}{25}\right)\right\} + 46, \quad (2)$$

Electric trains (category 3):

$$L^{3}_{Aeq25} = 28\lg v_3 + 10\lg\left\{arctg\left(\frac{l_3}{25}\right)\right\} + 28, \quad (3)$$

Speed trains (category 4):

$$L^{4}_{Aeq25} = 41\lg v_4 + 10\lg\left\{arctg\left(\frac{l_4}{25}\right)\right\} - 12, \quad (4)$$

where v_i is the speed of trains of category i, km/h; l_i is the length of trains of category i, m; i = 1,2,3,4.

The equivalent sound level during the time of evaluation is calculated by the formula:

$$L_{Aeq25,k} = 10\lg\frac{1}{T_k}\sum_{l=1}^{n_k} t_l 10^{0,1L_{Aeq25,1h,l}}, \quad (5)$$

where T_k is a time of evaluation, h, that is equal to 16 h (n_k = 16) at the daytime and 8 h (n_k = 8) at the nighttime; t_l = 1 h.

Equivalent sound pressure levels, dB, in octave bands at a distance of 25 m from the axis of the nearest main railway track for trains of the i-th category (i = 1, 2, 3, 4) are determined by adding the corresponding equivalent sound level, dBA, calculated according to (1) - (4) with the values of the relative spectra shown in Fig. 2 and in Table 3 obtained experimentally.

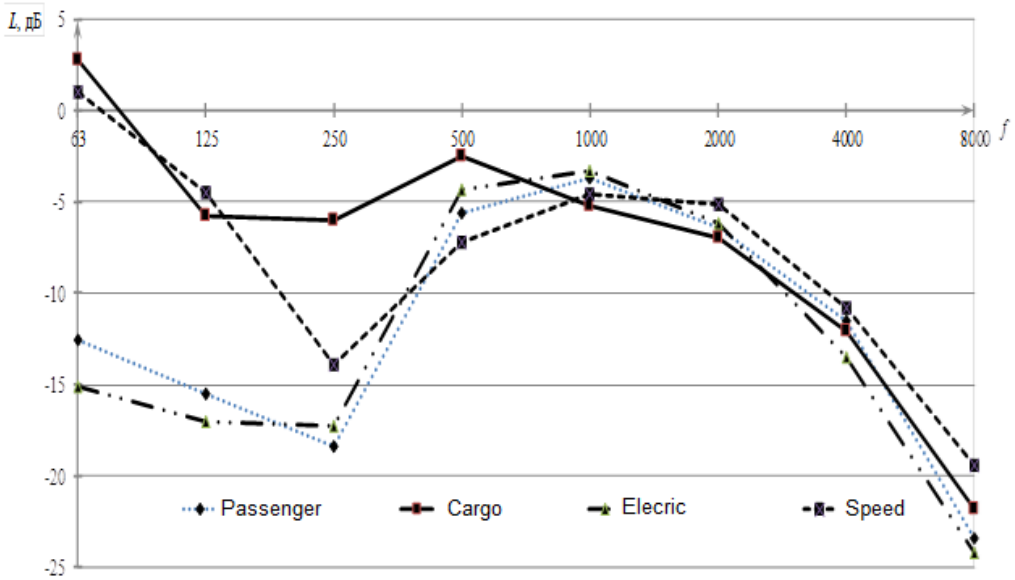

Figure 2 - Values of the relative spectra

Table 3 - Values of the relative spectra for different train types

Noise source	Relative frequency characteristic, dB, at the frequencies of the octave band, Hz							
	63	125	250	500	1000	2000	4000	8000
Passenger train	–12,6	–15,5	–18,4	–5,6	–3,7	–6,4	–11,5	–23,4
Cargo train	+2,8	–5,8	–6,0	–2,5	–5,2	–7,0	–12,1	–21,8
Electric train	–15,1	–17,0	–17,3	–4,3	–3,3	–6,2	–13,5	–24,2
Speed train	+1,0	–4,5	–13,9	–7,2	–4,6	–5,1	–10,8	–19,4

We take a point source located at the point of origin of the signals as a model of the noise source creating the maximum sound level of the train, since the measurement practice shows that the maximum levels do not accumulate but have instantaneous value. The measurements performed for the trains presented in table 2 let us to evaluate maximum sound levels of different train categories.

Comparison of the maximum sound levels of trains has shown:

- at the highest speeds, the most noisy trains are electric and passenger trains, their maximum sound levels are almost the same at the same speeds;
- the maximum noise levels of speed trains are lower compared to other train categories by 17-19 dBA, which is due to new low-noise technologies implemented and the best condition of the rolling stock. The noise characteristics of speed trains at a speed of 220 km/h are almost equal to the noise characteristics of passenger and electric trains at speeds of 80-90 km/h.

The dependency of maximum sound levels on speed for different categories of trains are shown on figure 3.

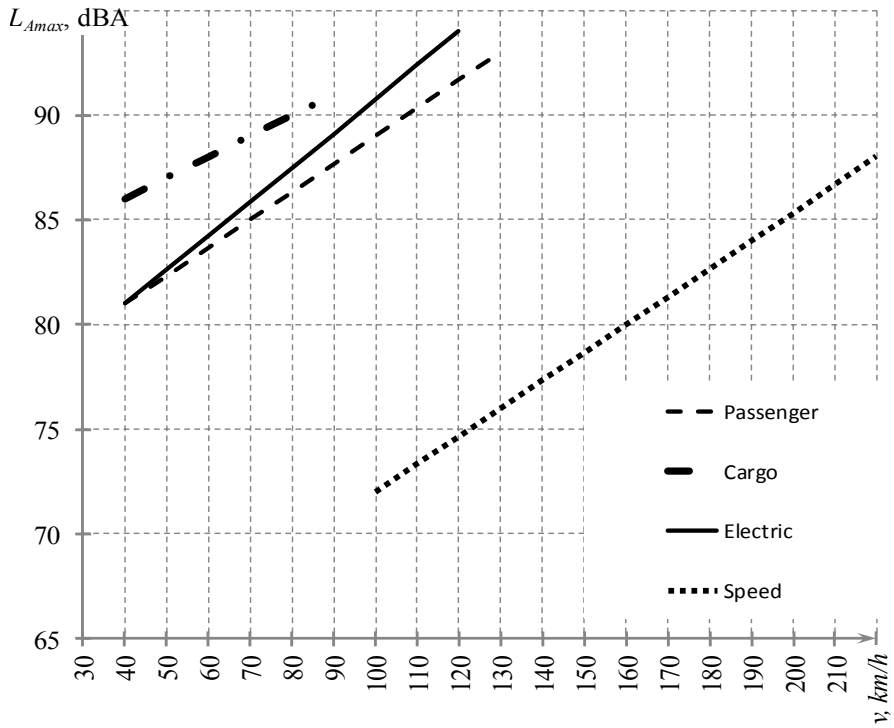

Figure 3 - Experimental dependencies of maximum sound levels on speed for different train categories

It is suggested to calculate the maximum sound level (L_{Amax25}, dBA), created by individual trains of the i-th category (1-passenger, 2-cargo, 3-electric, 4-speed trains) at a distance of 25 m from the axis of the nearest main railway track using the formulas:

Passenger trains (category 1):

$$L^{1}_{A\max 25} = 24\lg v_1 + 43\ , \tag{6}$$

Cargo trains (category 2):

$$L^{2}_{A\max 25} = 15\lg v_2 + 62\ , \tag{7}$$

Electric trains (category 3):

$$L^{3}_{A\max 25} = 27\lg v_3 + 37, \tag{8}$$

Speed trains (category 4):

$$L^{4}_{A\max 25} = 45\lg v_4 - 18, \tag{9}$$

where v_i is the speed of trains of i-th category, km/h; i = 1,2,3,4.

The maximum sound level of the train flow passing the given section during the evaluation period ($L_{Amax25,k}$, dBA) equals to the largest of the calculated levels according to formulas (6) - (9):

$$L_{A\max 25,k} = \max_i \left\{ L^i_{A\max 25} \right\}, \tag{10}$$

where $L^i_{A\max 25}$ is the maximum sound level of trains of *i*-th category, dBA.

The main measures of reduction of railway noise and their effectiveness are given in Table 4.

Table 4 - Measures of railway noise reduction

Place or method of noise reduction	Measures and constructions to reduce noise	Value of noise reduction, dBA		Total noise reduction, dBA
		wheel	rail	
Reduction of disturbing forces	Disk brakes	4	7	6
	Rail grinding	6	10	9
	Replacement of cast-iron pads with composite ones	6	9	8
	Track without joints	2÷3	2÷3	2
Reduction of wheel noise	Vibratory grinding of wheels	–5÷10	0	1÷2
	Changing the shape and size of the wheel		0	1
Reduction of railway noise	Vibratory grinding of the rail neck	0	3÷4	3
	Sound proof of rail neck	0	2÷3	2
	Under rail padding	0	1÷2	1
Reduction of noise on the way of propagation	Installing skirting on trolleys near the wheel	3÷6	0	2
	Installing the noise barrier near the rail head	0	4÷6	3÷5
	Installing the noise barrier at the distance of 3-5 m from the rail axis:			
	Barrier of 2 m high	–	–	6÷8
	Barrier of 3 m high	–	–	9÷11
	Barrier of 4 m high	–	–	12÷15
	Embankment of 3-4 m high	–	–	10÷12
	Cutting of 10-15 m in depth	–	–	12÷20
Combination of measures	Silent wheel and rail	10	4	5
	Reduction of roughness, silent wheel and rail	18	10	11

A very important conclusion is that due to different contribution of various elements of rolling stock and the track to noise generation processes, the total effect of noise reduction is not achieved by adding up the effects of individual noise protection measures [4].

This is well illustrated by the facts given in Table 4. For example, reduction the noise of the wheel by 4 dBA and the rail by 7 dBA gives the total effect of reducing the noise of the train by only 6 dBA. This fact should be taken into account at the development of integrated noise protection.

It is advisable to divide all methods and measures into two large classes:

- noise reduction in source achieved by reducing the disturbing forces (grinding of rails, turning the wheel brace, etc.) and by reducing the sound emission separately for the wheel (vibration dampening, etc.) and for the rail (soundproofing, vibration damping, etc.);
- noise reduction on the way of propagation (noise barriers, embankment, cutting, soundproof glazing, etc.).

It is possible to reduce the noise of rail transport using both measures in the source of origin and on the way of propagation. If we look at the technical norms for the newly produced trains approved in Russia, i.e. 84-87 dBA, it becomes obvious that for the new rolling stock the biggest attention should be paid for the noise reduction in source. The most effective measures to reduce the noise of existing train lines are measures applied on the way of propagation, i.e. noise barriers and their combination with overlays on the rail neck. Their effectiveness is comparable with the efficiency of the cutting of more than 10 meters in depth.

CONCLUSIONS

Railway noise is a serious problem for Russia. The sound levels of Russian trains are higher than noise of European rolling stock. So, it is necessary to create a national method of evaluation. The results of measurements performed for different trains let us to classify the trains and propose a method to calculate equivalent and maximum sound levels generated by different train categories. On the basis of measurements and literature search a classification of rail noise reduction measures was developed and their effectiveness was evaluated. For the new rolling stock the biggest attention should be paid for the noise reduction in source. The most effective measures to reduce the noise of existing train lines are measures applied on the way of noise propagation.

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ECOLOGICAL EDUCATION: ONE OF THE WAYS OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

Experience on development and deployment of new ideas of ecological education for the benefit of the sustainable development and the specialized manual prepared within an original course of "The Common and Applied Ecology" is presented. For the first time in the Russian Federation training of bachelors on the «Sustainable Development of Ecosystems» profile is offered and realized (profile 06.03.01 «Biology»), the purpose of the Main educational program of this profile is formation of professional competences in the sphere of sustainable development of ecosystems.

Keywords: ecological education, common and applied ecology, sustainable development, education for associated professionals.

The solution of global environmental problems, achievement of sustainable development and ecological safety of territories is impossible without the base of environmental management culture. Ecological education is not as much the section of biology, as complex discipline, science based on unity of development of the nature and society, a harmonious unification of natural and human sciences,

experience of environmental management in the past and the present. Ideas of the biosphere and noosphere by probably the last Encyclopaedist of the XX century academician V.I. Vernadsky are brilliant examples of such "ecologization" of natural sciences.

The cancelled Federal law "About State Regulation of Education in the Sphere of Ecology", gives such definition of "ecological education": education in the field of ecology is a continuous process of education, tutoring, self-education, accumulation of experience and development of the person directed to formation of valuable orientations, behavioural norms and obtaining the special knowledge of environmental protection, environmental management and ecological security realized in ecologically competent activity; ecological culture is an inherited experience of activity of a person in his interaction with the environment promoting healthy lifestyle, sustainable social and economic development, ecological safety of the country and each person.

But the question, from our point of view, should be raised more widely: it is necessary to speak not only about "ecological education", but also about "ecological culture", "ecological upbringing" (if education forms comprehension of relationships of cause and effect and ability to operate them, then bringing up creates the system of values and the purposes, motivations and estimates of activity), "ecological consciousness" (formation of ecological environmental awareness [or ecologization] goes two ways – rational, due to belief and understanding of sensible arguments, and irrational – due to adoption of some ideas on trust, receiving extramental emotional impressions), "ecological thinking" (most of adults are much more serious than children and they need more conscious myths and utopias "seasoned" with rational arguments that demands development of ecological thinking at which people plan actions, estimate them and predict consequences not only in social, economic, but also in the ecological way, "nature protection education" (forms ethical, civil and legal ideas of environment protection), "education for sustainable development" (the model unites ecological education and education for development of the world.

On December 20, 2002 the United Nations General Assembly at the 78th plenary session proclaimed that since January 1, 2005 "UN Decade of Education for Sustainable Development" begins. Next year at the fifth conference of ministers "Environment for Europe" (Kiev, 2003) "The statement for education for the benefit of sustainable development" was approved and it is offered to include to all countries the concept of sustainable development in the education systems of all levels. Then at a meeting of Committee on environmental policy of the Economic Commission for Europe (Vilnius, 2005) "UNECE Strategy for Education for Sustainable Development" which marked the beginning of the announced decade was accepted. This "decade" passed and it is possible to sum up the results.

One of the first definitions of the concept "ecological education" was given, apparently, at the first conference on this subject which passed in 1970 in the capital of the State of Nevada (USA) Carson City: "Ecological education represents process of understanding by the person the value of environment and specification of the original positions necessary for the knowledge acquisition and

abilities necessary for a comprehension and recognition of interdependence between the person, his culture and his biophysical environment. Ecological education also includes instilling of the practical skills in problem solving which are falling into to interaction with environment, development of behavior promoting improvement of quality of environment" (see, for example: [1, p.16]).

Ecological education for the benefit of sustainable development (EEBSD) became development of ideas of ecological education in general. Within the International plan of measures "Decade of Education for the Benefit of Sustainable Development of the United Nations, 2005-2014", realized by UNESCO (it was discussed in Vilnius [Lithuania] at the Meeting of Ministers of Education and a environment of UNECE on March 17-18, 2005) and adopted on the 171st session of the UNESCO Executive council (Paris [France], on April 11, 2005) five main goals of EEBSD are formulated: strengthening of the central role of education and training in common efforts in ensuring sustainable development; rendering assistance to establishment of communications and networks, to exchange and interaction between interested parties in the field of EEBSD; providing opportunities for specification and strengthening of prospect of sustainable development and moving towards this process within all forms of education and public informing; upgrading of teaching and tutoring within education for the benefit of sustainable development; development at each level of the corresponding strategy of expansion of opportunities within EEBSD. "EEBSD is reflection of our aspiration to provide the high-quality education which is characterized, in particular: cross-disciplinary and holistic approach: tutoring for the benefit of sustainable development should be included in the whole training program, but not be its separate subject; orientation to ideals: join of the ideals and the principles which are the cornerstone of sustainable development; critical thinking and solution of problems: strengthening of confidence at the solution of the dilemmas and challenges concerning sustainable development; by method of multilateral approach: Word, Art, Drama, Discussion, Experience, various pedagogical ways of tutoring for development of the corresponding processes; personal involvement - participatory manner in a decision making: students participate in a decision making how they should be trained; applicability: the experience accumulated during tutoring is used in everyday, private and professional life; relevance from the point of view of local conditions: the solution of local and also global questions and use of that language which trainees usually use" [http://unesdoc.unesco.org/images/0013/001390/139023r.pdf].

Let's remind [2-4] that in the USSR (in the mid-eighties last century), and then in Russia, ecological education had nature protection focus (there was a speciality "Environmental Protection and Rational Environmental Management" on which there was a training program both in technical colleges, and at biological, geographical and ecological faculties). In the nineties ecological education at the classical and technical universities was divided: the first - had more fundamental naturally scientific approach (the standards in the Ecology and Environmental Management direction and specialties "Ecology", "Geoecology" and "Environmental management" based on cross-disciplinary approach to tutoring was

developed), the second - used engineering-ecological approach (specializations "Health and safety" and "Environment protection". Today "these are rather branched systems having essential dynamics" [4 page 4]. After the summit "Rio +10" in Johannesburg (Republic of South Africa) a transition "from professional ecological, economic, geographical, etc. types of education to such economically and socially oriented model of tutoring which cornerstone the broad cross-disciplinary knowledge which is based on a comprehensive approach to development of society, economy and a surrounding medium has to be" was outlined. This transition is also carried out within EEBSD.

The dean of geographical faculty of the Moscow State University academician N.S. Kasimov [2, 3, page 34] formulates three main (but not exhaustive) organizational and methodical components which are likely to be essential to becoming of EEBSD in our country: economic – ensuring priority of sustainable development in management of economy (effective use of natural resources, the strategy of steady management for certain territories, resources and branches of economy); ecological – protection of wholeness of ecosystems, maintaining of stability of the biosphere, biodiversity and quality of the environment, environmental impact assessment; social – education in such areas as human rights, health and safety, conflictology, ethnology, anthropology and so forth.

In Russia broad interpretation of ecology entity is meant. It includes not only a traditional biological component, but also science about a environment and therefore, according to Kasimov, EEBSD will be formed on the basis of ecological education by "the deep tutoring", i.e. saturation of already existing objects by the ideas of sustainable development [5, 6]. In this case the subject "sustainable development" becomes certain substantial "umbrella" which covers all educational space of the objects involved in EEBSD.

The President of the Russian Federation V.V. Putin signed on January 5, 2016 the Decree No. 7 on carrying out in 2017 in the Russian Federation the Year of Ecology. In the annual Message to Federal Assembly (on December 1, 2016) he charged to the Government in 2017 "to prepare programs of saving of unique natural symbols of Russia, such as Volga (we will emphasize, Volga is on the first place. – Authors), Baikal, Lake Teletskoye in Altai". The solution of environmental problems in Russia is impossible without training of environmental professionals of the most high and modern level. It puts a problem of perfecting of ecological formation in a row of the most important strategic problems of country development. The foundation for the Western European model of ecological education was laid in the twenties last century by professor of botany from Scotland, the sociologist and town-planner Patrick Geddes (many foreign experts call him "the father of ecological education" though his predecessors can be considered Ж. - Zh. Russo, I. Pestalozzi, A. Humboldt, K.D. Ushinsky, D. Dewey and many others). Perhaps, he "was the first who noted the vital, fundamental interrelation between quality of a environment and quality of education of younger generations" [7, page 10]. He vividly was interested in ecology, resolutely opposed environmental pollution, stated a number of the interesting ideas about the purposes and problems of ecological education, offered a number of innovative

methods and technologies of tutoring of children in the nature and by means of the nature, actively defended the idea of development of the pupil as a complete person.

In the UN system the key organization for ecological education is UNESCO. In 1956 it defined the role of education as "intended to help to find a comprehension of environmental issues, the rights and duties as citizens and individuals, to receive a set of skills and knowledge for gradual improvement of biotic conditions and more efficient participation in economic and social development of society" [8, p. 71]. The question of a ratio between ecological education and education for sustainable development (which appeared on the dawn of the third millennium) has a set of treatments in the modern sources and the academic literature. We incline that tasks which education for sustainable development has to realize in many respects repeat those which were formulated by solutions of a number of the international forums and are recorded in documents by ecological education in general. Differences between ecological education and education for sustainable development are "functionally" minimal, however we should note that education for sustainable development is substantially a new (next) stage of development of ecological education. And it is considered in the modern international cooperation in the sphere of education and environmental protection as the efficient instrument of transition of the countries to sustainable development.

The analysis of science literature on problems of ecological education allowed to offer the author's ("integrated") version of the Sustainable development program.

Since 2013 at biological faculty of Saratov State University training of bachelors according to the main educational program "020400 Biology" on the Sustainable Development of Ecosystems profile began. The expediency of training of bachelors at this profile is determined by intensive development of the concept of sustainable development of mankind, including also its ecological component. Sustainable development of Russia is, first of all, ecologically sustainable development that is important for assessment of consequences of ecological factors impact on health of the person, demography and agriculture. Without ecological sustainability it is impossible to provide increasing of economic indexes for a long time. It is very important for a region to preserve biodiversity of ecosystems and form the local ecological framework. There is lack of training of bachelors on sustainable development in the system of higher education in Russia. It determines the need of training natural ecosystems specialists, preservation of ecosystems' biodiversity as a fundamental basis of sustainable development. The need for such experts is especially essential for the Saratov region and the Volga basin in general.

For implementation of the main educational program for the Sustainable Development of Ecosystems direction the biological faculty has the competent research and educational personnel, necessary laboratory and field equipment and educational literature. Besides, researches at departments of faculty (morphology and ecology of animals and botany) are conducted in various directions of studying and sustainable development of ecosystems. All this allows to conduct educational and scientific work in the field of studying sustainable development of ecosystems on high professional level.

The curriculum of a profile is constructed in such a way that, on the one hand, it allows to give to the student good common biological preparation, and, on the other hand, is professionally focused on studying of sustainable development of ecosystems and biodiversity. The professional cycle includes basic biological disciplines and disciplines focused on studying of biodiversity of ecosystems and methods of its preservation (including "Strategy and tactics of sustainable development", "Bases of studying and preservation of a biodiversity", "Anthropogenesis of the transformed ecosystems", "The modern problems of a fitotsenologiya", "Indication of sustainable development of ecosystems", "Natural complexes of regions", etc.). Much attention in the curriculum is paid to mastering the experimental methods: practical training make 2/3 classroom time on disciplines of a professional cycle. The laboratory of molecular biology, the Center of biotechnologies, "Botanical Garden of SGU" and reserved territories of the Saratov region and Hvalynsky national park can be used as bases for holding a work practice and realization course. Along with traditional forms of education at implementation of the main educational program the modern methods are widely used (problem tutoring, project management, business games, multimedia, etc.). More details see in publication [9].

The concept of transition of Russia to sustainable development, accepted on April 1, 1996, comes to an end with a key phrase (in the context of this work): "Driving of mankind to sustainable development, eventually, will lead to formation of the sphere of Mind (noosphere) predicted by V.I. Vernadsky when cultural wealth and knowledge of the Person living in harmony with environment become a criterion of national and individual wealth". And it quite corresponds to views of the academician D.S. Likhachyov [10, with. 314-315]: "Ecology is a moral problem… Without high morality and culture there cannot be the modern society, I emphasize the word modern. Because thanks to existence of the most difficult technique and the most crucial science our world became more subject to possible influence from the person".

Two main models lie in the base of education ecologization: compulsory ecological education and additional ecological education. The academician N.N. Moiseyev [10] allocated three levels of ecological education – "nature protection" (formation of emotional sensory perception of the world or receiving the technique knowledge), "scientific" (the logical analysis of theoretical ecology constructions within naturally scientific representations) and "conceptual" (ecology as a certain "subculture"); he claimed that "ecological" (better to say environmental) education and bringing up have to cover all age categories; everyone regardless of specialty, work, habitat and skin color has to obtain ecological knowledge, it's as fundamental as arithmetics. The level of ecological education of population, especially of persons who are going to hold posts of public servants has to be qualitatively increased [10, p.100]. It is possible to say that a high-moral, ecologically competent creative person is the base of sustainable development of society. In 1998 within the World Environment Day which is carried out in Moscow under the auspices of the UN Development Program (United Nations Environment Program – UNEP), the Moscow international declaration on

ecological culture was developed. Within this Declaration, the idea of ecological culture "assumes such way of life support at which society does not create threat of life on Earth through the system of cultural wealth, ethical principles, economic mechanisms, precepts of law and social institutes. It is possible on the basis of paying attention to general, the relative and only then national interests". Therefore ecological education has to be directed not to the progress ideology (the technology focused on the minimum level of acceptable environmental risk, often, step through a person) but to the Person, in his existence in a harmony and in a unification with the Nature.

"Laboratories" of ecological culture are botanical gardens (arboretums) of higher education institutions and academic institutions, libraries, the museums of the nature. For example the library of Institute of ecology of the Volga basin of RAS (created in 1983 on the basis of the Kuibyshev biological station of Institute of biology of reservoirs of Academy of Sciences of the USSR) is the largest library of ecological literature in the Volga region; nowadays the fund contains more than 75 000 units of storage, which include about 10 thousand foreign editions. The fund was created with great difficulties. A part of the books belonging in due time to All-Union geographical society (by the way in 1917 these books were requisitioned by Bolsheviks from library of Imperial [Smolny] institution for young ladies, Petrograd) was transferred to library of a biological research station by I.D. Papanin. The editions donated to the library is a separate part of fund. Books from private libraries of academicians V.N. Sukachyov and M.S. Gilyarov are unique (many of them contain dedicatory inscriptions of other famous scientists). The Special place in fund is held by home libraries of professor-hydrobiologist V.I. Zhadin, the director-organizer of the Kuibyshev biological research station N.A. Dzyuban. In 2001 at Institute of ecology of the Volga basin RAS the dissertation council in "ecology" profile was created. For years of its existence the fund of library was replenished with more than 200 abstracts and theses considered on council.

The possibility of information use in digital form does not reduce the value of the library in works of scientists, graduate students, students, school students not only from Togliatti, but also from other cities of the Volga region – Samara, Saratov, Nizhny Novgorod, Kazan, Astrakhan, Ufa, Ulyanovsk. Employees of library pay much attention to questions of education in the field of ecology and ecological culture. It caused the fact that the library contains one of the complete collections of educational literature on ecology.

Why do humanities specialists need ecology? The question is not idle. It seems, there was an economic geography, quite worthy scientific discipline studying the territorial organization of economic life of society, laws and regularities of its development (we will notice that the term "economic geography" was injected by Mikhaylo Vasilyevich Lomonosov …). But, as soon as in the country processes on updating of contents and structure of university education began (including economic), inevitably tens of new economic disciplines reflecting the modern realities appeared. They were connected, first of all, with change of type of economic development and transition to market economy which pressed

some outdated and traditional disciplines. A huge number of new books, including the best western textbooks is published and translated. Accession of Russia to Bologna Process made inevitable formation of new two-stage structure of education "the bachelor – the master". But, apparently, the innocent "economic geography" suffered in this fascinating process of rebuilding. It was decided to be changed for ecology. Ecology (eikos – the home, a logiya – science) – science about the home; economy (eikos – the home again, nomos – the rule of housekeeping) – science about maintaining this house. These are very close concepts which, of course, do not contradict but only supplement each other. At the same time we will not forget that the global economy led to critical problems in existence of the mankind, and the modern economic theory was powerless to prevent and solve them. Here it is possible to pay an attention to global environmental problems, each of which is generated substantially by uncontrollable economic influence of the Man (for example, the problem of global climate change which drew a close international attention and caused a huge number of publications). Thus, development of our civilization is unstable, and the future can bring global crises in the most various spheres – ecological, economic, social. Probably, it is the most important and first argument in favor of studying of ecology by economists.

It is necessary to agree with professor of the Moscow State University S.N. Bobyliov [12] who points to several critical problems, unresolved by traditional market economy. In particular, on the first place he puts underestimation or lack of the price of many natural resources and services. Sad rule of market economy: "What has no price does not exist and is not considered in the course of economic decisions". In this context, knowledge of some fundamental laws of the modern ecology (as a naturally scientific discipline) has to help to make economic process in the world steadier. It is the second argument for studying of ecology by economists.

The third argument pro is that ecology, economy and sociology (three sciences which will define in many respects the course of this century) have in their basis a science which is also rather new, but different from the paradigm of naturally scientific approach. It is Systemology, or science about the composite systems (see, for example, [13]). And therefore, it is possible to gain an impression about systemological bases of economy by studying ecology (also related to composite systems). A feature of the ecological education based on a systemic paradigm is focusing on formation of values and relations. For this reason it is necessary to provide opportunities for stage-by-stage formation of system of beliefs, values, relations and also experience of adoption of ecologically responsible decisions in contents and methods of ecological education among students.

The content of ecological education while training economists at the modern higher school has to provide formation of the following specific skills: perceiving the environment in its economic, ethical, esthetic and other aspects; defining objects and the phenomena in the environment; estimating the place and role of separate alive organisms in natural communities; predicting emergence of possible externalities, i.e. the outer effects of economic activity influencing subjects of this activity and counting eksternalny expenses; counting indicators of environmental

capacity of environmental management system on branch and macro-level; estimating economic efficiency of environmental management and ecological damage, interpreting the results, formulating conclusions; estimating economic efficiency of nature protection actions and ecological investment projects; interpreting and critically estimating the environment; searching for the facts speaking about current condition of the environment.

Finally, the last argument: as it was already noted above, in 2012 there was a celebration of the 20 anniversary of the UN Summit in Rio de Janeiro where representations about sustainable development of mankind were sounded. We will repeat that the Sense of these representations comes down to the fact that sustainable development is a stable social and economic development which is not destroying the natural basis; today's development should not be carried out to the detriment of future generations – we do not give resources to inheritance to children - we borrow from them. The new mechanism of achievement of sustainable development – transition to "green economy" – was discussed at the summit "Rio + 20" and, naturally, should find its reflection in courses by ecological education in economic higher educational institutions. The ecological right represents a set of the precepts of law governing the public relations in the sphere of interaction between society and the nature for the benefit of preservation and rational use of the environment for the present and future generations. G.P. Krasnoshchekov [14-16] fairly considered that the concept "ecological right" arose at the time of "stagnation" in USSR when the term "environment" caused particular irritation of party officials. It is possible to assume that the change of the point of view from sharply social environmental issues which immediately include economic activity to theoretical science suited the authorities. The name turned out beautiful, but not correct: the ecology is a science, therefore, the ecological right is a branch of right, governing the relations with science (there is no geological, hydrological right, but there are mining law, water law, the land right and so forth). If we accept that the object of ecology research is ecosystems and the biosphere, then, by analogy, it is necessary to speak about the biospheric right or about the eco-right.

The manual [16] contains eco-right history in Russia, common (the provisions serving institutes of the singular part), the singular (the institutes having purpose owing to specifics of an object [a subject of use or protection]) and special part of eco-right (ecology and space, the international ecological law, the comparative ecological right and so forth), subject and methods of regulation of the eco-right. Issues of policy, economies and ecology are closely interdependent and influence at each other. The advancement of science depends on tendencies in the legislation and vice versa. Only at complex studying of all these questions it is possible to reach positive effect, exception of mistakes, arrangement of the exact priorities. Within "The ecological doctrine of the Russian Federation" (the order of the Government of the Russian Federation of August 31, 2002 No. 1225-r) the problem of creation of an efficient legal mechanism of ensuring preservation of the environment and ecological safety and also perfecting of law-enforcement practice for ensuring adequate responsibility for ecological offenses and its inevitability is noted. For its success it is necessary to eliminate contradictions between natural

resource and nature protection standards of the legislation of Russia and also between the legislation in the field of environmental protection and norms of other branches of right.

Scientific and technical progress sets all new and more difficult tasks for the higher education and, therefore, for its leaders – the universities. It is well known that one of the common features of the modern higher education is its cross-disciplinary character as on "joint" of sciences the new progressive ideas and technologies are born. Therefore it is not surprising that universities which are multidisciplinary and combine basic researches with applied developments, have to adequately react to calls of the rapidly changing world.

In modern Russia along with the "classical" universities (national research universities and among them – Nizhny Novgorod State University of N.I. Lobachevsky and Saratov Chernyshevsky State University) these functions are performed also by "profile" universities (technical, economic, medical etc) including the Samara State Economic University. Let's emphasize that only universities are the most perspective bases for integration of high school and academic science creating fruitful conditions for cross-disciplinary interaction on the basis of close cooperation with institutes of the Russian Academy of Sciences. This is so because of structurally functional organization and the carried-out mission. Long-term creative cooperation of Institute of ecology of the Volga basin of RAS with the above-mentioned universities can be an example of that.

Thus, scientific and practical work "A cycle of works on ecological education for the benefit of sustainable development for naturallyscientific and economic specialties of higher education institutions" adequately reflects the social and economic situation in the country and provides formation of "condensation points" in the most vulnerable sphere of the state: interaction between society and the nature for the benefit of sustainable development. Ecological knowledge is that "intellectual cement" which will allow to combine efforts of society and state in training of highly qualified personnel capable to make an efficient contribution to progressive development of Russia; development of fundamental and applied science as quality bases of education and sources of new knowledge and technologies for efficient solution of social, economic and ecological problems of the modern society; development of all-university knowledge transfer culture; significant contribution to development of Russian education and participation in work of the higher school of Russia on formation of integrated system of higher education of Europe; active interaction on social and economic and cultural development of the country and Volga Federal District.

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DANGEROUS TRANSPORTATIONS (CARGO) - THE ECOLOGICAL SAFETY OF DANGEROUS GOODS TRANSPORTATION BY ROAD TRANSPORT

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ABSTRACT

The article presents a generalized model for monitoring the factors that are contributing to the occurrence of a traffic accident in road transport. The results of the interaction of the "Environment – Technics – Human" system's elements are considered as indicators of risk at the time of commission of the road traffic accident, that are defined as the frequency of realization of the undesirable events are possible to commit in a certain period of time in a certain area. In the examples the risk indicators for each of the elements of the system "Environment – Technics – Human" are meant for a single traffic accident, and for places of their concentration.

Key words: vehicle, traffic accident, individual risk, a quantitative security precaution.

The necessity in transportation of dangerous goods is determined by objective need to ensure the functioning of modern economy. More than half of the goods in the world, transported by all kinds of transport are explosive, corrosive, flammable, toxic or radioactive [Federal law dated by 23.07.2008 N 160-FL"About transport safety"]. The fact is that the transportation of dangerous goods is a very relevant problem because of the connection with environmental aspects. The damage caused by consequences of this type of accidents, because of the characteristics and physic-chemical properties of the dangerous goods is magnified, presenting a real danger to the life and health of people, causing

destruction of material assets and also become a nuisance of serious environmental harm to the natural environment [1, 2].

Activities in the sector of transportation of dangerous goods by road transport are regulated by "Rules of cargo transportation ... "[The RF Government resolution dated 15.04.2011 No. 272 (ed. by 22.12.2016) " transportations of cargoes by transport"], under which dangerous goods must be transported only by special vehicles along the route, agreed by the sender. The developed system is an important tool for monitoring potentially dangerous segment of the economic activities of the government, controlling the number of vehicles, participating in the traffic as well as optimizing the potential risks of adverse impacts of transported goods on the environment. Also the problems of preventing such accidents with this type of transport are not considered enough.

Accidents with the transportation of dangerous goods by road are classified as road traffic accidents and according to Accounting Rules, are to be taken into account by internal affairs authorities, vehicle owners, state administration of roads, owners of departmental and private roads [Resolution of the Government of Russian Federation from 29.06.1995 N 647 (edited on 04.09.2012) " Adoption of rules of accounting of road traffic accidents"]. However, to the state statistical reporting only road accidents where people have been killed or injured are included. For this reason, accidents involving vehicles transporting dangerous goods, which cause only logistical damage are not included to the state statistical reporting. As a consequence, the preventive impact of this type of accidents is general in nature, and not providing the proper level of security.

The solution to this problem is possible by introduction the stage "of the Analysis of the factors and risks contributing to the occurrence of accidents in the areas of accident clusters along the route" into the process of preparation and transporting of dangerous goods by road.

The place of concentration of road accidents is the section of road or street somewhere limited by the length and characterized by a sustainable and non-random commit of road accidents [6 The order of the RF Ministry dated 07.07.2003 N 525 "About improvement of legal regulation of the activities of the traffic service for and traffic management of the State inspection of safety traffic of the Ministry of internal Affairs of Russian Federation"].

Man-caused danger of places with concentration of road accidents is considered as a property that characterizes the protection of traffic participant and safety of vehicles and objects of street-road network, interacting within the boundaries of the potentially dangerous area. The condition of man-caused danger of such places is directly depends on the enforcement of established norms and rules, both in terms of optimal exploitation, and under the impact of certain negative (threat) factors on structural elements.

Qualitative analysis of risks contributing to the occurrence of the accident in the places with concentration of road accidents is to explore the factors contributing to the occurrence of each traffic accident individually, with the subsequent averaging of the obtained results.

The system "Environment – Technics – Human" (hereinafter ETH) is the object of analysis the causes of traffic incident, where environment, technical objects and the human factor are combined [GOST 27.001-81 System of standards “Reliability in technique“, 3, 4].

The system "ETH" is a polysystem because it is composed of technical means and people (operators), and as a result all processes occurring between elements of the system are needed to be managed. Meanwhile exactly the process of controlling the vehicle by the operator is a major reason of accidental events, and the fact is, that more than 80 percent of all traffic accidents are caused by the fault of drivers themselves, whereby the "human factor" is regarded as the main way of preventing accidents in road transport" [5,6].

The list of risk factors of the "ETH" system and the numerical values characterizing them are presented in the table No. 1.

Table 1 – A structure of the system "environment – technics – human"

Item category	**Name of the group of factors**	**The number of indicators**
environment	profile and plan of the road	6
	road conditions	10
	weather conditions	9
	illumination level	5
technics	the objects of street-road network (SRN)	28
	the disadvantages of objects of street-road network	29
	factors influencing the mode of traffic	27
	technical condition of vehicles	15
human	the driver	68
	the vehicle occupant	18
	pedestrian	7
	another participant of traffic	2

It should be noted that the specificity of driving the car, including the transport equipped to transit dangerous goods is the lack of indicators or mechanisms, is absences of indicators or devices fixing the actions of the operator (person) in conjunction with elements of "environment" and "technics" of the "ETH" system. In these terms the most effective way to identify and range the dominant danger is the symbiosis of two methods - "Statistical analysis of industrial injuries" and "logical-graphical tree structure" [6]. The method, based on statistical data of the sources and reasons of accidents and fixed causation between events allows us to identify combinations of failures leading to the main event (emergency) [7, 8]. A standard indicator of quantitative measurement of risk is a scale in which the units of risk are used as measure. The risk is represented as multiplication of the frequency of implementation of the unwanted event to the scale of a certain kind of outcome [9, 10].

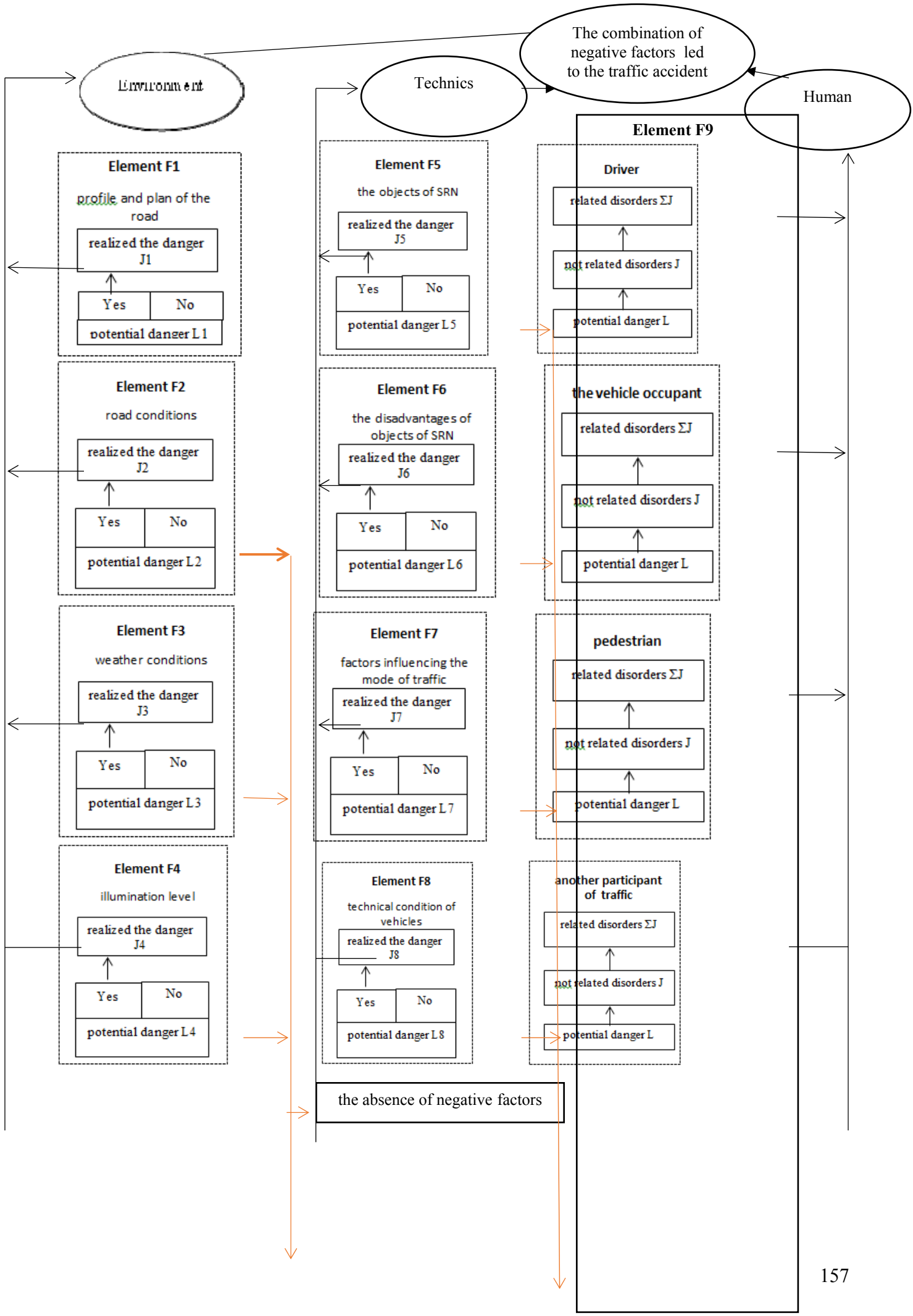
The combination of negative factors led to the traffic accident
Environment
Technics
Human
Element F1
profile and plan of the road
realized the danger J1
Yes
No
potential danger L1
Element F2
road conditions
realized the danger J2
Yes
No
potential danger L2
Element F3
weather conditions
realized the danger J3
Yes
No
potential danger L3
Element F4
illumination level
realized the danger J4
Yes
No
potential danger L4
Element F5
the objects of SRN
realized the danger J5
Yes
No
potential danger L5
Element F6
the disadvantages of objects of SRN
realized the danger J6
Yes
No
potential danger L6
Element F7
factors influencing the mode of traffic
realized the danger J7
Yes
No
potential danger L7
Element F8
technical condition of vehicles
realized the danger J8
Yes
No
potential danger L8
Element F9
Driver
related disorders ΣJ
not related disorders J
potential danger L
the vehicle occupant
related disorders ΣJ
not related disorders J
potential danger L
pedestrian
related disorders ΣJ
not related disorders J
potential danger L
another participant of traffic
related disorders ΣJ
not related disorders J
potential danger L
the absence of negative factors

Figure 1 - Qualitative characteristics of the risks contributing to the occurrence of the incident

The value of individual risk is determined by the following formula:

$$R_n = \frac{n}{N}, \quad (1)$$

where n is the number of occurrences of the species;

N is the total number of accidents over a certain period of time.

The consistent analysis of factors with the aim of establishing the degree of their influence on the accident with the subsequent ranking is the essence of high quality analysis of risks. Fig. 1 shows generalized constrictive model showing the possible connection of negative factors of all elements in the "ETH" system contributing to the occurrence of a single incident.

The study of the properties of places with concentration of road accident is carried out on the basis of available statistical data through the introduction of statistical indexes I_n and J_n for each factor of the "ETH" system.

Statistical indicator I_n is a potential risk factor F_n or the frequency of incidents committed as a result of the negative impact of indicators of the investigated factor to the total number of accidents. For example, the risk of an accident in conditions of limited visibility, ice slick, on a non-regulated crossroad or if there is a fault in the brake system.

The statistical indicator is calculating I_n the following way:

TA (Traffic accident)

$$I_n = \frac{TA_n}{TA_{tn\,total}}, \quad (2)$$

where I_n – the statistical index of influence of the negative factor n's groups;

$TA_{tn\,total}$ – the total number of road accidents recorded in the accounting area during the reporting period;

TA_n – the number of road accidents recorded in the accounting area during the reporting period, which recorded the factors included in group n.

Statistical indicator J_n is the implemented risk factor F_n or the frequency of traffic accidents on selected types of traffic regulations that are in causal connection with the mechanism of the accident and committed as a result of the negative impact of indicators of the investigated factor to the total number of accidents. For example, the risk of meeting an accident as a result of breaking the rules of overtaking, crossing the carriageway in the wrong place, exit the vehicle on the move or working in the roadway without reflective vest.

The statistical indicator J_n is calculated the following way:

$$J_n = \frac{TAN_n}{TA_{tn\,total}}, \quad (3)$$

where J_n – a statistical index of the effect of breaking the traffic rules by the group n;

$TA_{tn\,total}$ – the total number of road accidents recorded in the accounting area during the reporting period;

TAN_n – the number of road accidents recorded in accounting area during the reporting period, where negative factors of group n are recorded, in conjunction with breaking the traffic rules concerned to the group of disorders of n (under the influence of negative factors of n group).

Based on presented approach, according to the accident rate in Tatarstan Republic during the period of 2015 and 2016 calculations were carried out of the statistical values of impact indicators *I* and *J*, the generalized values of which are presented in tables №№2,3.

Table 2 - The list of indexes *I*

Belongs to the category of the item	The name of the index	The average value of index
F_1 «Environment»	I_1 profile and plan of the road	0,129
F_2 «Environment»	I_2 road conditions	0,377
F_3 «Environment»	I_3 weather conditions	0,460
F_4 «Environment»	I_4 illumination level	0,224
F_5 «Technics»	I_5 the objects of street-road network (SRN)	0,494
F_6 «Technics»	I_6 the disadvantages of objects of street-road network	0,415
F_7 «Technics»	I_7 factors influencing the mode of traffic	0,102
F_8 «Technics»	I_8 technical condition of vehicles	0,009
F_9 «Human»	I_9 braking the traffic rules	0,873

Table 3 - The list of the index *J* influence

Belonging to the category	The name of the index	The average value of index
F_1 «Environment»	J_1 braking the traffic rules, influenced by the profile and plan of the road	0,555
F_2 «Environment»	J_2 braking the traffic rules, influenced by the road conditions	0,564
F_3 «Environment»	J_3 braking the traffic rules, influenced by the weather conditions	0,564
F_4 «Environment»	J_4 braking the traffic rules, influenced by the illumination level	0,586
F_5 «Technics»	J_5 braking the traffic rules, influenced by the (SRN)	0,248
F_6 «Technics»	J_6 braking the traffic rules, influenced by the	0,605

	disadvantages of objects of (SRN)	
F_7 «Technics»	J_7 braking the traffic rules, influenced by the factors influencing the mode of traffic	0,858
F_8 «Technics»	J_8 braking the traffic rules, influenced by the technical condition of vehicles	0,005
F_9 «Human»	J_9 concomitant braking the traffic rules	0,403

Quantitative analysis of risks contributing to the occurrence of accidents, is calculated the following way:

$$P_{ta} = F_{Envtronment} + F_{Tecmics} + F_{Human}, \quad (4)$$

in this case

$$P_{Envtronment} = F_1 + F_2 + F_3 + F_4, \quad (5)$$

$$P_{Tecmics} = F_5 + F_6 + F_7 + F_8, \quad (6)$$

$$P_{Human} = F_{concomitant} + F_{direct}, \quad (7)$$

Factors from 1 to 8 are calculated:

$$P_n = I_n(J_n + 1), \quad (8)$$

And factor 9:

$$P_9 = \left(J_9 + \sum J_9\right), \quad (9)$$

In general, the calculation is carried out this way:

$$P_{ta} = I_1(J_1 + 1) + I_2(J_2 + 1) + I_3(J_3 + 1) + I_4(J_4 + 1) + I_5(J_5 + 1) + I_6(J_6 + 1) + I_7(J_7 + 1) + I_8(J_8 + 1) + \left(J_9 + \sum J_9\right), \quad (10)$$

The determination of the power of influence of the separate negative factors is carried out according to the following formula:

$$W_n = \frac{F_n}{P_{ta}} 100, \quad (11)$$

where W_n – the power of individual group of factors n;
F_n – the index of influence of the group factors n;
P_{ta} – the total index of influence.

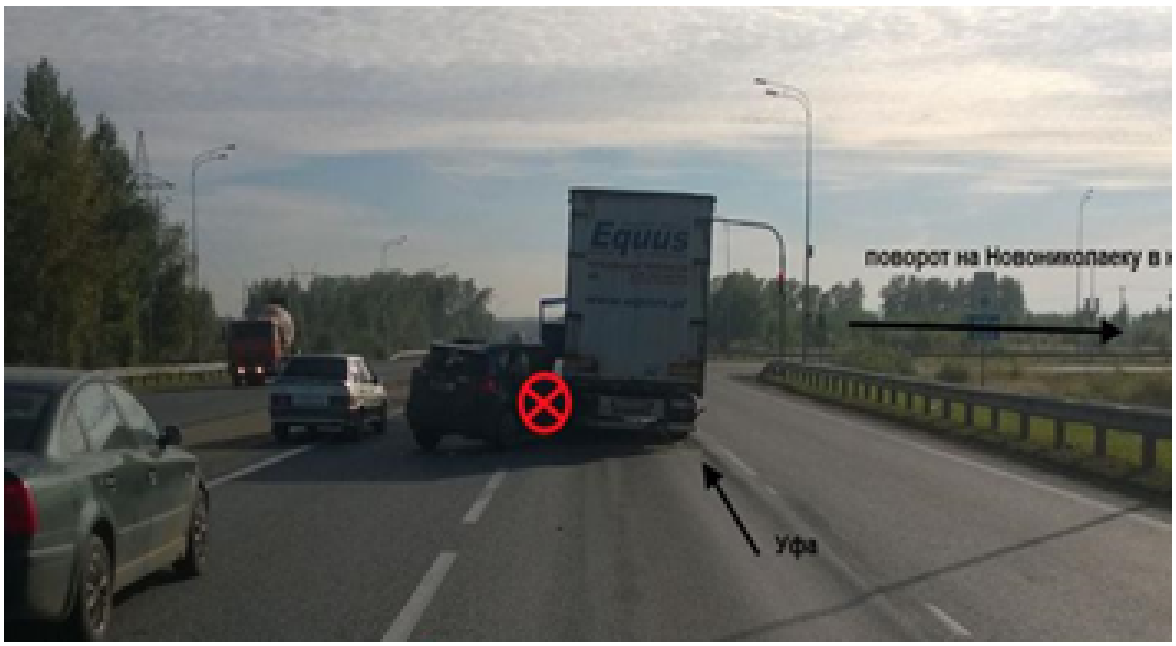

Figure 2 - Place with concentration of road accidents

The result is a qualitative value of technogenic safety of the accident area, expressed in fractional calculus, and the quantitative importance of technological security, which varies from 0 to 1.

According to the developed methodology the calculation of areas of accident clusters identified along the routes of transport of dangerous goods and intercity bus transportation was done.

As an example, fig. 2 shows 796 km of autobahn M7-VOLGA, which is characterized as a place of concentration of accidents, where in 2016 were more than 10 traffic accidents, 6 of them are taken into consideration and are to be included in official to the state reporting.

The results of the analysis carried out in accordance with the proposed method is given in table 4 and give an opportunity to identify the main factors contributing to the occurrence of accidents, and to substantiate measures for reducing the risk of their Commission.

According to the results, the greatest danger for road users is the crossroads and the intersection of Federal highway with local roads. The situation is getting worse in a period of deteriorating of road conditions, and the main type of incident – is hitting parked vehicle or pedestrian. Obviously, speed reduction in traffic is unexpected for road users, and solution to this problem is possible by implementation of a number of technical measures aimed to attract the driver's attention to reduce speed, such as installing additional signs that inform of approaching a regulated intersection, the arrangement of the noise bands, etc.

Proposed tools for assessment of the influence of risk factors in the places of concentration of road accidents based on the analysis of statistical data allow to estimate the influence of factors ETH and, consequently, to form recommendations adapted to the route for drivers of transport carrying dangerous goods.

Table 4 - The results of calculation of the factors influence

The indicator		9 of March	7 of April	7 of June	4 of September	11 of November	11 of December	specific weight
Environment								
F1	profile and plan of the road	0	0.085	0.085	0	0	0	7%
F2	road conditions	0	0.235	0.235	0	0	0	19%
F3	weather conditions	0	0	0	0	0	0	0%
F4	illumination level	0	0	0	0	0	0	0%
the amount of the factor environment influence								26%
Technics								
F5	the objects of SRN	0.099	0.091	0.092	0.099	0.099	0.098	24%
F6	the disadvantages of objects of street-road network	0	0	0.01	0	0	0.067	4%
F7	factors influencing the mode of traffic	0	0	0.01	0	0	0	0%
F8	technical condition of vehicles	0	0	0	0	0	0	0%
the amount of the factor Technics influence								28%
Human								
F9	concomitant braking the traffic rules	0.107	0.178	0.177	0.244	0.210	0.210	46%
the amount of the factor Human influence								46%

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EUROPEAN PROJECTS ON ENVIRONMENTAL NOISE AND LOW EMISSION ZONES – THE EXPERIENCE OF LIFE MONZA

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ABSTRACT

Currently, noise is a major environmental health problem in Europe and road traffic is the most dominant source of environmental noise with an estimated 125 million people affected by noise levels greater than 55 dB Lden. A special regard to urban planning that consider Low Emission Zones and Low Emission Corridors emerged in the demonstrative actions of running projects. The idea of building a network among these projects and other International projects regarding Environmental noise has been drafted.
Environmental Noise Directive, "END" is the EU legislative instrument for the assessment and management of environmental noise. LIFE program, being the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU, since 1992 has co-financed more than 4300 projects. In this paper a non-exhaustive list of LIFE projects dealing with Environmental Noise is shown.
Low Emission Zones (LEZ) have been implemented in more than 100 cities in Europe and they are the most common measures adopted in EU, considering traffic planning. The introduction of Low Emission Zones as urban areas subject to road traffic restrictions is shown in order to ensure compliance with noise and air pollutants limit values, set by the administrative government of the cities, aiming to define criteria for analysis and management methods of Noise Low Emission Zone.
The experiences of eight Life projects are shortly summarized and a description of the Noise Low Emission Zones concept, implemented in Life MONZA project is given.

Key words: noise, environment, projects, programs, low emission zones

1. INTRODUCTION

From 1992 the European Union has been supporting nature, environment and climate action via the LIFE funding instrument. To celebrate this anniversary a series of events around Europe has been organized during 2017, also jointly with the celebration of 25th anniversary of the EU Habitats Directive and of Natura 2000 network of protected areas.

On the occasion of the 25th anniversary of the LIFE Program, a meeting has been organized in Florence among those who are committed or interested in LIFE projects dealing with the various aspects of environmental noise pollution issues, to find and discuss the achievements, current experiences and future developments. Each project has been presented, showing targets, effects on environment and population, benefits achieved and future development.

A special regard to urban planning that consider Low Emission Zones and Low Emission Corridors emerged in the demonstrative actions of running projects.

The idea of building a network among these projects and other International projects regarding Environmental noise has been drafted.

In this paper, the experiences of eight Life projects are shortly summarized and a description of the Noise Low Emission Zones concept, implemented in Life MONZA project is given.

2. ENVIRONMENTAL NOISE, END DIRECTIVE AND PROJECTS

Environmental noise is defined as "unwanted or harmful outdoor sound created by human activities, including noise emitted by transport, road traffic, rail traffic, air traffic and from sites of industrial activity".

The Directive 2002/49/EC (the so called Environmental Noise Directive, "END") is the EU legislative instrument for the assessment and management of environmental noise and provides the definition reported above.

The Directive was adopted on 25 June 2002, and came into force on 18 July 2002 with two main objectives, defined in its Article 1:

- to achieve a common European approach to avoid, prevent or reduce the effects of exposure to environmental noise harmful for health, which includes annoyance;
- to provide a basis for developing Community measures to reduce noise emitted by major sources, in particular road and rail vehicles and infrastructure, aircraft, outdoor and industrial equipment and mobile machinery.

The END is being implemented over 5-yearly cycles (rounds). Round 1 took place from 2007-2012 and Round 2 is taking place between 2012-2017.

As established by Article 11, a review of the Directive's implementation is required once every five years. A technical study to inform the first implementation review of the END was undertaken in 2010 and the European Commission published a Report outlining the findings from the first implementation review in 2013. The second implementation review assessed

progress over the most recent five-year implementation period, has been recently produced and presented.

The main aim of Art.1 of the END, remains highly relevant: collecting comparable data/ information based on a common, EU-wide approach to assessing the extent of population exposure at specific dB(A) thresholds is a pre-requisite to achieving the END's second objective, informing the development of noise measures through EU source legislation.

Table 1 – LIFE Projects regarding Environmental Noise (Source: http://ec.europa.eu/environment/life)

LIFE - SOUNDLESS (España) New generation of eco-friendly asphalts with recycled materials and high durability and acoustic performance LIFE 14 ENV/ES/000708
LIFE Solar Highways (Nederland) Solar panels as integrated constructive elements in highway noise barriers LIFE 13 ENV/NL/000971
ISRNM (Latvia Latvija) Inovative Solutions for Railway Noise Management LIFE 11 ENV/LV/000376
NOISUN (Sverige) NOIse barriers with SUN energy production for district heating system (NOISUN) LIFE 11 ENV/SE/000837
BIAS (Sverige) Baltic Sea Information on the Acoustic Soundscape LIFE 11 ENV/SE/000841
HARMONICA (France) HARMOnised Noise Information for Citizens and Authorities LIFE 10 ENV/FR/000211
NOISEFREETEX (España) Demonstrative solutions to reduce noise pollution in industrial areas, using finishing technologies in textile materials LIFE 09 ENV/ES/000461
QSIDE (Nederland) The positive effects of quiet facades and quiet urban areas on traffic noise annoyance and sleep disturbance LIFE 09 ENV/NL/000423
P.A.A.S.A. CUENCA (España) Cuenca Municipal Action Plan for Sustainable Environmental Acoustics LIFE 08 ENV/E/000110
SPAS (Österreich) Sound and Particle Absorbing System LIFE 06 ENV/A/000345
NoMEPorts (Nederland) Noise Management in European Ports LIFE 05 ENV/NL/000018

In the frame of END implementation, some projects have been funded by EU under its different funding lines. In particular, the Life program has given an important contribution, co-financing innovative and demonstrative projects located across the European Union that explore ways to facilitate the implementation and enforcement of EU policy and legislation on air quality management and the prevention and reduction of air and noise pollution.

3. LIFE PROJECTS ON ENVIRONMENTAL NOISE

LIFE program, being the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU, since 1992 has co-financed more than 4300 projects. For the 2014-2020 funding period, LIFE will contribute approximately € 3.4 billion to the protection of the environment and climate. In table 1 a non-exhaustive list of LIFE projects dealing with Environmental Noise is shown.

For celebrating the 25th anniversary of Life program, on 11 July 2017, a LIFE workshop with eight projects representatives has been hosted by the University of Florence.

The eight projects have been chaired by Italian co-ordinators as first beneficiaries of the co-financing given by the European Commission through the LIFE program. Projects have addressed environmental issues related to noise pollution since 2008.

The projects' logos are represented in Figure 1 and short descriptions are given in the following of this chapter. A specific chapter is then devoted to LIFE MONZA (LIFE15 ENV / IT / 000586) that deals with methods for Noise Low Emission Zone introduction and management.

More detailed information on projects can be found in projects' websites.

H.U.S.H. - LIFE08 ENV / IT / 000386 - The project had the general objective of contributing to the harmonization of national noise management standards with European ones contained in European Directive 49/2002, relating to the determination and management of environmental noise, starting from the realization of studies and interventions in the city of Florence, considered as a pilot case. Common methods for designing specific and strategic solutions have been identified, a new system (procedures and databases) has been identified for action planning through pilot case testing and a collection of Guidelines for Integrated Noise Reduction Planning have been produced. http://www.hush-project.eu/it/index.html.

NADIA - LIFE 09 ENV/ EN / 000102 - The project involved the provinces of Genoa and Savona, the municipalities of Vicenza and Prato and the CIRIAF (Interuniversity Research Centre on Pollution from Agents Physics) of Perugia. Noise was verified at the main provincial roads, in the provinces of Genoa and Savona, and in the city centre of Vicenza. Critical areas have been identified, with particular attention being paid to "sensitive" sites (schools, nursing and rest homes, etc.) and an innovative Action Plan was set up that includes the participation of the population and the main stakeholders.

In pilot areas, requalification projects (barrier installation, sound absorbing asphalt, high performance insulating sound windows in school buildings) and information moments, such as technical seminars and lessons at schools, have been carried out.

Figure 1 – Logos of connected LIFE Projects on Environmental Noise

QUADMAP - LIFE 10 ENV / EN / 000407 - The main objective of the project has been to develop a harmonized methodology for selection, evaluation (taking into account both quantitative and qualitative parameters) and management of quiet areas (with interventions such as noise mitigation and better utilization of areas increasing user satisfaction), overcoming the current impasse. The project focuses on the issue of quiet in urban areas, where noise is one of the major sources of pollution among the main sources of discomfort. The project's final results will help urbanists in applying standard procedures for identifying, analysing and prioritizing intervention within QUAs (Quiet Urban Areas).

GIOCONDA - LIFE13 ENV / EN / 000225 – The project aims to involve young people as protagonists of a participatory democracy action based on the following reasons: young people are the most vulnerable to environmental pressures; many scientific research and prevention tools affect young people but do not involve them; young people today will play a role in the near future as decision-makers to improve the state of the environment and health; their perception of environmental hazards makes us better understand the ideas, attitudes, fears and hopes of society all over. The GIOCONDA final product is an

instrument that can help administrations make informed decisions about health and the environment, taking into account the opinions of young people and their families and local environmental data. The areas where the GIOCONDA project has been carried out are: Ravenna, Valdarno Inferiore, Naples and Taranto. The major environmental problems that have been taken into account are the atmospheric and acoustic pollution, which in the urban environment also affect the health of citizens.

DYNAMAP - LIFE13 ENV / IT / 001254 – The project aims to develop a dynamic mapping system to detect and represent in real time the acoustic impact generated by road infrastructures. The main objective of this project is to facilitate and reduce the cost of periodic updating of acoustic maps, which the European Directive 2002/49 / EC on ambient noise requires to be developed every 5 years. The project involves the development and installation of an automatic monitoring system (based on low cost custom sensors and a GIS platform software) on two pilot areas located in Rome (Italy) along the A90 motorway (Ring road) and within the urban agglomeration of Milan (Italy). Systems will then be subjected to extensive one-year monitoring to verify their reliability, effectiveness, and efficiency.

NEREIDE - LIFE15 ENV / EN / 000268 - The project aims to test the use of new low noise porous road pavements made up of recycled asphalt and recycled rubber dust from exhausted pneumatic tires. These materials will be hot-blended with binders to produce bituminous mixtures with specific advantages like: reduce the disposal of waste materials, which will be recycled, and reduce the use of virgin materials (by promoting resource efficiency and proper waste management); obtain better acoustic performance than currently available, allowing significant noise reduction in urban areas and improving health; improve safety in urban areas by obtaining drainage surfaces and good surface textures; reduce air pollution during asphalt laying.

BRENNER LEC-LIFE15 ENV / IT / 000281 – The project aims to make the vehicular traffic on the Brenner axis more respectful of the health of the resident population and more compatible with the characteristics of the territory, in order to protect the particular Alpine environment crossed. The BrennerLEC project is located in the context of a sensitive area such as the Alps and aims to create a "LEC" (Lower Emission Corridor) along the Brenner Highway axis in order to obtain a clear Environmental benefit in the fields of air protection and climate protection, as well as noise reduction.

The reduction of polluting emissions is pursued through the following strategies: traffic flow management during intense traffic situations with a combination of dynamic speed reduction and activation of the dynamic lane; dynamic management of the maximum permitted speed as a function of air quality; management of traffic flows near the major inhabited centres with the help of "intelligent" signage.

4. NOISE PROTECTION IN LOW EMISSION ZONES - THE LIFE MONZA EXPERIENCE

Currently, noise is a major environmental health problem in Europe and road traffic is the most dominant source of environmental noise with an estimated 125 million people1 affected by noise levels greater than 55 dB Lden.

Low Emission Zones (LEZ) have been implemented in more than 100 cities in Europe and they are the most common measures adopted in EU, considering traffic planning. EU Directive 2008/50/EC on ambient air quality and cleaner air for Europe considers the establishment of LEZ a measure to be adopted in air quality action plans. The introduction of Low Emission Zones, urban areas subject to road traffic restrictions in order to ensure compliance with the air pollutants limit values, set by the a common and well-established action in the administrative government of the cities. The impacts on air quality improvement are widely analyzed, whereas the effects and benefits concerning the noise have not been addressed in a comprehensive manner.

At the same time, there is a lack of a comprehensive and integrated administration process about LEZs. The definition, the criteria for analysis and the management methods of a Noise Low Emission Zone are not clearly expressed and shared yet.

The project LIFE MONZA (acronym of Methodologies fOr Noise low emission Zones introduction And management - LIFE15 ENV/ IT/000586) addresses these issues.

The first objective of the project is to introduce an easy-replicable method, and related guidelines, for the identification and the management of the Noise Low Emission Zone, intended as urban areas subjected to traffic restrictions, whose impacts and benefits regarding noise issues will be analyzed and tested in the pilot area of the city of Monza, located in North Italy.

The second objective regards specific top-down measures, adopted by the municipality and able to turn up the area in a permanent Noise LEZ, concerning traffic management, road paving substitution and introduction of two pedestrian crossings.

The third objective is to reduce the average noise levels in the pilot area of Libertà district, with positive complementary effects also on the air quality and benefits on wellbeing conditions of inhabitants.

The fourth objective is to involve people in an active management system of a more sustainable lifestyle choices (bottom-up measures), related to the reduction of noise and the improvement of air quality and wellbeing conditions, in their living and working environment. In order to encourage the local community involvement and to strengthen the dialogue between citizens and public bodies, many activities will be carried out, as meetings in primary and high schools, in order to raise awareness about noise effects, and also ideas contests for Noise LEZ picture and logo and questionnaires on quality of life and noise perception. A mobile app to manage voluntary and sustainable actions and to measure benefits and concrete changes in people lifestyle will be developed.

In order to contribute to the implementation of the European directives, avoiding duplications and overlaps, detection of the synergies existing between the issues related to noise pollution and air quality will be tested during the project.

The four objectives have been translated in five main project actions, described in figure 2.

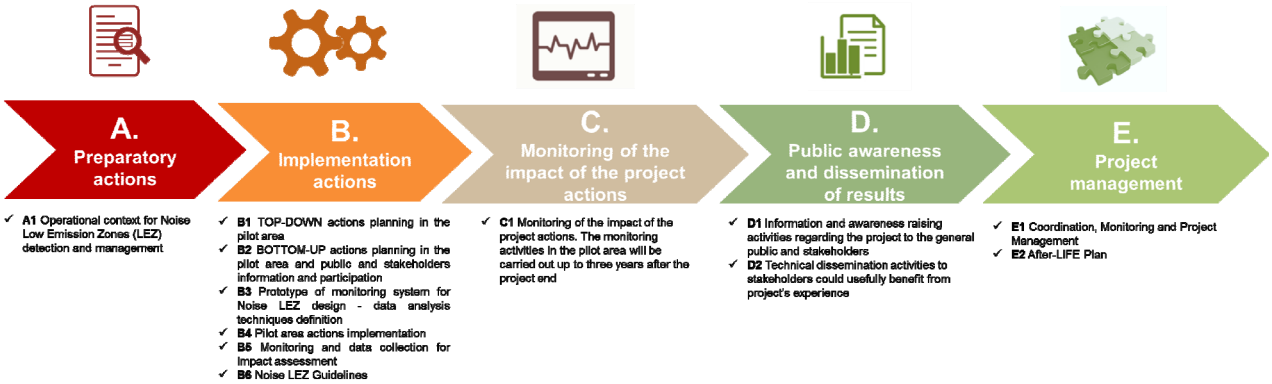

Figure 2 – The actions' scheme of LIFE MONZA project

Focusing on the Air Quality monitoring within the pilot area, according to requirements provided by Directive 2008/50/EC, low cost and easy diffusive sampling techniques are used for a large scale air pollution surveys with a high spatial resolution. In order to compare the spatial variability of air pollution before and after the noise LEZ implementation, NO2 and benzene land use regression models in a defined urban area of Monza, including the noise LEZ, are developed. The objectives of monitoring will be to assess whether the implementation of the noise low emission zone contributes, as an ancillary and serendipic effect, to reduce air pollution levels in the pilot area.

Quality of life is monitored as well, via a two-step survey performed before and after the institution of the noise LEZ zone (about 2000 citizens and stakeholders are involved). The WHO QOL-Bref questionnaire, is used as it is the only tool that has a specific environmental section, validated in Italian language. It comprises 26 items, which measure the following broad domains: physical health, psychological health, social relationships, and environment.

Finally, regarding the noise monitoring phases planned in pilot area, the activities are carried out referring to the standard methods, using sound level meters of class I precision, and also by developing and using a smart low-cost monitoring system. A prototype system for smart monitoring has been designed and implemented, in order to be used as a continuous monitoring unit. In particular, the state of art about smart noise monitoring systems has been defined by the Italian National Environmental Agency (ISPRA), and a smart monitoring system design and data analysis procedures have been implemented by the Department of Industrial Engineering of the University of Florence (DIEF), both partners of LIFE MONZA project.

Smart low-cost noise monitoring systems, allowing an extensive and long-term noise monitoring, in medium sized territorial scale as urban area, seem to be able to ensure an appreciated quality output measurement data. 10 monitoring stations are expected to be installed in the pilot area of Libertà district.

After the end of LIFE MONZA project, the prototype will be given for free to Municipality of Monza that will take care of using it for monitoring activities in the three years after the project end.

The methodology will contribute to the implementation of the EU Directive 2002/49/EC, related to the assessment and management of environmental noise (Environmental Noise Directive - END), which introduces noise action plans, designed to manage noise issues and effect, including noise reduction if necessary. In figure 2 the area interested by Noise LEZ in the city of Monza is represented.

Figure 3 – The pilot area of LIFE MONZA project

5. CONCLUSIONS

Cities worldwide are growing and they must look for creative and innovative solutions to reduce noise in the frame of urban planning and solution design projects. In EU the Environmental Noise Directive has established a set of tasks to be performed in member states relative to Noise Mapping and Action Planning.

EU have supported the implementation of original solution and demonstrative experiences via some funding lines. Life program has been one of the most important funding instruments for applying END disposals in pilot areas of different European cities. A connection among projects regarding urban noise and noise produced by transport infrastructures has been recently established, aiming to share the developed methodologies and to create a network of data and case studies. A specific interest has emerged towards the consideration of noise as element of Low Emission Zones in cities, despite the END does not provide a

definition of LEZ in relation to noise and LEZ are not considered as action to take into account in noise action plan drafting. In fact, in Annex V of the Directive, among the minimum requirements for action plans, some examples of actions that competent authorities should taken into account are suggested: traffic planning and land-use planning and other issues certainly linked with in Noise LEZ introduction and management. The project LIFE MONZA results, defining criteria for Noise LEZ introduction and management, and related guideline, will contribute to introduce new types of actions to carry on for noise action plans set out in Annex V of the Directive.

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SIXTH INTERNATIONAL ENVIRONMENTAL CONGRESS ELPIT-2017

20-24 September 2017, Samara-Togliatti, Russia

COMFORTABLE LANDSCAPES AND SOUNDSCAPES IN URBAN SPACES

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ABSTRACT

A strong impact on the landscape is caused by the increasing number of cities and infrastructures (roads, railways, airports and all the physical networks necessary for the transport). The landscape is the particular physiognomy of a territory determined by its physical, biological, anthropic and ethnic characteristics.
A landscape has its own acoustic identity. However, we are part of the environment (landscape+soundscape) because whenever and wherever we are completely immersed in a space during our living experience. Holistic approach for planning and designing landscape is described.
Integrated landscape designing, with the holistic approach, is a way of managing a landscape and a soundscape that brings together multiple factors, who collaborate to integrate different layers, with the purpose of achieving more sustainable and pleasant landscapes.

Key words: landscape, soundscape, holistic approach, planning, designing

1. INTRODUCTION

It is widely agreed that the Earth is currently in the Anthropocene age, a period of Earth's history during which humans have a decisive influence on the state, dynamics and future of the Earth system.

The number of the world's population, the phenomenon of the urbanization and the effects of the science and technologies are dominant factors in the planet evolution. Every activity produced by human beings has a direct or indirect reaction on the environment. A strong impact on the landscape is caused by the increasing number of cities and infrastructures (roads, railways, airports and all the physical networks necessary for the transport). This event is changing our *phono-*

sphere, that is going to be characterized more by anthropophonies than biophonies and geophonies. The disruption of the acoustic environments has, as a result, a noise pollution and it creates a situation of general discomfort for users'. Designers are responsible in managing and creating landscapes and soundscape and they should take responsibility for their own part in this issue.

2. LANDSCAPE ANT ITS DEFINITIONS

According to the definition given by the European Landscape Convention (Florence, 2000), the landscape is a certain part of territory, as perceived by the populations, whose character derives from the action of natural and / or human factors and their interrelations. Considering the codes of cultural heritage, landscape is meant as a homogeneous part of a territory whose characters derive from nature and human history and from reciprocal interrelations.

In other words the landscape is the particular physiognomy of a territory determined by its physical, biological, anthropic and ethnic characteristics. Landscape is strongly connected to the observer and the way he/she perceives and lives it. As perceived sensation of every living being, and in particular human being, landscape becomes a commonly known landscape when shared cultural models are used. Finally it is important to underline that landscape is an autopoietic system: it redefines itself and its component; it is self-supported, it modify and reproduces itself as a dynamic entity.

3. IMMERSIVE LANDSCAPES AND SOUNDSCAPES

If a landscape is represented by all the natural or/and man-made features of a space and how they integrate and complement each other, a soundscape is a sound or combination of sounds that forms or arises from an landscape. The idea of soundscape refers to both the natural acoustic environment (*biophony*, consisting of natural and animal sounds; *geophony* as the sound of natural elements); and environmental sounds created by humans (*anthropophony*: musical composition, sound design, language, work, and sounds of mechanical origin resulting from use of industrial technology).

A landscape has its own acoustic identity, characterized by:

- *keynote sounds*: they are created by nature (geography and climate: wind, water, forests, plains, birds, insects, animals). The keynote sounds may not always be heard consciously, but they "outline the character of the people living there" [1]. In many urban areas, traffic has become the keynote sound;
- *soundmark:* a sound which is unique to an area. "Once a Soundmark has been identified, it deserves to be protected, for soundmarks make the acoustic life of a community unique" [1].

Crucially, the term soundscape also includes the listener's perception of sounds heard as an environment: "how that environment is understood by those living within it" and therefore mediates their relations.

The disruption of these acoustic environments has, as a result, a noise pollution or a situation of general discomfort. A sense of annoyance is perceived also when sounds aren't in the "right place".

In terms of "fidelity" we may say that modern soundscapes, and urban soundscapes in particular, are poor. These low fidelity (LO-FI) soundscapes are very common in urban areas as well as in highly frequented places like commercial centres, superstores, stations, where the overall sound becomes homogeneous and indistinguishable, making it difficult for people (listeners) to "focus", recognise, and understand individual sounds. There is no deep perception of sounds in the LO-FI soundscape: In bars, shopping malls, etc, composed and individual sounds can never be distinguished and identified even if the listener has a "well experienced" ear, like it happens when he/she hears the sounds of a forest, a farm, a music (High fidelity soundscapes).

However, we are part of the environment (landscape+soundscape) because whenever and wherever we are completely immersed in a space during our living experience. Our senses and feelings are submerged by continuous stimulus causing pleasant or unpleasant sensations.

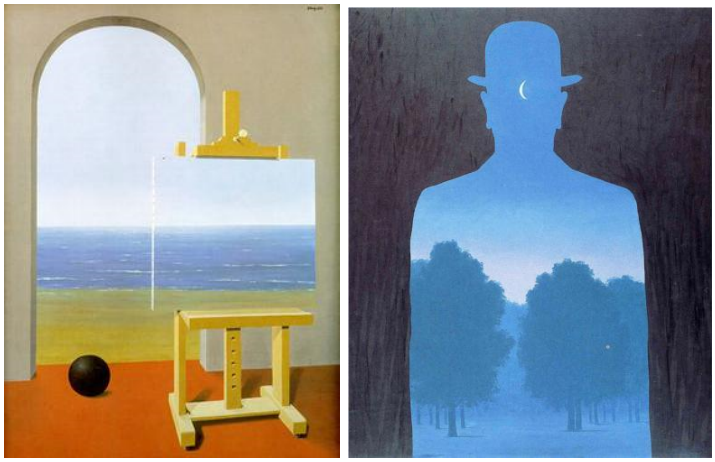

Figure 1 – Magritte, "The human condition" (on the right) and "A friend of order" (on the left)

4. THE ATHROPOCENE AGE

"Anthropocene" is a term introduced by the Nobel Prize winner Paul Crutzen and Eugene Stoermer in 2000. It is widely used to denote the present age, in which many geologically significant conditions and processes are profoundly altered by human activities. These include changes in urbanization and global warming. This word has emerged as a popular scientific term used by scientists, the scientifically engaged public and the media, to designate the period of Earth's history during which humans have a decisive influence on the state, dynamics and future of the Earth system. It is widely agreed that the Earth is currently in this state. [2, 3]

Although mankind is 200.000 years old, only in the 1950, a study reports the number of population, the urbanization and the effects of the science and technologies as dominant factors in the planet evolution. This statistical study reports that most of the earth's surface is made of infrastructures (specially transport installations) and most of the humanity lives in urban agglomerations. In Europe, in 2050, almost 84% of people are going to live in cities.

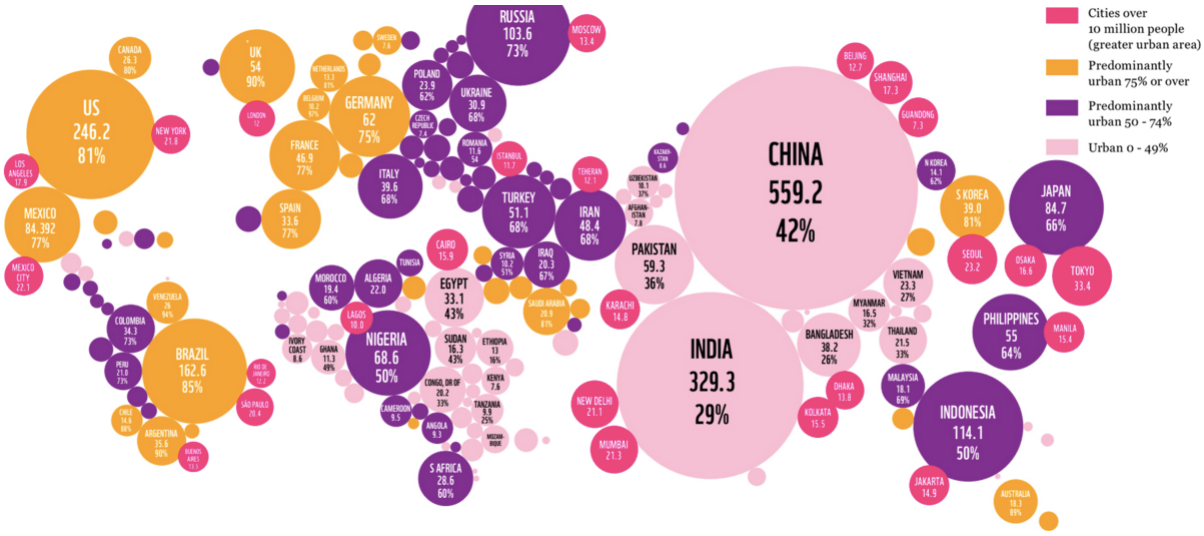

Figure 2 – People living in cities (Source: WWF Word Atlas, 2013)

For this reason, the future landscapes must considerer as predominant elements like buildings, infrastructures, machineries.

Transport infrastructures (roads, railways, airports and all the physical networks necessary for the transport), cause sounds and noises that affect directly and indirectly soundscapes (anthropophony). Nowadays, the *phono-sphere* (acoustic component of the world), is characterized more by anthropophonies than by biophonies and geophonies and it has a clear effects on the actual landscapes. The transfer time from a city to another, among agglomerations, from each point of the Earth's surface to an agglomeration, is progressively reducing. Today, less than 10% of the Earth's surface is far more than one single travelling day from a city. The idea of landscape is transforming itself from a concept of contemplation to an idea of living space (a space to be lived). People are immersed in the landscape, through their multi-sensorial perception, so the acoustic aspect is one of the most important issue into enjoying the landscape.

5. PLANNING AND DESIGNING LANDSCAPES: THE HOLISTIC APPROACH

Holism and holistic approach are a concept and a method usually referred to a health and healthcare philosophy where the human body is considered and treated as a whole entity. It is an approach to patient care in which the physical, mental and social factors are taken into account in evaluation and diagnosis of the patient's condition, rather than considering just the diagnosed disease.

As in medicine, the holistic approach in designing an urban space or a building means thinking landscapes and built environment as layers of the same design: physical and emotional. The concept that landscapes are multi-dimensionally, connected with the idea of temporal design [4].

Designers responsible in managing and creating landscapes and soundscapes should use all of their "multiple intelligence" and skills, considering some variables that derive by the theory of global comfort, considering circular economy in the choice of materials that should be sustainable as far as possible in terms of recyclable and recycled materials.

The holistic designer is somebody acknowledged of the complexity of the urban spaces, that can create landscapes, taking responsibility for his/her own part in this process.

In this paragraph some examples of holistic approach in acoustic design are reported.

Some projects show how the attempt to connect landscape and soundscape is really searched by designers. Two examples of these experiences are:

- in Zadar (Croatia), an experimental musical instrument plays music by way of sea waves and tubes located underneath a set of large marble steps;
- in Dresden (Germany), an intricate system of drains and funnels is attached on the outside of a colourful house and when it rains the entire building becomes an instrument.

Figure 3 – Sea organ in Croatia, Zadar (on the right) Musical rain building in German, Dresden (on the left)

In the urban space is a real need to create some protected areas with a pleasant soundscape. These kinds of areas are defined as quiet areas. In the following, some urban areas in Italy, in which landscape and soundscape are considered simultaneously in designing phase, are shown.

In schoolyards, acoustic barriers can be built as interactive elements for pupils: as a bench, as a blackboard or as a vertical garden. Transforming the barrier areas in playgrounds and didactic areas.

Figure 4 – Barriers at “Don Minzoni” School, at “Dionisi” School, at “Vamba-Montessori” School in Florence

In a landscape sometimes can be useful to correct the soundscape by introducing new sounds, as in the sonic gardens, where sculptures diffuse composed soundscapes as a mix of natural sound and artificial sounds typical of the area with the aim of masking the traffic noise in active control mode.

Urban Planning and Design for Global Comfort should consider protected trails in noisy areas and innovative strategic solutions like “tranquillity trails”, green zones, and Noise Low Emission Zones.

Urban sonic gardens can be implemented creating a responsive and immersive integration of nature and technology for noise mitigation and wellbeing, introducing diffusion of music and composed soundscapes, made of music and natural sound as well.

In figure 5 some examples of protected trails are reported. In figure 6 some examples a sonic garden and the covers of some background music used for noise masking and pleasant soundscape creation are shown.

Figure 5 – Examples of Protected trails in cities

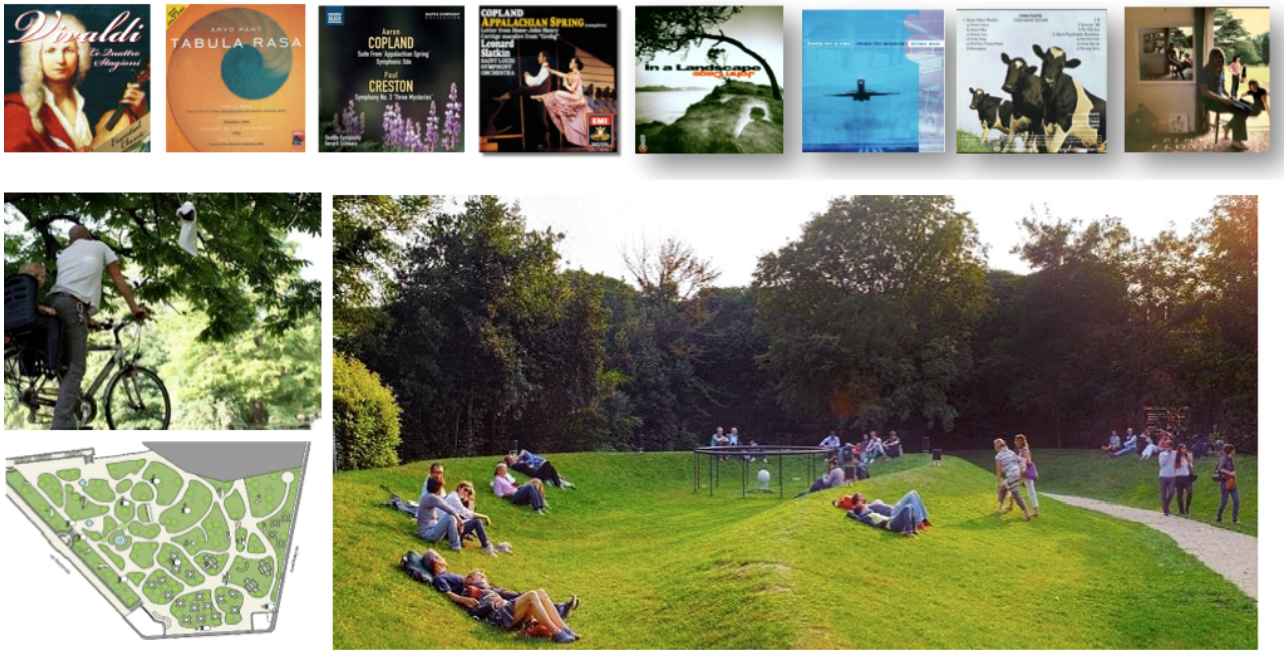

Figure 6 – Sonic gardens and music for soundscapes

6. CONCLUSIONS

Integrated landscape designing, with the holistic approach, is a way of managing a landscape and a soundscape that brings together multiple factors, who collaborate to integrate different layers, with the purpose of achieving more sustainable and pleasant landscapes.

The global comfort holistic approach is based on the idea of planning and designing urban areas and buildings safeguarding people's safety, health, and serenity, respecting the laws of nature and harmonious development. Comfortable and pleasant landscapes and soundscapes derive by the integrated approach, where acoustics plays an important role as one of the founding elements of the man-habitat-environment system. The "holistic" planners and designers should always work in teams, where their competences are integrated with those of experts in environmental, building and room acoustics, since urban landscapes (and soundscapes) are perceived as world around us and not in front of us.

Smart and serendipic solutions should be considered as a part of the global comfort scheme: smart urban planning shows various connections with smart noise action plans. Serendipic_attention can lead to added values in terms of acoustic benefits, not increasing costs, and vice versa. It allows to achieve the primary objective of the design with one or more free secondary pleasant added benefit, Finally, participatory planning and design schemes should be implemented by Action Planners and Solutions Designers collecting Stakeholders and users opinions on strategic issues, useful for planning and designing phase.

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SIXTH INTERNATIONAL ENVIRONMENTAL CONGRESS ELPIT-2017

20-24 September 2017, Samara-Togliatti, Russia

AN URBAN PLANNING METHODOLOGY BASED ON BALANCING CO_2 (EMISSION AND ABSORPTION)

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ABSTRACT

A set of chemical equations to determine emission and absorption of CO_2 inside the municipality boundaries id developed. Based on these equations, we have developed an accounting methodology for CO_2 emissions and absorptions that is applicable to the municipal territory. It is expected this methodology to become a tool for planners and designers as well to be used in territorial emissions trading - this tool enables planners and architects to apply the knowhow gained in the approach to land planning and architecture for development of general trading rules for territory as a whole, in favour of sustainability.
A CO_2 tool for sustainable planning and design based on the Green Gas Protocol (GHG Protocol) is proposed in this paper, using a methodology for CO_2 accounting, relating emissions of all kind (from stationary combustion, from purchased electricity, heat or steam, from transport or mobile sources and forest fires). Although science have explained all the CO_2 emission and absorption subject, through chemical equations, its application in terms of urban policies is not yet quite implemented. Our methodology, introduced in this paper is applied in *PDM* elaboration (Municipal Master Plan). This methodology requires measurement accuracy to ensure fairness in buying and selling shares of carbon. However, in high complexity environments, it is difficult to be applied. To ensure feasibility to this methodology, it is necessary to reintroduce the concept of *urban perimeter* when developing the *PDM* (Municipal Master Plan).

Keywords: low carbon, cities, buildings, planning, design, urban perimeter, forest fires.

1. INTRODUCTION

A team of researchers at Lisbon University - Architecture Faculty, developed a set of chemical equations to determine emission and absorption of CO_2 inside the municipality boundaries [1]. Based on these equations, we have developed an accounting methodology for CO_2 emissions and absorptions [2] that is applicable to the municipal territory. It is expected this methodology to become a tool for planners and designers as well to be used in territorial emissions trading - this tool enables planners and architects to apply the knowhow gained in the approach to land planning and architecture for development of general trading rules for territory as a whole, in favour of sustainability.

A CO_2 tool for sustainable planning and design based on the Green Gas Protocol (GHG Protocol) [3, 4] is proposed in this paper, using a methodology for CO_2 accounting, relating emissions of all kind (from stationary combustion, from purchased electricity, heat or steam, from transport or mobile sources and forest fires).

The Portuguese urban legislation has abandoned the concept of *urban perimeter*, in elaboration of *PDM* - (Municipal Master Plan) [5], which allowed construction along the roads in countryside, dispersing the construction through the territory. This way, the special containment of urban agglomerates is lost (see figure 1).

This concept of *urban perimeter* increases the energy efficiency, because the lack of construction outside this bounder urban perimeter reduces transportation distances, the average transport distance, decreasing CO2 emissions. Reintroducing *urban perimeter* concept, CO_2 emissions decrease, so, sustainability and environmental ecology are promoted [6].

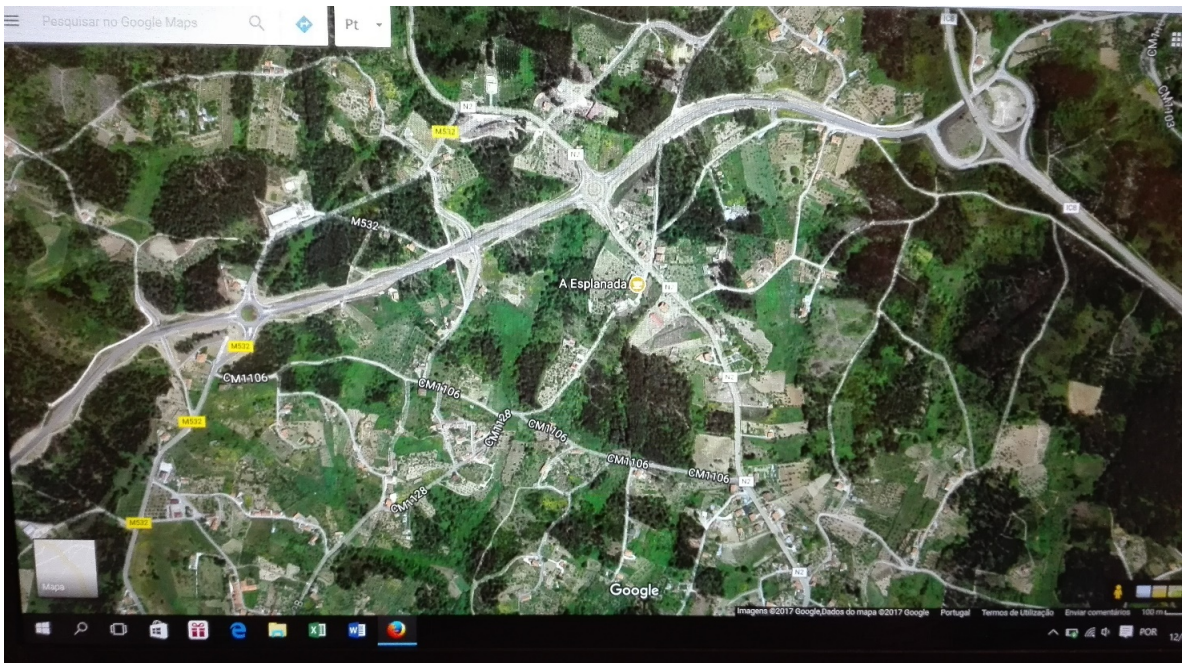

Figure 1 – Example of “dispersed construction” along the roads

The *Plano Director Municipal* PDM (Municipal Master Plan) in Portugal is the most important instrument of territory local management. One of the relevant challenges humanity faces is the raising CO_2 production and emission. It is important to develop techniques and legal instruments, allowing public and private controllers to implement policies to stop this CO_2 excess in the atmosphere.

Using the concept of *urban perimeter,* it has another advantage, regarding civil protection. Concentrating urban agglomeration turns forest fire fighters much easier to operate [7]. On contrary, dispersing houses along the roads is much more difficult to defend buildings from fire, because it demands higher number of fire fighter and equipment.

For this scale problem has an adequate solution only on political levels, with legal regulations, elaborating assertive laws, easy accepted by citizens and with easy application.

This subject, in scientific terms, is widely transdisciplinary, enclosing diverse and very distinct areas of science.

2. POLITICAL FRAMING FOR THE PROPOSED METHODOLOGY

In local and territorial level of planning policies, it is necessary to develop urban and municipal plans incorporating measures and methodologies to minimize or counterbalance the CO_2 emissions.

Nowadays, although the local decision makers can be interested and worried with CO_2 emissions issues, due to the lack of public pressure they do not make use of the instruments and the policies to solve the problem. Therefore, these legal instruments are not yet implemented.

The proposed methodology analyses the subject as follows: Applying different levels of municipal taxes, it encourages planning measures to allow the use of balance between CO_2 absorption and emissions in the municipality [8].

This means, decision makers and citizen voters are interested to implement measures inside the municipal planning policies in order to decrease the municipal taxes.

3. PROPOSED METHODOLOGY

The proposed methodology intends to establish an accounting of CO_2 emissions in municipal areas, having as an objective to verify whether the impact on people's life, with its higher capacity of the existing natural territory drains (natural CO_2 absorption) it is worthy [1,8] (see figure 2).

The absorption of CO_2 in the standard counties in Portugal is essentially water surfaces of rivers and reservoirs, and the forest surface present in the municipality. Engineering has established the chemical equations to determine the amount of CO_2 absorbed by water lines and forest [8]. This knowledge allows designing methods of CO_2 emissions on the municipal territory.

Patterns of CO_2 production in the municipality are essential due to electric energy production, CO_2 emissions from the transport sector, (public and private

transportation) due to combustion engines with fossil fuel and forest fires.

Design Methodology:

- Regroup the territory based on limits of the municipality quantifying watersheds area.
- Apply the methodology calculation of CO_2 emissions rocking (balance).
- Verify whether rocking emissions for the municipality area in study is positive or negative; (i.e., if these areas are drains or emission CO_2).
- Apply a new border to territory planning, with a new fiscal tax if result of absorption is negative.
- This fiscal organization related to $C0_2$ liquid rocking in municipality will originate a bigger rationalization of ground use, and will include penalties for the emitting areas, that will have to develop *PDM* (Municipal Master Plan) policies and instruments of territorial management forcing investment in solutions to create absorption.
- If the balance is negative, in other words CO_2 emission are greater than absorption, it is necessary to redraw the population groups borders, by adjusting the *urban perimeter*s decreasing duration and extensions of collective and individual transportation, with the goal of reduce CO_2 emissions.

The important role in this Design Methodology is the typology of urban occupation (house/building) and defines the *urban perimeter*s of agglomerates (villages and towns), with implications to mobility and transportation. This management document defines the amount and forest planning, agricultural and urban areas. In a similar way it conceives a management to the watersheds, i.e., planning construction of new dams, because water dams are a CO_2 absorption drain. In situations where it occurs positive rocking, with absorption of higher CO_2, is considered in the autarchic tax (*IMI* –real estate municipal tax), so the proprietors will pay less *IMI* tax. If the reduction in the *IMI* value is relevant it will initiate "a process of pressure from population", so the *PDM* must be adjusted and contemplate measures to correct the negative deficit in balancing of emissions and absorptions.

Figure 2 – Production and emission of CO_2

4. IMPLICATIONS OF ABSENCE OF '*URBAN PERIMETERS*' IN *PDM* (MUNICIPAL MASTER PLAN)

The lack of '*urban perimeters'* with scattered agglomerates in territory has two very important consequences:

- Increases transport duration, produces CO_2;
- Dispersion of buildings through rural territory generates serious implications to populations safety in event of forest fires.

Recently in Portugal, in 17 June of 2017, in the councils of *Pedrogão Grande* and *Castanheira de Pera* there was a huge forest fire that caused the death of 67 people [9] (see figure 3).

Figure 3 – Forest fires in *Pedrogão Grande*…

This fire alerts us to some conclusions. In face to the high dispersion of buildings across countryside, fire fighters were unable to reach all areas houses to fight the fire surrounding the houses.

Due to necessary balance in production and absorption of CO_2, and the need to prevent the construction of buildings inside the forest, it is important to consider in *PDM* the importance of the '*urban perimeter'* for each urban agglomeration [7].

Adjusting the boundaries of *urban perimeter*, the transport duration is reduced with consequent decreasing of CO_2 production, and the housing dispersion through the forest is prevented, increasing the safety of people against forest fires.

On the other hand, with no dwellings in the forest, when forest fires occur, firemen can concentrate their efforts in the fight against fire, because the number of local houses fires is reduced, so reducing the burning area and CO_2 [4].

5. CONCLUSIONS

Architects and urban planners must play a vital role in reversing the trends and negative consequences related with CO_2 emissions. Developing this platform, it is up to architects and planners to assume a role in "the process of land planning and natural resource management" [4].

In the Design Methodology developed, it is necessary to select an unit area where we apply the calculations (production and absorption). Thus, we have chosen the municipal territory as unit area. This criterion is justified by political administration now in force in Portugal – the county.

The intention of this paper is to provide a contribution to conceptualize sustainable architecture and planning in four pillars:

- The need for accounting of CO_2 emissions in a specific territory is aimed to assist the decision-making process in regional and urban development and architecture, considering the county area.

In this paper it is assumed the next step to be undertaken to see whether the balance of emissions for the county territory is positive or negative, or higher than a determined level. That is, if these areas are CO_2 sinks or emitters, and the aim is to check their future use in a scheme of emissions-trading as applied to the territory areas as a whole. This scheme of emissions-trading would lead to a greater rationalization of land use, and include penalties for emitting areas, that could then be invested to improve areas of sink.

Consider different urban perimeters scenarios studied during PDM´s elaboration in transportation distances in order to adjust a certain balance between CO_2 production and absorption.

When the balance between CO_2 production and absorption is higher than certain level, municipalities must pay a tax fee (or penalty) to the Central Government. So, these amounts will be distributed to the municipalities with lower level of CO_2 emission.

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MICROWAVE TECHNOLOGIES FOR THERMOPLASTIC POLYMERS WASTE PROCESSING TO THE LEVEL OF MONOMERS OR OLIGOMERS

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ABSTRACT

The most important task for the modern polymer industry is to find rational methods for the secondary processing of polymer products. These materials are inherent property to be preserved in natural conditions for a long time due to high resistance to environmental influences, therefore, disposal of polymer waste can be considered as an actual environmental and economic task. We consider the process of the microwave field action on the destruction of the different type polymers to monomer or oligomer stages, not for stage of secondary polymer applications as usual. The first is the interaction of polyethylene terephthalate (PET) with ethylene glycol (EG) to produce the monomer or oligomer bis-hydroxyethyl-terephthalate (BHET). The second is the polystyrene (PS) heating by using thermo-transformers, for example, similar active carbon (AC), characterized by a high specific conductivity at the microwave, in order to get styrene monomer or oligomers. Results of conducted theoretical and experimental studies are presented in order to show that the use of microwave energy for the intensification of de-polymerization of PET and PS can improve such technological indicators as the manufacturing time and saving the necessary electrical energy in both tasks. Additionally, it is shown the highest yield of monomers and oligomers of PET and PS (near 60-75%) as a result of its microwave de-polymerization assisted by using given catalyst for

reactions of glycolysis and indirect heating accordingly. The ecological advantages of microwave treatment vs mechanical and chemical processing are shown.
Keywords: polymer product, polyethylene terephthalate, polystyrene, waste utilization, secondary processing, microwave technology, de-polymerization, glycolysis, ethylene glycol, monomer, indirect heating, active coal, oligomer

1. INTRODUCTION

The most important task for the modern polymer industry is to find rational methods for the secondary processing of polymer products. These materials are inherent property to be preserved in natural conditions for a long time due to high resistance to environmental influences, therefore, disposal of polymer waste can be considered as an actual environmental and economic task.

The greatest contribution to the total mass of polymer wastes is made by polyethylene terephthalate (PET) – approximately 25% – and annually the volume of generated waste is increased by 10 million tons. PET, thanks to a wide range of properties, has found application in various areas of production, but the main use remains in the manufacture of food packages (bottles and food containers).

Currently, there exist and are developing various recycling technologies for PET. The most promising areas are mechanical and chemical processing, each of which is characterized by its advantages and disadvantages.

Mechanical recycling provides a simple secondary use of the same materials with certain losses in their properties. In this case, secondarily used polymers are sources of fumes and gases released during their aging. The basis of chemical processing is the production of the final product in the form of a monomer or oligomer, which can be used to produce new polymer raw materials. In this connection, the problem arises of developing optimal chemical methods for processing and recycling waste.

The chemical methods consist in the de-polymerization of PET wastes when interacting with various solvents at high temperature and/or pressure to produce monomers or oligomers suitable both for the manufacture of various plastics and for the re-synthesis of PET. These methods require considerable energy costs, the use of expensive chemical reagents, but there are possible to use raw materials of lower quality, because chemical processes allow for additional purification.

Substantial improvement in the quality of the ongoing reactions during chemical processing, reduction of energy costs and shortening of the heat treatment time can be ensured by using the energy of electromagnetic microwave radiation as a source of heat [1-5]. Of the existing chemical processing technologies (hydrolysis, glycolysis, methanolysis, aminolysis, etc.), the most preferred for microwave treatment is glycolysis, using chemical reagents (glycols) with a high value of the dielectric loss tangent at frequencies of 1-3 GHz.

Another polymer, polystyrene is a thermoplastic polymer material that has found wide application in many industries, from the production of household goods and finishing with building materials. In this connection, the issue of recycling and recycling of used materials from polystyrene is acute. A promising

technology for the processing of polystyrene, which makes it possible to obtain the initial styrene monomer, is chemical processing (de-polymerization or thermal degradation), initiated by heating the polymer to high temperatures.

The final product of the reaction can be used in the repeated production of polystyrene [6] or in the production of other materials [7, 8]. In [9], a method is proposed for obtaining carbon submicron particles in an atmospheric pressure gas discharge plasma using de-polymerization products of polystyrene. As a source of thermal energy in the reaction of thermal degradation of polystyrene, it is possible to use the electromagnetic field of high intensity microwaves. Polystyrene has low losses in microwave range. For this reason, direct heating of this polymer in electromagnetic field with chemical agents is not feasible.

In this paper, we consider the process of the microwave field action on the destruction of the different type polymers:

- firstly, during the interaction of PET with ethylene glycol (EG) – the reaction of glycolysis to produce the monomer or oligomer bis-hydroxyethyl-terephthalate (BHET);
- secondly, during the polystyrene heating by using thermo-transformers, that is, substances with high losses in the microwave range, capable of transmitting a transformed heat of the heated product [6], for example, similar active carbon (AC), characterized by a high specific conductivity at the microwave, in order to get styrene monomer or oligomers.

2. PET GLYCOLYSIS DE-POLYMERIZATION ASSISTED BY MICROWAVE HEATING

PET glycolysis reaction is carried out at atmospheric pressure and at a temperature of 180-210 °C. The oligoester obtained during the cleavage, depending on its purity, can be re-applied in the second stage of polymerization to obtain a new PET or in various chemical processes.

Theoretical base of this process of heating the reaction mixture under the action of the microwave field is the construction of an approximate mathematical model [10-13]. The object of the action is represented as a dielectric of a two-layer structure consisting of a layer of EG and PET, with a normal incidence of a flat electromagnetic wave on its boundary (Fig. 1.).

The EG and PET layers have thickness of h_1 and h_2 respectively, and have known electro physical parameters: density ρ, heat capacity *C*, thermal conductivity λ, the real part of the complex dielectric constant ε and the tangent of the dielectric loss angle tgδ. For simplicity of investigation in this paper, heated objects are represented as homogeneous isotropic media, the electro physical and thermal properties of which do not change in the operating temperature range.

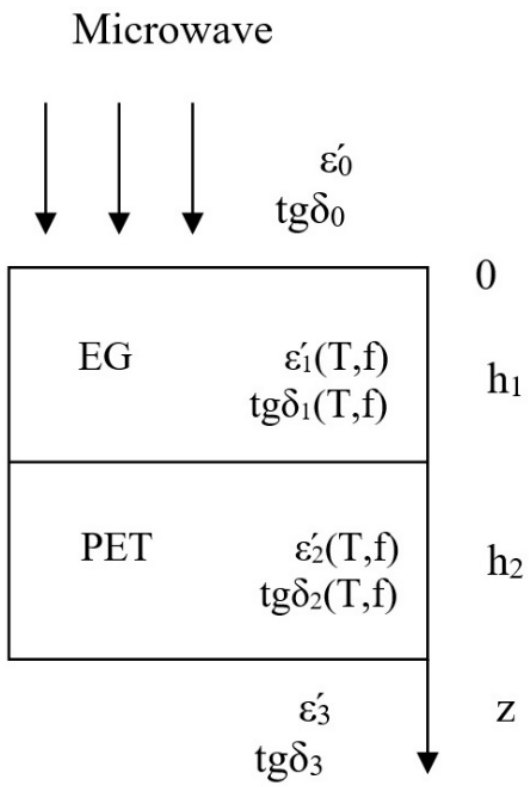


Figure 1 – Normal incidence of a flat electromagnetic wave on EG and PET layers

Calculation of the distribution of the temperature field along *z* axis of the structure was carried out according to the method presented in [14-18]. The problem reduces to a joint solution of the electrodynamics and heat conduction equations. At normal falling of a plane wave from air on an investigated structure after end of transients in each layer, two waves are formed – falling and reflected, extending along an axis z in a positive and negative direction accordingly. The complex amplitudes of the fields in the *i*-th layer are represented in the form

$$E_i(z) = t_i \exp(-ik_i z) + r_i \exp(ik_i z),$$
$$H_i(z) = \frac{\left[t_i \exp(-ik_i z) + r_i \exp(ik_i z)\right]}{\omega_i}, \quad (1)$$

where $i = 0, \ldots 3$, t_i is the transmission coefficient; r_i is the reflection coefficient; $t_0 = 1$; $r_3 = 0$; $\omega_i = \sqrt{\mu_i / \varepsilon_i}$ is the wave resistance. Boundary conditions are given proceeding from the condition of continuity of the magnetic and electric fields at the interfaces of the layers. The determination of the field amplitudes in each layer reduces to determining the reflection coefficients and the passage from the system of equations of the boundary conditions.

The temperature field in a plane-layered structure is determined by a system of differential heat equations

$$\begin{cases} c_1\rho_1 \dfrac{dT_1}{dz} = \lambda_1 \dfrac{\partial^2 T_1}{\partial z^2} + q_1(z), t > 0, 0 < z < h_1, \\ c_2\rho_2 \dfrac{dT_1}{dz} = \lambda_2 \dfrac{\partial^2 T_2}{\partial z^2} + q_2(z), t > 0, \\ h_1 < z < (h_1 + h_2). \end{cases} \quad (2)$$

The right side of the equations includes the heat loss function, which determines the distribution of thermal sources within each layer

$$q(z) = 0.5\omega\varepsilon'' \left| \dot{E}^2 \right|. \quad (3)$$

where ω is the circular frequency, ε'' is the imaginary part of the complex dielectric constant. The initial and boundary conditions were given in the form

$$\begin{gathered} T_1(z,0) = T_{нач}, T_2(z,0) = T_{нач}, \\ -\lambda_1 \frac{dT_1}{dz}(0,t) = k_1(T_1(0,t) - T_{medium}), \\ \lambda_2 \frac{dT_1}{dz}(h_1 + h_2, t) = k_2(T_2(h_1 + h_2, t) - T_{medium}), \\ T_1(h_1,t) = T_2(h_1,t), -\lambda_1 \left.\frac{dT_1}{dz}\right|_{z=h_1} = \lambda_2 \left.\frac{dT_2}{dz}\right|_{z=h_2} \end{gathered} \quad (4)$$

The system of heat conduction equations for given initial and boundary conditions was solved by a finite difference method according to an implicit scheme on a grid whose nodal points coincide with the boundaries of the layers.

Graphs of the layers temperature dependence on the distance deposited coordinate *z* for different time intervals are presented in Fig. 2. From the graphs shown, it is seen that with increasing exposure time, the uniformity of heating increases and for a reaction time of 30-40 minutes reaches a maximum value. To carry out physical modeling of the PET de-polymerization process, an experimental setup (Fig. 3) was constructed, consisting of a microwave source – a magnetron generating at a frequency of 2450 MHz with a power of 700 W and a resonator chamber connected to a magnetron by means of a piece of a rectangular waveguide. In the chamber is a glass vessel with reactants of 500 ml volume, coupled with a reflux condenser through an opening in the upper wall of the resonator chamber.

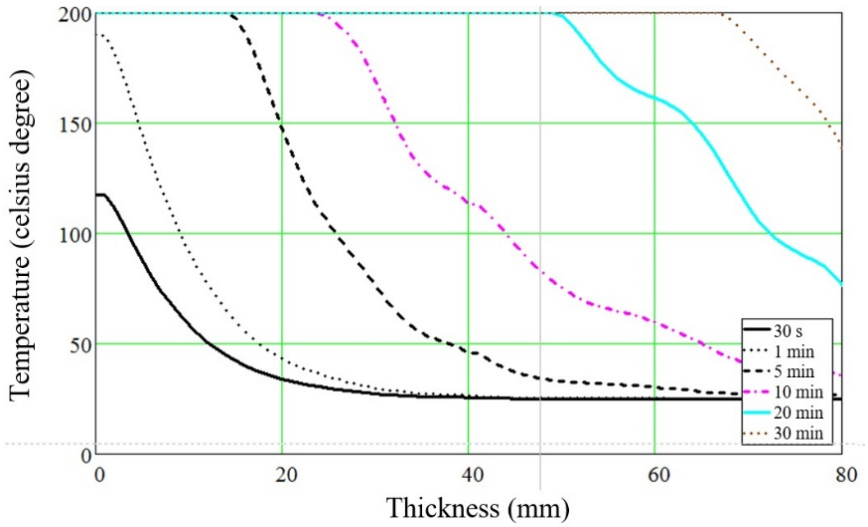


Figure 2 – Graphs of the layers temperature dependence on the distance deposited coordinate z for different time intervals

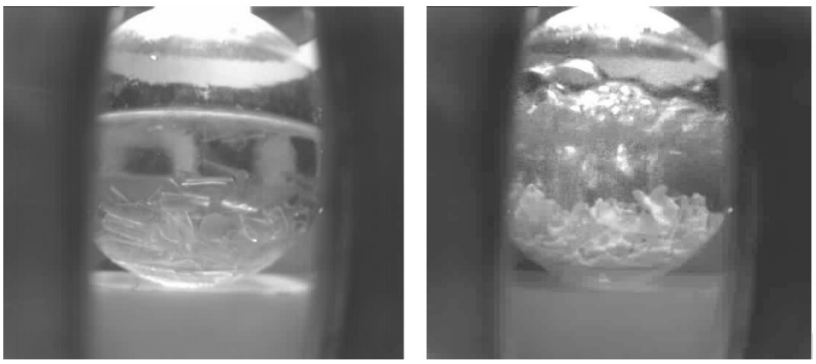
Figure 3 – Experimental set-up for EG and PET heating

The design of the resonator determines the maximum intensity of the electromagnetic field in the space of the heated vessel. The reaction catalysts were conventional laboratory chemicals, such as sodium carbonate, sodium bicarbonate, caustic barium and zinc acetate. The range of the ratio of the initial amount of PET to ethylene glycol was from 1: 4 to 1:10, the catalyst concentration was constant at 1% of the total mixture.

As PET, bottles for carbonated beverages were used, pre-cleaned, washed and ground to size 5×5 mm. The reaction in a closed resonator chamber was monitored by a video camera recording the whole process on a computer, and the temperature was recorded from the surface of the bulb using an infrared

temperature meter. The temperature data was used in the feedback channel to maintain the desired reaction temperature.

The frames for initiating the reaction (a) and for a time of 30 min (b) in the case without the use of catalysts are shown in Fig. 4.



a *b*

Figure 4 – The frames for initiating the reaction (a) and for a time of 30 min (b) in the case without the use of catalysts

The glycolysis product was obtained as a post-filtration residue containing ethylene glycol, BHET and a small number of other oligomers.

Comparison of the results was carried out in accordance with the result of the BHET reaction and the time spent for the decomposition. The dependence of the BHET yield on the de-polymerization time for the cases of using three catalysts and the maximum radiation power of the generator are shown in Fig. 5.

The highest yield of BHET (67%) in the case of the use of zinc acetate was observed with a reaction time of 30-40 minutes. The amount of BHET increases during this time, after which the proportion of oligomer decreases. This is explained by the fact that glycolysis is a reversible equilibrium reaction; the reverse reaction is poly-condensation. In case of heating by the classical method, all other conditions being equal, the de-polymerization time is 6-7 hours.

3. POLYSTYRENE DE-POLYMERIZATION ASSISTED BY MICROWAVE HEATING WITH THE USE OF THERMO-TRANSFORMER

Theoretical evaluation of the characteristics and properties of the polystyrene (PS) heating process and thermo-transformers use in the microwave field shows that it is suggested a mathematical modeling of heating of a dielectric medium with energy of the electromagnetic field reducible to a joint solution of Maxwell's and non-stationary thermal conductivity equations.

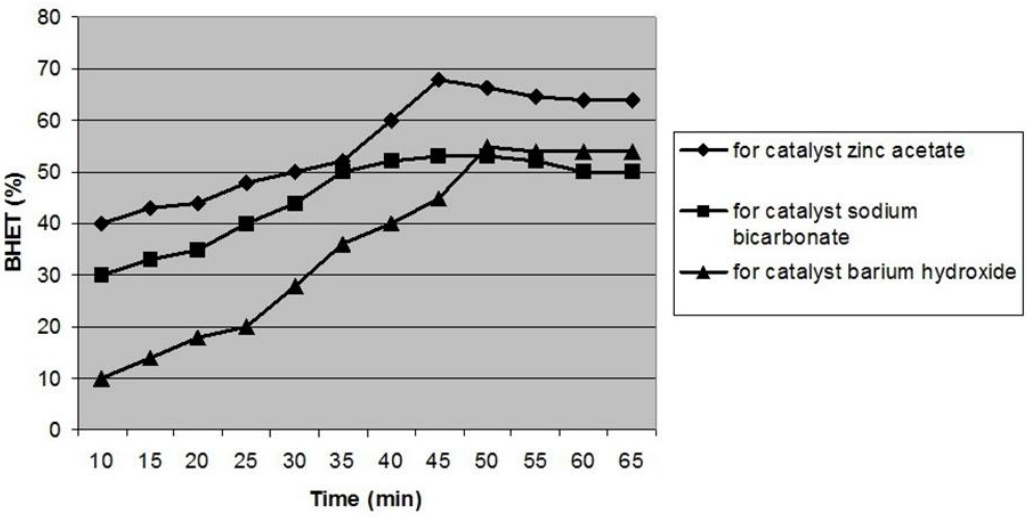


Figure 5 – The dependence of the BHET yield on the de-polymerization time for the cases of using three catalysts and the maximum radiation power of the generator

This is about layered dielectric, on which normal flat electromagnetic wave falls. Number of layers is determined by the particular study of structure, namely the relative arrangement of polymer particles and thermo-transformer ones. After the transitional processes in each layer there are two plane waves – incident and reflected, propagating along axis in positive and negative directions respectively.

The model is similar to model presented by (1)-(4) and Fig. 1, but the number of layers is *n*.

Two models of polystyrene heating were used:

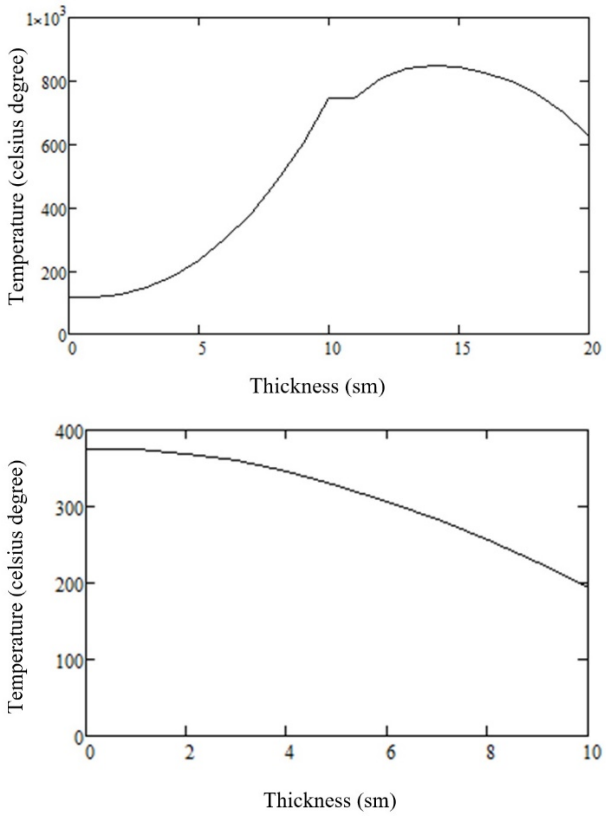
- the first – a layer of PS particles is above the layer of thermo-transformer (active coal – AC), both layers thickness is 100 mm;
- the second – one layer of 100 mm thick, consisting of a mixture of PS and AC particles. Availability in mathematical model of heterogeneous mixture of the two components leads to need to calculate the effective values of complex dielectric permeability of the mixture, determined by Lichteneker's formula.

The distribution of temperature in two-layer structure of the first model is shown on Fig. 6,a and in a single-layer structure of the second model is shown on Fig. 6,b, with a heating time of 120 s and the intensity of the incident wave is 5000 V/m.

Simulation shows that greater uniformity of the temperature field is achieved with mixing particles of PS and AC. Further increase of the heating uniformity is possible with the existence of underlying AC layer, allowing increasing the temperature of polystyrene in the lower part of the layer.

To study the process of PS de-polymerization in the microwave field with the presence of AC, raw of experiments were done to get styrene monomer and other low molecular weight products from waste polystyrene materials.

The purpose of the experiments was to evaluate the composition of the final product and determine its percentage yield.



a *b*

Figure 6 – The distribution of temperature in two-layer (a) and single layer (b) structures

The essence of the experiment consisted in the release of volatile fractions by heating a mixture of polymer and AC in the microwave field, followed by condensation at atmospheric pressure. A laboratory setup for microwave sublimation, similar to presented on Fig. 3, has been developed.

De-polymerization of PS took place at a temperature of ~ 260 °C. The temperature was controlled by a contact method using a thermometer with a fission rate of 2 °C and a contactless method using a pyrometer with a measurement accuracy of 0.1 °C. The mass yield of the final product containing styrene monomer and a number of low molecular weight fractions from PS wastes was ~ 60%. At a ratio of PS to AC 3:1 and a mass of PS near 30 g, a gaseous phase formed 4-6 seconds after the start of heating, which was further condensed as a yellowish liquid. The total de-polymerization time was 7 minutes.

Identification of the final product of de-polymerization of PS was carried out by different methods [19-21], but finally by using Fourier-infrared spectrometry on a TENSOR 27 device (Bruker, Germany) in the wave number range of 7500-370 cm^{-1}. Three IR Fourier spectra of one sample of the final product were examined:

- immediately after de-polymerization (Fig. 7);
- after evaporation of volatile components from the surface of the substance in the hood for a period of two hours (Fig. 8);

- after evaporation of volatile components from the surface of the substance, located in the hood, for a period of 19 hours.

The IR Fourier spectra of the sample after evaporation of volatile fractions within a time interval of 19 hours practically does not differ from the analogous one for a time interval of two hours.

The one shown in Fig. 8 spectrum corresponds to a mixture of low molecular weight products: dimer, trimmer and styrene oligomers. The difference between this spectrum and that shown in Fig. 7 is explained by the presence in it of the elements of the volatile fraction – styrene monomer.

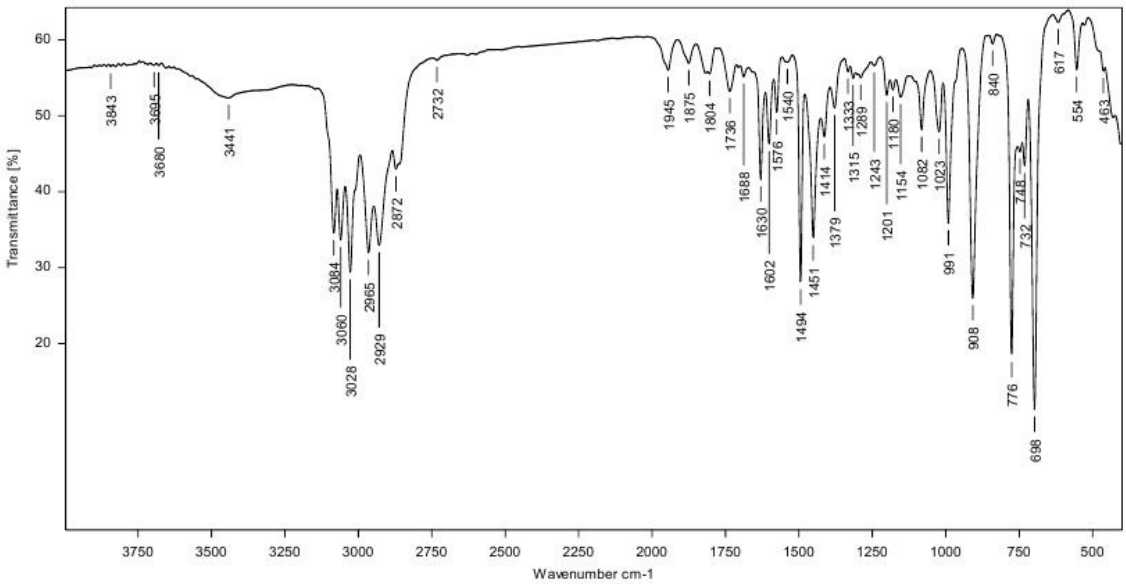


Figure 7 – The IR Fourier spectra of the sample after de-polymerization

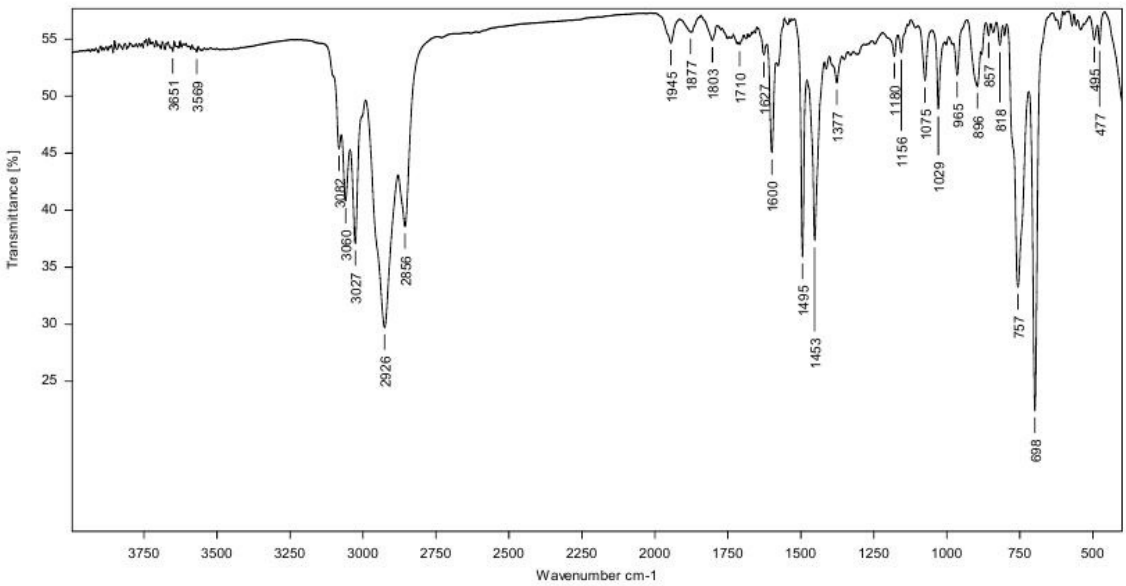


Figure 8 – The IR Fourier spectra of the sample after evaporation

Analysis of the obtained IR Fourier spectra showed the presence of styrene monomer (~ 15%), styrene oligomers (~ 60%), as well as other de-polymerization products (~ 25%) in the sample.

4. CONCLUSIONS

De-polymerization of PET in microwave field using polar dielectric (for example, glycol) and catalyst can help to get the highest yield of BHET monomer (67%) in the case glycolysis with a reaction time of 30-40 minutes and temperature 200 °C under atmosphere pressure.

De-polymerization of PS in electromagnetic field of a microwave range of high intensity for indirect microwave heating of polystyrene till 260 °C in the presence of thermo-transforming elements (for example, active coal) makes it possible to obtain a 60% yield of styrene oligomer and 15-20 % of its monomer.

As a result of the conducted theoretical and experimental studies, it was shown that the use of microwave energy for the intensification of de-polymerization of PET and PS can improve such technological indicators as the manufacturing time which is reduced to 1-2 hours against 6-8 hours, in comparison with traditional technologies, and saving the necessary electrical energy to 70% in both tasks.

Thus, given technologies can be considered as promising for the modern polymer industry in order to find rational methods for the secondary processing of polymer products.

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SIXTH INTERNATIONAL ENVIRONMENTAL CONGRESS ELPIT-2017

20-24 September 2017, Samara-Togliatti, Russia

DAM MONITORING USING FIBER OPTICAL TEMPERATURE AND MICROWAVE LEVEL SENSORS

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ABSTRACT

Many regions of different countries are the regions in which the passage of spring floods can lead to serious economic and social consequences. Different systems for monitoring water bodies (installations for the hydrological posts during the flood period) had been put into practice. Today, the full automation and improvement of technologies and means for monitoring the condition of dams and other hydraulic structures are on the foreground. Among the main areas of focus is the use of fiber optic sensor technologies to measure the temperature of dams and gates, as well as constant monitoring of the water level. Recently, taking into account design characteristics, it can be considered as a competitor of fiber optic leveling devices – microwave level meters, built on the principles of transferring fiber optic technology to microwave one. Results of conducted theoretical and experimental studies are presented in order to show that the use of fiber optical distributed or quazi-distributed temperature sensors and microwave level meters can improve such technological indicators as the accuracy and reliability of dam and its gates monitoring systems in both tasks. Additionally, it is shown how to build fiber optic telemetry software defined networks for dam temperature monitoring and how to organize constant visualization of dam situation. System based on UAV cluster with active focused arrays can effectively solve the problem of transmitter channel organization regardless of distance to monitoring center, and can help to organize not just common 3D image of dam, but its special parts along by flight trajectory

changing of one of the UAVs. The Republic of Tatarstan, Russia was chosen as a region for given technologies approbation.

Keywords: dam monitoring, software defined networks, fiber optical distributed or quazi-distributed temperature sensor, microwave level meter, Bragg grating in coaxial cable, hydrological post, monitoring center, information, transmitting channel, UAV, focused antenna array

1. INTRODUCTION

The Republic of Tatarstan is a region in which the passage of spring floods can lead to serious economic and social consequences. Under the worst scenario of spring flood development, 220 populated areas with about 20 thousand people, 48 socially significant sites, 55 road sections with a total length of 75.3 km, 27 economic objects and 36 bridges can get into the flood zone. At present, 834 ponds are located on the territory of the Republic of Tatarstan.

Since 2005, on the initiative of the Ministry of Civil Defense and Emergency Situations in the territory of the Republic of Tatarstan, a system for monitoring water bodies (installations for the hydrological posts during the flood period) has been put into practice. In rural areas, responsible persons are identified from the number of local residents who will daily provide monitoring results of the state of water bodies to the Ministry of Civil Defense and Emergency Situations of the Republic of Tatarstan, and with a sharp rise in the water level every 4 and 2 hours. Thus, during the flood period, sensor stations will be deployed in 47 small river sections, 145 ponds and 39 potentially hazardous municipal facilities, i.e. in total there will be 231 posts. The introduction of the republic's water bodies state through continuous monitoring practice, the creation of sensor stations makes it possible to ensure a trouble-free passage of the spring high water and prevent the destruction of ponds during the flood period.

Today, the full automation and improvement of technologies and means for monitoring the condition of dams and other hydraulic structures are on the foreground. Among the main areas of focus is the use of fiber optic sensor technologies to measure the temperature of dams and gates, as well as constant monitoring of the water level [1-4]. Recently, taking into account design characteristics [5-11], it can be considered as a competitor of fiber optic leveling devices – microwave level meters, built on the principles of transferring fiber optic technology to microwave one. The proposed technologies are presented in this article, which also concludes discussing about the transmission of information methods about the state of dams from hydrological sensor posts to the monitoring services.

2. DISTRIBUTED AND QUAZI-DISTRIBUTED FIBER OPTICAL TEMPERATURE SENSOR SYSTEMS

In [4], an attempt was made, to expand the application areas of the concept of software-defined networks to heterogeneous, multilayer, multiservice, technologically heterogeneous fiber-optic telemetry systems that use nonlinear stimulated Raman (SRS), stimulated Mandelstam-Brillouin (SMBS) and Rayleigh (RS) scattering in optical fiber and Bragg reflection (BR) from fiber Bragg grating (FBG) with the ability to detail on request information on temperature, pressure and other parameters at an arbitrary point and ensure a unified management. The basis for this is the assumption of the unity of processes occurring in multiservice data transmission networks and in information and measurement multilayered networks for collecting and processing distributed information [12-14].

Software-defined networks (SDN) are based on the centralized management of the processes of transmission, collection and switching of information, and the management principles themselves are universal, in contrast to the specified processes. The processes of information transfer, collection and switching can be heterogeneous, implemented on equipment of various configurations, cover various sources, provide individual services with arbitrary characteristics and control at the level of packages and/or layers. The abstraction of the control panel from the process implementation panel makes it possible to view the latter as a «black box» with resource savings in the absence of the need to monitor the internal communications of the networks. In this case, the SDN is not isolated from internal queries to the control panel when implementing various processes and must have certain resources for their implementation. These resources can be interfaces through which an application can request information or access to elements of the network or to its layers, which in general should cover and be applicable to disparate applications.

For example, consider a combined system as a prototype of SDN Fiber Optic Telemetry for Dam Temperature Monitoring (FOT-DTM).

A combination of distributed fiber optic sensors (FOS) and FBG in one fiber is possible to calibrate the first. The combination of distributed temperature FOS and quasi-distributed pressure sensors on FBG will allow for the joint processing of information to obtain pressure-temperature fields in the gates of the dam.

The authors did not find any projects that would benefit from all four types of measurement procedures at the same time. Modern technologies, including the patent solutions of the author and scientific school of KNRTU-KAI [15-17], make it possible to make program-determined procedures for the formation in the fiber the responses of various nature (SRS, SMBS, RS and BR) on the temperature and pressure in the gates or dams and universal – the procedure of poly-harmonic probing of responses, taking into account their similar quasi-resonance character.

These factors determine the urgency of the development of FOT-DTM systems based on software-defined combined reflectometry.

The planned methods and approaches to the development of FOT-DTM based on software-defined combined nonlinear reflectometry are based on the

unity of the structures of the formed responses of the optical fiber to the external action – temperature and pressure. At a certain level of power of the laser radiation exciting the optical fiber, the resonance contours of the Mandel'shtam-Brillouin and Raman scattering are formed. A similar resonant circuit can also describe the spectral characteristics of the Bragg grating reflection. If the first carry the distributed information about the measured parameters, the latter allows to obtain point or quasi-distributed information. The additional reflectometric information is carried by the RS, which can be characterized in connection with the SMBS as respect to the Landau-Plyachek ratio.

The first approach. A single radiation source is used to form a fiber response to external influences and synthesis of its special shape or spectrum optimized for recording the spectrally-spaced responses from various non-linear effects and reflections from Bragg gratings tied to the central wavelength of the shaping radiation. Some pair effects of such an implementation are known, a complex variant of the formation and use of a response from four types of scattering and reflection from a Bragg grating has not yet been studied. Its implementation could introduce information redundancy into the measurement process, the use of which would lead to improved metrological characteristics of the systems being developed.

The second approach. It is based on poly-harmonic sounding of the received resonant responses. Recently, considerable progress in terms of accuracy and resolution of measurements, as well as practicality of application, have achieved the technology of narrowband poly-harmonic probing of FBG, which makes them competitive with classical methods of converting information by metrological characteristics, simplicity and cost of implementation. Their main advantage is the absence of the need to carry out measurements in the resonance region of the spectral characteristic (shown in a number of papers [16-18]), which makes it possible to eliminate the influence of the power instability of the forming laser radiation. The above-mentioned circumstances determine the relevance of the topic and the scientific and technical problem of developing methods and means for poly-harmonic analysis of spectral characteristics intended for separate recording of physical fields of different nature (temperature, pressure) and constructing on their basis an optoelectronic FOT-DTM using complex effects of nonlinear OFDR with their program-defined registration and management.

Traditionally, constant monitoring is primarily used to monitor pressure and temperature in the dam. Analyzing the comparative parameters of various scattering and reflection processes in an optical fiber, we can assume the structure of a single mask for their multiplexing and access to the control panel of the FOT-DTM. This mask can be based on a set of filters with the parameters of central wavelengths and bandwidths specified in Tab. 1 with respect to the carrier frequency of optical radiation and implemented on the basis of structured Bragg fiber gratings.

From the point of view of the formation of multichannel distributed gratings, their versions with sinc-sampling and discretization of only phases, super structured lattices and gratings based on the Talbot effect have been developed and

demonstrated [19-21]. Among the listed above, the greatest attention is drawn to gratings with phase shift and only phase sampling, which can be made with simple phase masks with minimum requirements for parameters of modulation of the refractive index and uniformity of characteristics of its profile.

Table 1 – Interface parameters for structured FBG

Signal	Contour	Central (resonant) frequency	Bandwidth	FWHM
SRS	Gauss	13,1 THz (±100 nm from pumping carrier)	25...45 GHz	10...20 THz
SMBS	Lorentz	10...11 GHz (±0,1 nm from pumping carrier)	20...100 MHz	10...50 MHz
BR	Gauss	0 (1550 нм)	0,1...1 nm	0,05...0,5 nm
BR from π-FBG	Gauss / Lorentz	0 (1550 нм)	0,01...0,05 nm	0,005...0,025 nm

The required mask variant is shown in Fig. 1, based on the assumption that each filter should allocate a section corresponding to its type of scattering in accordance with Tab. 1.

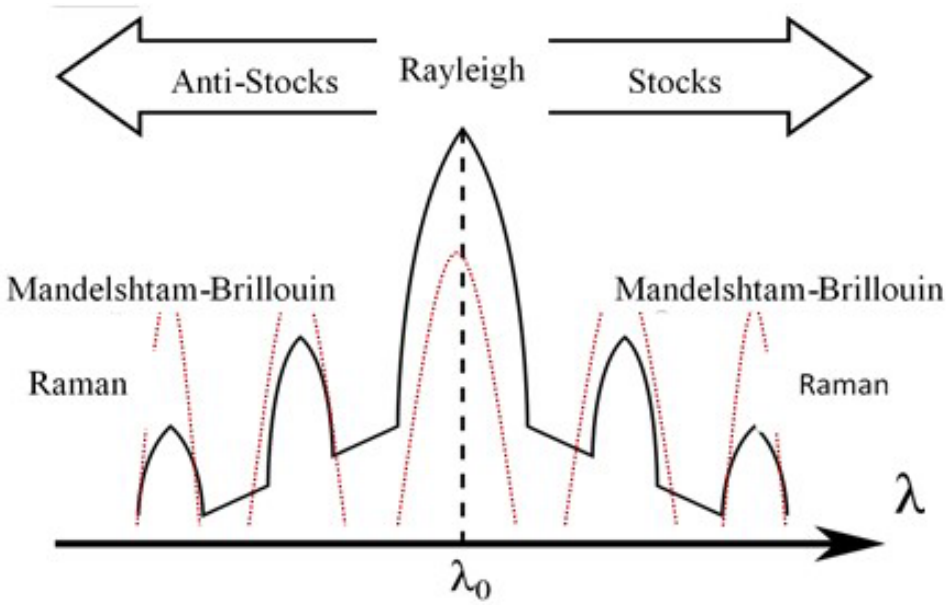

Figure 1 – Graphical representation of mask form for multiplexing scattering signals (dotted line)

One of the main tasks of FBG quazi-distributed technologies is the multiplexing of a large number of fiber-optic sensors in the structure of one network in order to reduce the contribution of expensive interrogation equipment

to its cost and the development of a system capable of measuring at a variety of locations located in the general case, in an arbitrary order. The cost of single-channel FOT-DTM is relatively high. Aggregation of the sensors leads to a reduction in the cost, taking into account the possibility of reducing the cost of common for all sensors the probing source, the photodetector, or, more preferably, both devices.

As a rule, multiplexing is used for aggregation of FBG. Multiplexing is the simultaneous transmission of two or more information channels along a common path. FOT-DTM includes three main parts or subsystems: FBG, fiber optic channel and interrogator. Due to the fact that the last subsystem is the most expensive, the multiplexing of a larger number of sensors in the structure of a single FOT-DTM with the use of a common interrogator leads to a reduction in the cost of a single point measurement channel. Thus, multiplexing is one of the most important processes for the construction of FOT-DTM.

There are a number of different topologies for constructing FOT-DTM. They are divided into four main configurations: serial and parallel bus, star and tree, each of which, in turn, can be a transmitting or reflective type. More complex topology related to hybrid networks and most suitable for dam monitoring is shown in Fig. 2.

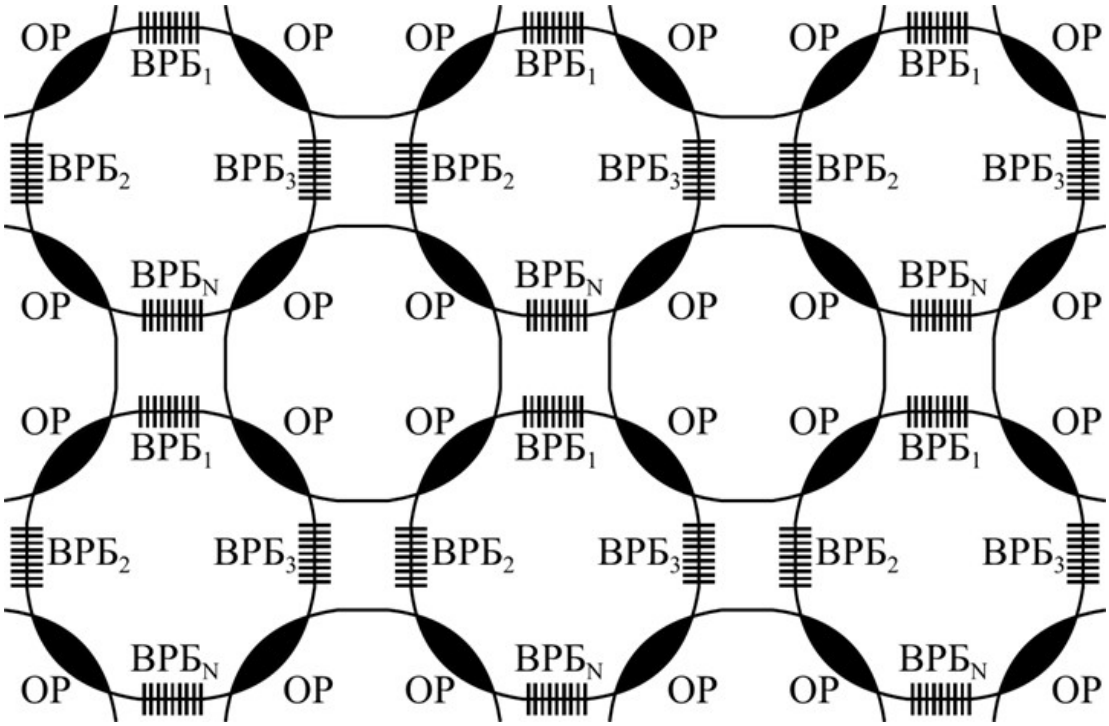

Figure 2 – Mesh topology of quazi-distributed FOT-DTM sensors:
ОР – optical coupler; ВРБ – fiber Bragg grating

One important factor that should be kept in mind when working with FOT-DTM in general and with FBG in particular is the optimization of the value of the received signal level from each of the sensors. The fiber-optic transmission system

always has a sufficient level of optical power, an energy potential defined, for example, as the difference between the maximum signal level that can be detected by the photodetector without saturation, and the minimum at which the system will operate with an acceptable signal-to-noise ratio. If in the star topology the choice of the splitter divisor is simple (1/N, where N is the number of sensors to be multiplexed), then for the design of the mesh topology, more suitable for our purposes (Fig. 2), this question is very complicated. In the simplest case, when it is desirable that all splitters have an equal partitioning ratio, the optimal value will still be 1/N.

The examples of using similar fiber optic textile one can be found in [3], where from we took photos presented on Fig. 3.

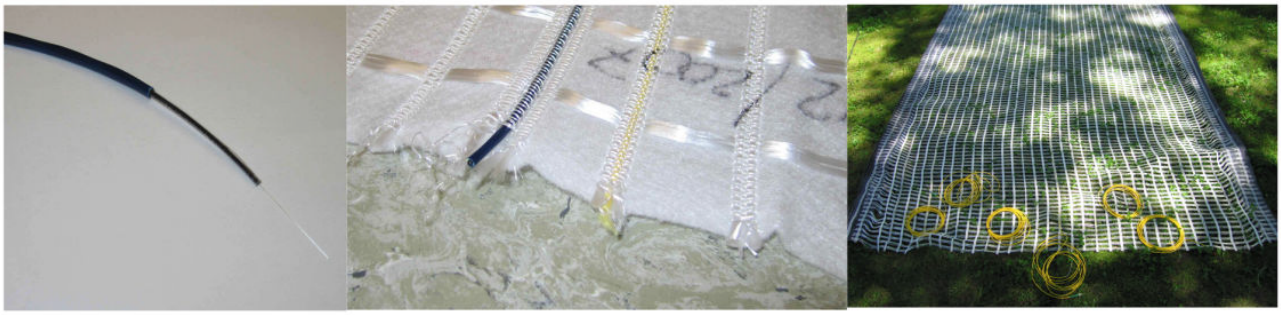

Figure 3 – Special glass fiber cable for strain sensing manufactured by Fiberware, Germany (left) and two different types of geotextiles (middle: nonwoven geotextile, right: geogrid) manufactured by STFI, Germany with embedded glass fiber cables [3]

Minimizing the number of channels used to maintain the physical level of measurements is one of the important tasks in the design of fiber-optic sensor networks. While maintaining metro-logical requirements for the elemental system of the system, the availability of free channels makes it possible to implement transport layer reservation, to organize feedback channels, to quickly change the system configuration, to introduce new sensor groups, for example, fire detection, environmental monitoring and etc.

Multipoint or quasi-distributed FOT-DTM consisting of sequential FBG (for level measurements) demonstrate the main advantage of FOS networks – many sensors use one fiber to transmit information signals back to it in a reverse direction, which are de-multiplexed by a single receiving device. For the minimization, channel structures can be used that contain the same type of sensors, grouped in a certain order with a change in the reflection coefficient, the width of the FBG transmission bandwidth, etc., according to a certain law.

This implies a spectral analysis of the information obtained that very complex in optical range. We can propose only interferometry with frequency shift FSI [22], that makes it possible to extract information from the information signal both about the location and the coefficient of reflection of several, even spectrally overlapping, gratings. In contrast to the other methods, FSI is based on the Sanyak

interference. The measured parameter is the phase difference between two components of the probing radiation that have passed the same path in the fiber and have the same frequency shifted relative to the carrier radiation, but have received this offset at various points in their path. The position of the sensor is determined from the relation connecting the phase change and the magnitude of the component shift in frequency.

Microwave level meters, built on the principles of transferring fiber optic FBG technology to microwave one is simpler [11-12].

3. MICROWAVE WATER LEVEL METER

The microwave converter is a water level meter based on a coaxial cable. The objective of the experiment was the physical substantiation of the possibility of using a microwave converter – a level meter based on a coaxial cable (LMCC) with periodic in-homogeneities, identifying recommendations for the technical implementation of its conversion elements for measuring the water level.

Experimental modeling of the LMCC was performed on a widely available 10D-FB coaxial cable. Drilling of periodic in-homogeneities – holes for manufacturing LMCC was carried out on a drilling machine "Encore Corvette 46" in manual mode.

The structural scheme and appearance of the experimental LMCC setup for measuring the water level in the reflection mode are shown in Fig. 4.

It consists of the following elements:

1. Cylindrical tank made of polypropylene with geometric dimensions: inner diameter – 107 mm, height – 1040 mm, volume – 9351,7 cm^3.

2. Coaxial cable of brand 10D-FB with single-row arrangement of holes (Figure 5). Coaxial cable parameters: total cable length, taking into account the coordinated load and two N-type connectors – 1035mm; length of cable without connectors – 909 mm. Parameters of in-homogeneities: number of holes in the cable – 25; the period of the structure is 30 mm; the diameter of holes – 8 mm; the depth of the hole is 4,8 mm. A view of the holes in the coaxial cable is shown in Fig. 5.

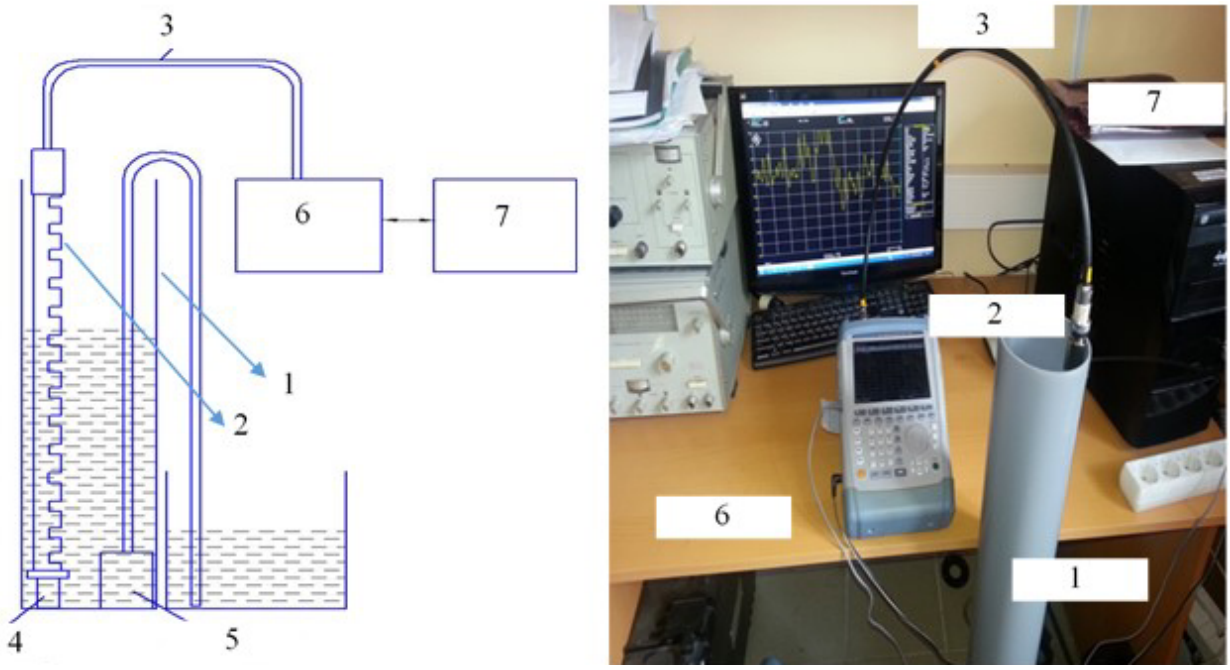

Figure 4 – The structural scheme and appearance of the experimental LMCC setup

3. Connecting coaxial cable of 1 m long.

4. The coordinated load having SWRV≤1,12 in the range up to 6 GHz. The appearance of the coordinated load is shown in Fig. 5.

5. Submersible pump.

6. Vector network analyzer Rohde & Schwarz FSH8, which has a range of frequencies up to 8 GHz.

7. PC with the program FSH8 View for storing measurement results in the form of arrays of data.

Figure 5 – LMCC sensor

Technique of the experiment and results. The methodology for measuring the characteristics of LMCC in the reflection mode used as a level meter consists of the following operations:

1. Carrying out a single-port calibration of the FSH8 with the use of a 10D-FB coaxial cable without holes with a coordinated load as a port matching operation via a connecting cable. This operation is designed to compensate for the self reflections of the coaxial cable, which worsen the overall reflection characteristics of the LMCC.

2. Drill holes in the coaxial cable with the specified period, quantity, diameter and depth of the holes.

3. The coordinated load is connected to the LMCC connector and the latter is sealed with a plastic container.

4. The free end of the LMCC is connected via a connecting cable to the FSH8 and the reflection coefficient is measured for air filling of the holes.

5. LMCC is lowered into the tank with controlled liquid for its entire length.

6. By means of a pump immersed in the reservoir, the liquid is evacuated in volumes corresponding to a change in the level in the reservoir per hole, with each step a reflection coefficient in a given frequency range is fixed in the form of an array of data.

The measurement in the transmission mode will differ by the method of preliminary calibration (clause 1), which consists in using as a connecting operation – assembly of a connecting coaxial cable, measuring cable without holes and coaxial bending.

Using a sealing material with dielectric parameters close to the parameters of the internal dielectric of the cable, or having known electro-physical parameters of the hardener, it is possible to minimize the effect of sealing on the characteristics of the cable. The LMCC with the parameters specified above, made with sealing of the side walls of the holes according to the above procedure, in the running mode has a frequency dependence of the transmission coefficient shown in Fig. 6. The central resonance frequency in this case is 3.98 GHz with a transmission factor of –17.39 dB.

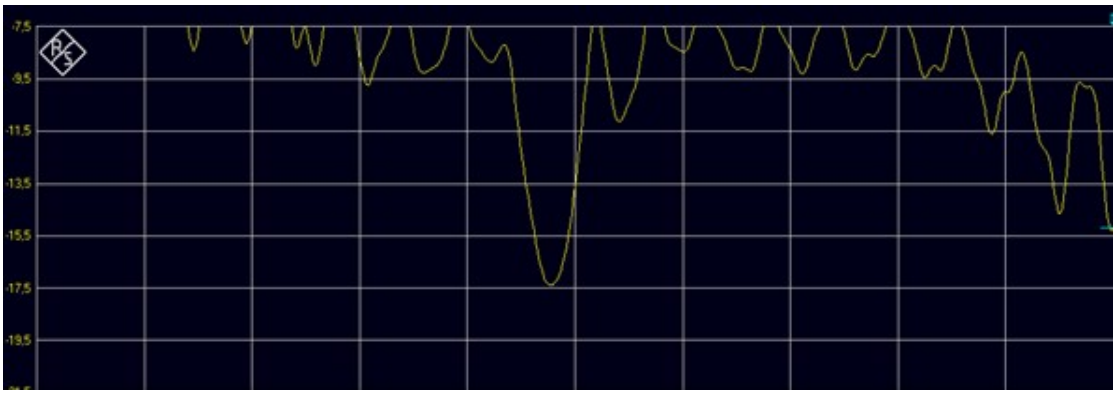

Figure 6 – The frequency dependence of the transmission coefficient of the LMCC

The experimentally obtained dependence of the amplitude ratio for the measurement of water level is shown in Fig. 7.

4. TRANSMITTER CHANNELS AND DAM VISUALIZATION

In [23] introduced an internet-based water level monitoring and measuring system and there was achieved template matching by correlation to detect water-level with images captured from CCD camera. Finally experiments demonstrate

that water level was accurately measured with the proposed method by this system. In [24] described a test platform for collection of high resolution 3D data from a small UAV and shown experimental examples of applications for such data. These applications include: improved situation awareness, 3D measurement/documentation; seeing through vegetation (local ground model) for further geometrical conclusions; target detection (persons) with change detection in a partly obscured environment of trees.

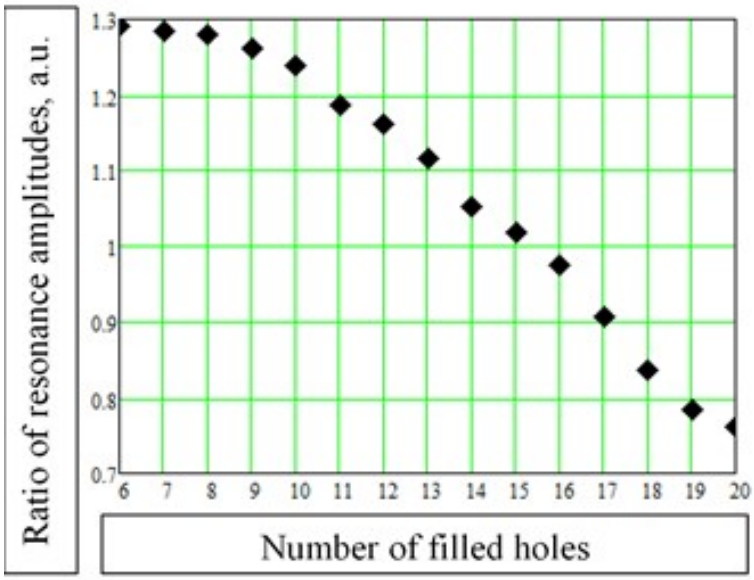

Figure 7 – Dependence of the resonances amplitudes ratio from the number of filled holes

The disadvantage of both methods is using of one camera and one channel for transmitting information, though the monitoring center may be near dam 2,5-4 km, or significantly further 40-250 km.

According to the network-centric concept [25], two features will characterize prospective aviation facilities: speed of control and self-synchronization, that ability to self-organize from below.

An important role in its implementation is assigned to unmanned aircraft: from well-equipped large up to small-sized, up to the launch from the hands. One of the directions of application small-sized unmanned aerial vehicles (UAV) provides for the use of groups of UAV – clusters. These groups, which have the ability to self-synchronize and endowed with elements of artificial intelligence must take the decision a number of civil defense technical problems. A prerequisite for the effective functioning of such groups is to provide a radio exchange not only between the elements of the group, but also between the group as a whole and the remote control point.

To ensure energetically efficient radio communication, small-size UAV with remote correspondent proposed to use the principle of active phased arrays, when the elements of the grid are the radio transmitting devices of individual UAV. Look for situation when the dimensions of the cluster, the wavelength, and the

distance to the remote monitoring center correspond to optimal far-field condition. In these conditions, the remote monitoring center have to be at distance equal 40-250 km. At the same time, for a number of situations that correspond to promising applications of organized groups of small-sized UAV for dam monitoring, the distance to the monitoring center can be smaller, by at least an order of magnitude.

The proposing idea is to provide radio communication at distances substantially less than the conditional boundary of the far zone. For this purpose, the radiation of the active phased array should be focused at a given point in space, corresponding to the location of the monitoring center. Thus, active focused arrays can be an effective tool to solve problems of providing communication with a group of small-sized UAV between each of them, as well as to implement effective electronic measures to connect with ground-based monitoring center and solve it tasks about exploration and visualization dam in a whole or it special zone, for example, with the level meter.

5. CONCLUSION

In this paper, we discuss how to build fiber optic telemetry software defined network for dam temperature monitoring, how to solve the problems of water level measurements and to organize constant visualization of dam situation. Results of conducted theoretical and experimental studies are presented in order to show that the use of fiber optical distributed or quazi-distributed temperature sensors and microwave level meters can improve such technological indicators as the accuracy and reliability of dam and its gates monitoring systems in both tasks. System based on UAV cluster with active focused arrays can effectively solve the problem of transmitter channel organization regardless of distance to monitoring center, and can help to organize not just common 3D image of dam, but its special parts along by flight trajectory changing of one of the UAVs.

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PROVISION OF ECOLOGICAL SAFETY OF WATER SUPPLYING SYSTEM OF INDUSTRIAL ENTERPRISES

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ABSTRACT

The paper is devoted to choosing of adequate measures for the prevention and occurrence of accidents at thermal power stations the scientific and methodological framework and quantitative risk assessment of their appearance. To conduct the technosphere risk analysis the method "Tree structure" was used. The tree structure of the linkage of causes and consequences in different possible events in the water systems of the Kazan CHP-2 and its territory (qualitative risk analysis) is developed. The results of the quantitative analysis of the possible consequences of the introduction of hardware-software complex of "Safe city" will allow achieve considerable decrease in risks of emergency situations on industrial objects in Kazan.

Key words: accidents, thermal power stations, quantitative risk assessment

The system of water supply of the industrial enterprises represents a difficult complex of the constructions interconnected in work. Constructions have to be calculated to ensure their efficient work in the chain, and the consumer as a result received the necessary quantity of water of the set quality under a required pressure. For this purpose the estimated expenses are strictly determined for each of the constructions:

- the maximum daily flow, on which water intake constructions, the treatment plant, the tank and pump stations of the first and second lift are calculated;

- the average hour expense per day of the maximum water consumption, required to establish the estimated (average) hourly productivity of water intake constructions, the purification plant and calculation of conduits of the first lift;

- the maximum hourly and the corresponding momentary water flow, on which water supply system and the productivity of the pumping station when giving a fire or maximum economic consumption without regulation of pressure structures is calculated.

Ensuring the reliability of production water supplying systems has particular importance. A number of companies not only prevents any interruption (even short-term), but also reducing the water flow in the production system.

In terms of the specifics of potentially dangerous objects of Kazan which do not have backup water sources, in case of lack of water supply the risk of emergency situations caused by the technogenic fires because of lack of water in the systems of fire-water supply will increase. However, all of these companies, except of the branch of JSC "Tatenergo" - Kazan thermal power station (CHP)-2, do not have the technological cycles, stopping which can cause new ES, where the most significant consequences of the lack of supply will be observed.

Therefore, to choose adequate measures for the prevention and occurrence of accidents at CHP the scientific and methodological framework and quantitative risk assessment of their appearance are necessary. In this regard, the development of analytical methods of analysis and assessment of risks with the purpose of increasing the level of safety and reducing the harmful effects of factors of accidents on the environment become particularly relevant.

At CHP-2 water is used for cooling (condensation) of exhaust steam, cooling air, gases, oils, bearings of auxiliary machines. Water is also needed to compensate the loss of steam and condensate, both inside the plant and external heat consumers, as well as to move through the pipes ash and slag to be removed. The oil coolers of turbine and auxiliary equipment are consumers of water too. In addition, water is consumed for commercial and domestic use. One of the main reason of technogenic emergency situation in Russia is the high level of depreciation of technological equipment and the unsatisfactory condition of fixed assets in general. [6]

To conduct the technosphere risk analysis we use the method of "Tree structure" (method of professor V. L. Romanovsky). The method of "Tree structure" incorporates the graphic-analytical so called predecessors' methods and is their further development. In particular, the equitable accounting of all components of the system "human-machinery-environment" is possible, it may have some leading events, the effect of subsequent events on the previous is allowed (i.e., the "scrolling" part of events in time), the developments in the different "branches" of the structure depending on changes in the current situation, the operator of the "totality of events" appeared – the similar to an artificial neuron, which allows to include aspects of psychology, Economics and other disciplines to the analysis.

Fig. 1 shows the tree structure of the linkage of causes and consequences in different possible events in the water systems of the Kazan CHP-2 and its territory (qualitative risk analysis).

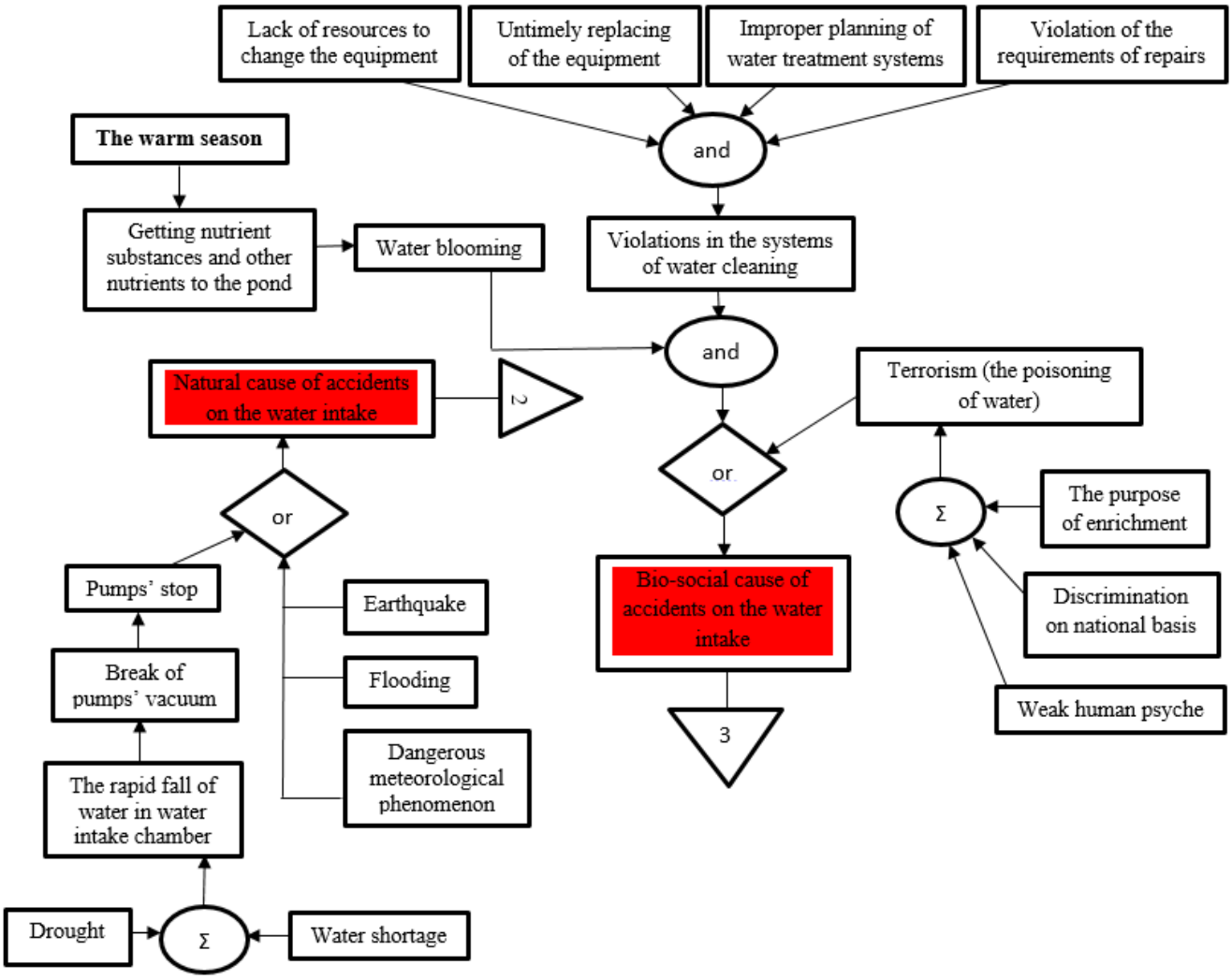

Figure 1 (A) – The tree structure of the chain of events in the systems of water supply of Kazan CHP-2

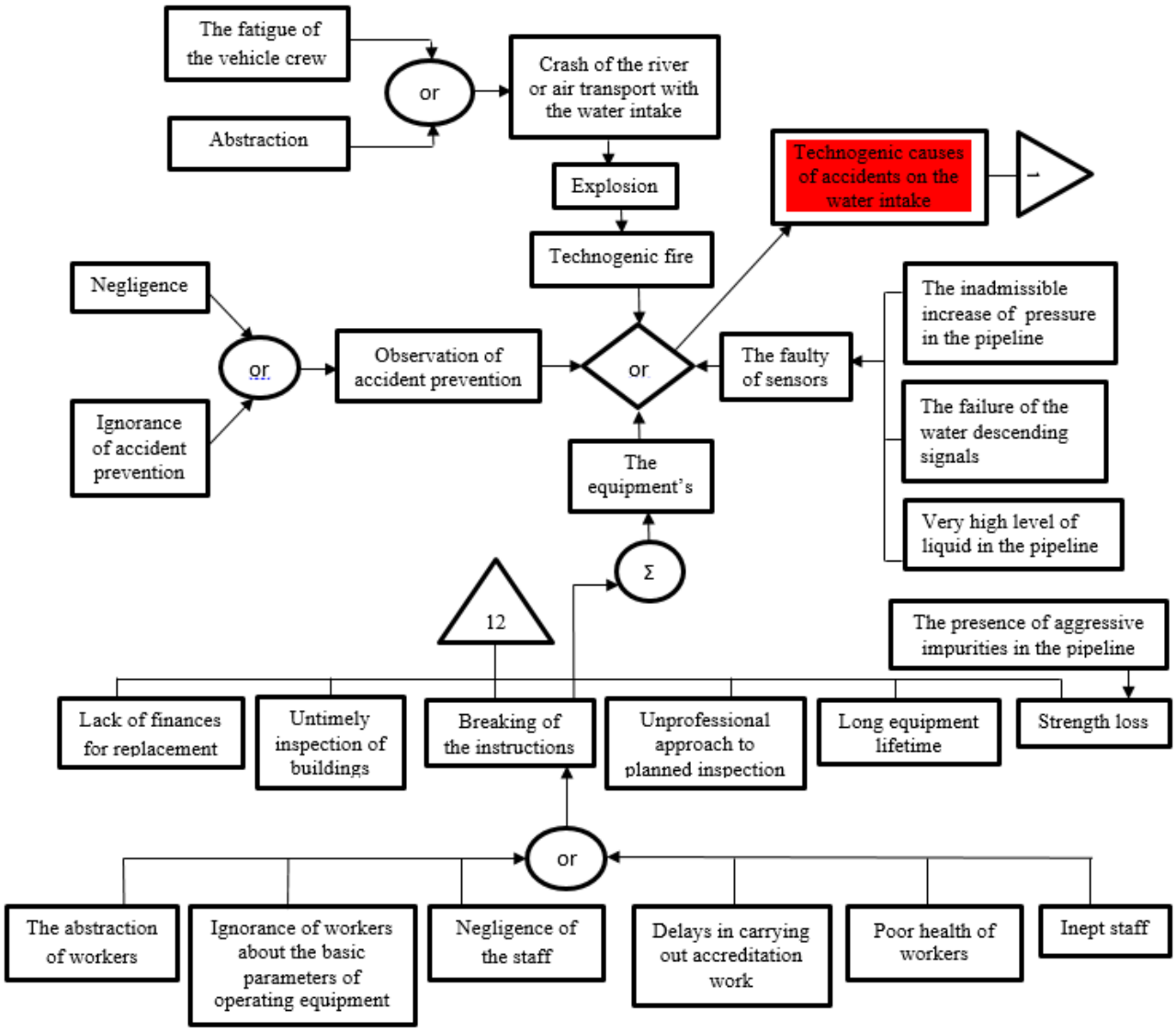

Figure 1 (B) – The tree structure of the chain of events in the systems of water supply of Kazan CHP-2

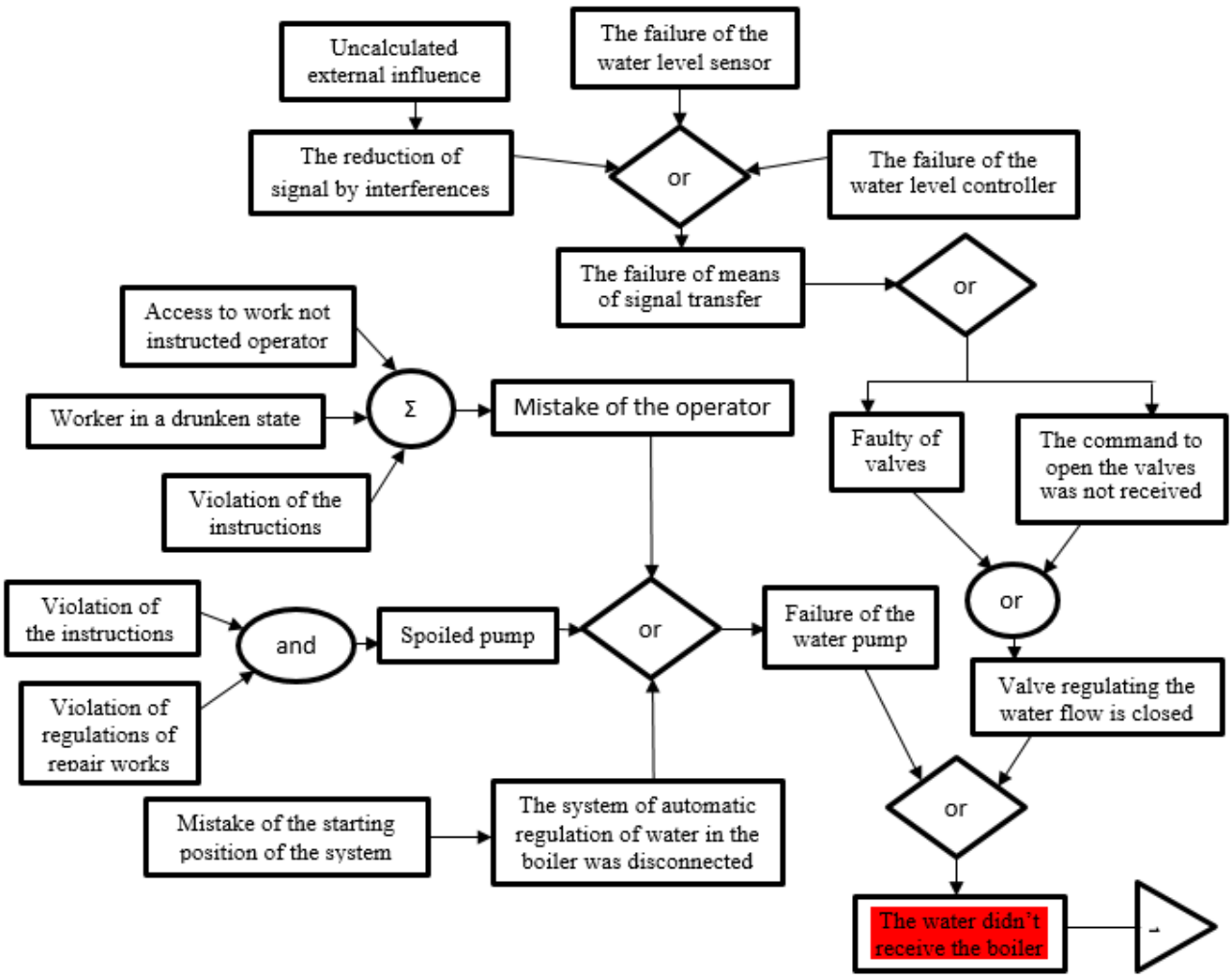

Figure 1 (C) – The tree structure of the chain of events in the systems of water supply of Kazan CHP-2

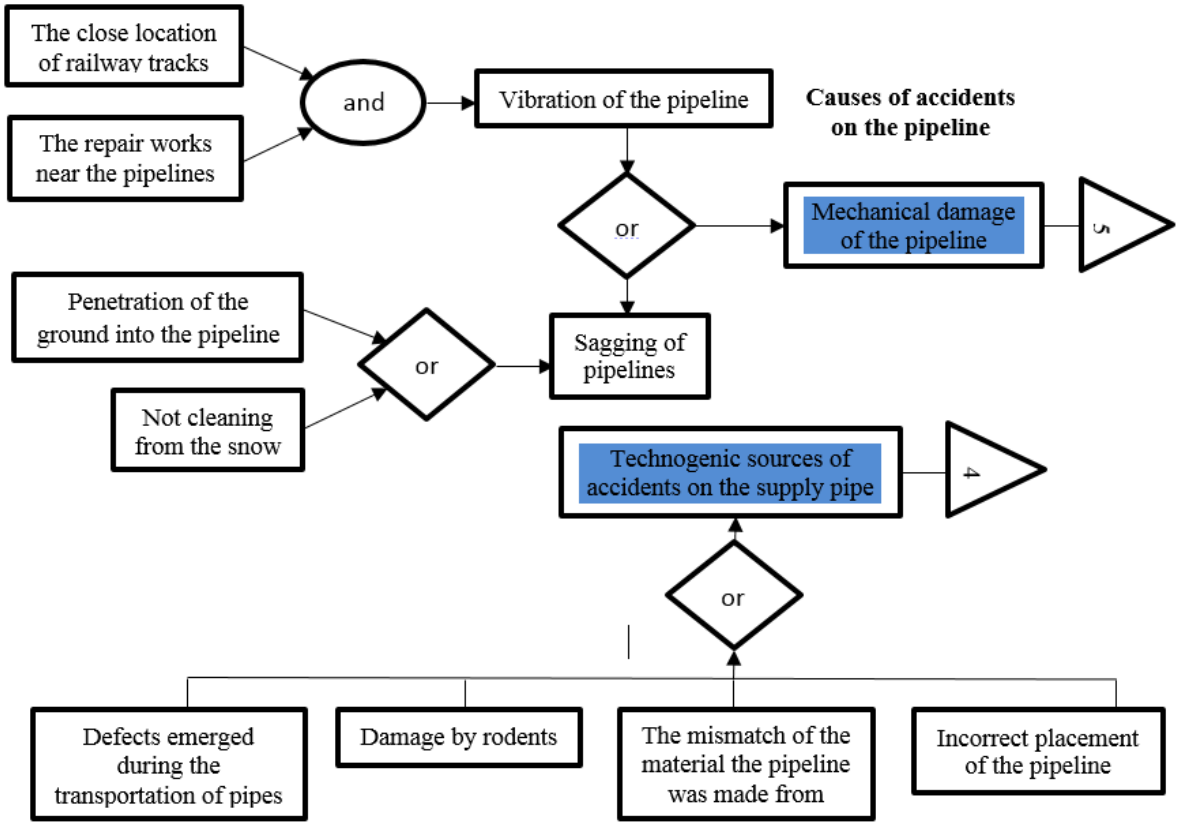

Figure 1 (D) – The tree structure of the chain of events in the systems of water supply of Kazan CHP-2

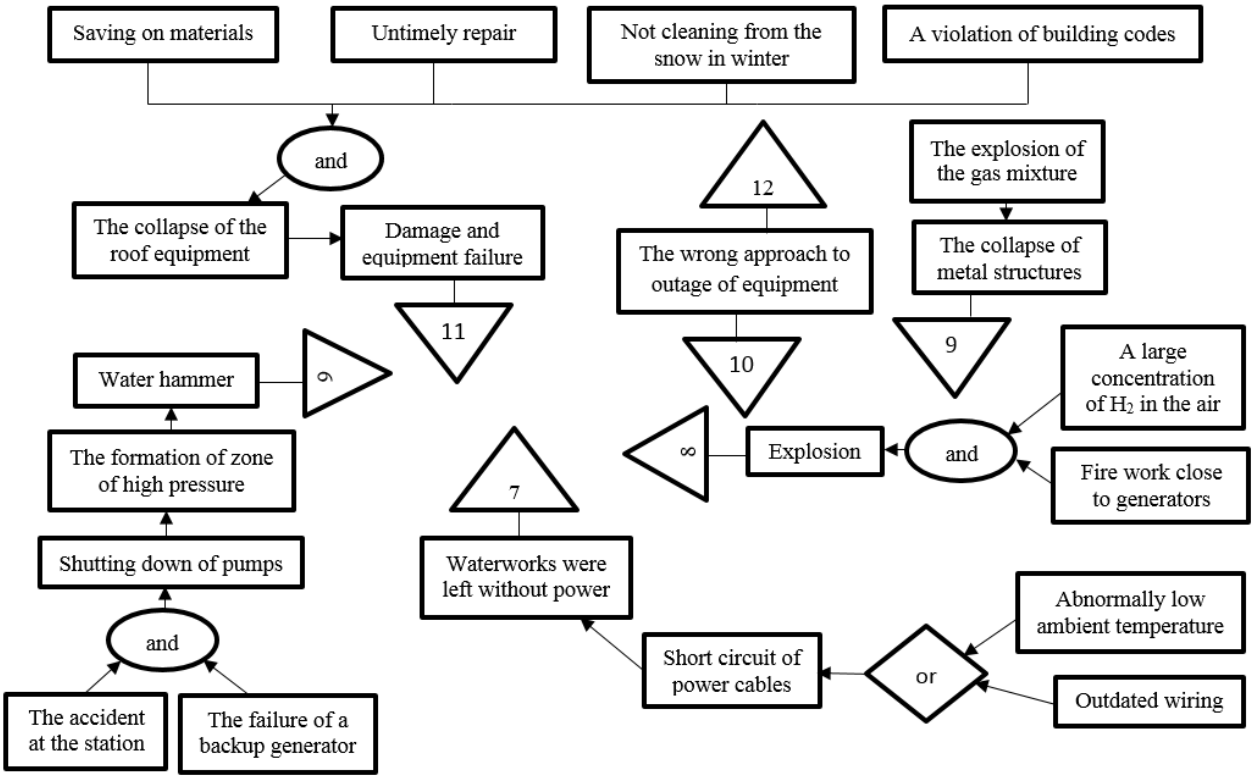

Figure 1 (E) – The tree structure of the chain of events in the systems of water supply of Kazan CHP-2

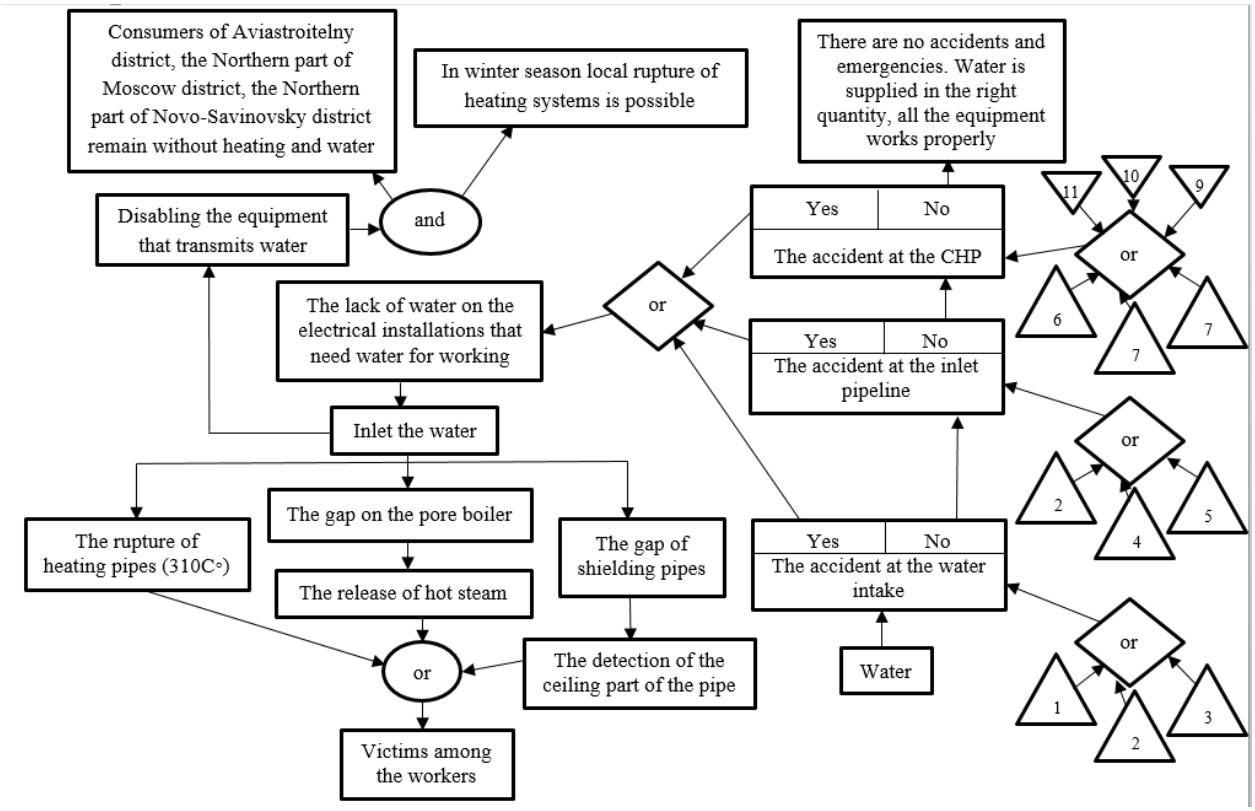

Figure 1 (F) – The tree structure of the chain of events in the systems of water supply of Kazan CHP-2

Despite on the lack of the approved standard and methodical documentation for the risk assessment of accidents on water intakes, there is a number of departmental techniques, allowing to estimate risk of accidents in our country and abroad [6]. The existing techniques of probability of emergence risk assessment are difficult, cumbersome mainly due to the lack and uncertainty of the original data ehe analysis Risks is divided into two types: qualitative and quantitative. Quantitative analysis consists of determining values for risk of adverse events, assessment of the effectiveness of various actions directed to reduction of risk and selecting appropriate solutions. Quantitative analysis consists of determining the probability of final head after the tree structure is created that meets the purpose of the analysis, taking into account the probabilities of the initial events.

Probabilities of input events are given in table 1. Probabilities are taken from various references and statistical data about emergency situations on the territory of Tatarstan Republic for the last 20 years.

In real life, the probability (p) of realization is exactly impossible to calculate, it is only possible to estimate its value. The analysis of literary sources showed that almost no information about the comparison and analysis of the results of the probability calculation of accidents' occurrence by different methods. [6]

Table 1 - Probabilities of initial events

№	The initial event	The probability
1	Lack of resources to replace equipment	$1 * 10^{-3}$
2	Untimely replacement of the outdated equipment	$3 * 10^{-4}$
3	Wrong planning of water treatment systems	$3 * 10^{-4}$
4	Violation of periodicity of repair works	$1 * 10^{-2}$
5	Water blooming	$1 * 10^{-5}$
6	The scarcity of water	$1 * 10^{-4}$
7	Meteorological dangerous phenomenon	$1 * 10^{-6}$
8	Drought	$1 * 10^{-4}$
9	Fooding	$1 * 10^{-6}$
10	Earthquakes	$9{,}8 * 10^{-4}$
11	Terrorism	0,001
12	Distraction of a worker	0,01
13	Ignorance of workers about the basic parameters of operated equipment	$3 * 10^{-5}$
14	Negligence of staff	$1 * 10^{-3}$
15	Failure in carrying out accreditation works	$1 * 10^{-5}$
16	Poor health of a worker	$2 * 10^{-3}$
17	Incompetent staff	$1 * 10^{-4}$
18	Untimely inspection of buildings	$1 * 10^{-4}$
19	Unprofessional approach to planned inspection	$7 * 10^{-4}$
20	Long Equipment lifetime	$2{,}5 * 10^{-5}$
21	The presence of aggressive impurities	$1 * 10^{-4}$
22	Ignorance of accident prevention	$5 * 10^{-7}$
23	Crash of the river or air transport with the water intake	$5 * 10^{-6}$
24	Error the starting position of the system	$2 * 10^{-3}$
25	Deterioration of the material	$6 * 10^{-4}$
26	Worker could be drunk	$2 * 10^{-3}$
27	Access to the operator, who wasn't instructed	$1 * 10^{-5}$
28	An unplanned external influence	$2 * 10^{-2}$
29	Failure of water level Sensor	$2 * 10^{-2}$
30	The failure of water level controller	$0{,}9 * 10^{-4}$
31	Faulty of valves	0,05
32	The order to open the valve wasn't not receive	0,05
33	The defects obtained during the transportation of pipes	$1 * 10^{-3}$
34	The damage of pipe received by rodents	$1 * 10^{-2}$
35	The mismatch between the material from which the tubing is manufactured to the requirements	$2 * 10^{-5}$
36	Discrepancy of the pipeline placement to rules of building	$3 * 10^{-4}$
37	Hit of soil in a water supply system	$7 * 10^{-6}$

38	Lack of snow cleaning	$1*10^{-6}$
39	The close location of railway routes to the pipelines	$1*10^{-6}$
40	Repairs in the vicinity of pipelines	$7*10^{-6}$
41	The accident at the power plant	0,05
42	The failure of a backup generator	$1*10^{-2}$
43	Violation of regulations of building	$1*10^{-4}$
44	Saving materials	$1*10^{-3}$
45	A high concentration of H_2 in the air	$1*10^{-6}$
46	The explosion of the gas mixture	$1*10^{-5}$
47	Fire work close to generators	$1*10^{-3}$
48	Abnormally low temperature of environment	$1*10^{-6}$
49	Outdated wiring	$1*10^{-3}$
50	Faulty of sensors	$0,9*10^{-4}$

We do the calculations by all the branches of the tree structure in accordance with the rules and ratios provided in [7]. The calculation results show that the most possible events are prerequisites for the development of accidents can be:

- Violation of the instructions by the stuff (probability P = 0,013);
- Violation of the instructions by the stuff equipment failure at the water Intake (probability P = 0.002);
- Failure of signal transmission's means because of failure of the water level sensor for water Intake, failure of the water level control or decrease the signal transmission by interference (probability P = 0.04);
- Valve regulating water flow is closed, due to failure of valves or if the instruction at valve opening is not received (probability P = 0,097);
- The water didn't received the boiler because of the valve regulating the water supply is closed or failure of the water feeding pump, (probability P = 0,099);
- Technogenic causes of the accident at the water Intake (probability P = 0.003);
- The technogenic reason of accident is in the intake pipe (the probability P = is 0.102);
- Sagging of the pipeline due to the falling of the soil into the pipeline or lack of cleaning piles from snow (probability P = 0.011);
- The accident at the water Intake because of natural, biological, social and technogenic reason (the probability P = the 0.103);
- The accident at the CHPP-2 due to water hammer or hydraulic structures if the CHP remains without power due to the explosion, collapse of metal structures, illiterate approach to outage of equipment or damage to and failure of the hardware itself (probability P = 0.055);
- The lack of water where it is necessary (probability P = 0,153).

These risks belong to the group of unacceptable risks (R > 1*10-3), a range of activities is needed to minimize them.

In accordance with the methodical instructions developed by JSC "VNIIG named after B. E. Vedeneeva" the risk of danger in water is a measure of hazard characterizing the possibility of ES and the seriousness of its effects people's health, lives, property and the natural environment.

Increasing the General level of natural-technogenic safety, the responsiveness of forces and resources when there is a threat of ES and accidents in water supply systems can be ensured with the help of automated program complex "Safe city".

To reduce the risk of an accident it is necessary to determine the systems of hardware-software complex called "Safe city", using which we can influence the events to reduce the probability of their realization in a given situation. Select the following systems:

1. Warning and awareness systems. The most important condition for the timely adoption of measures to protect the population at threat of major industrial accidents is timely warning. Systems of warning and information allow selectively notify the workers of plants and districts, who are consumers of Kazan CHP-2.

2. The system 112. When receiving emergency calls about accidents on the Ka-zan CHP-2, water Intake, etc. the information is redirect by operators to the unified duty dispatcher service of Kazan and emergency on-line services in accordance with their competence for the organization of emergency response.

3. A monitoring system. Through the automated program complex "Safe city" program the data of systems for monitoring are processes by dispatchers of single service desk.

This system includes:

- The system of monitoring the pressure in pipe networks. Because of a large number of different kinds of connections, as well as the gradual aging and deterioration of pipeline systems, the amount of leaks is growing. The condition monitoring system of pipeline network to fight against hidden leaks (search, localization and elimination) is based on certain concept and uses the telemetry, because it is equipped with devices for data transmission over radio links, cellular networks. The basis of this concept is the separation of the water supply network to the areas of accounting and the flow measurement at the entrance to each district.

- System for early identification of threats deformations pipelines.

- GIS, which allows you to see all components of the security system uninterrupted water supply on a 3D plan of the area with the reflection of their functional conditions, increasing efficiency of elimination of possible technical deviations.

As a result of complex monitoring of the technical condition and monitoring of development of dangerous processes in soil it is possible to achieve high performance in forecasting ES connected with accidents at water intakes. [5]

4. A video surveillance system. Will allow real-time track, to monitor and analyze the situation in case of an accident.

5. The system of fire alarms. In general, a fire alarm designed to detect fire in the initial stage of ignition and transmission of alarm signal to the security panel. It is able to give signal bout the fire or the smoke in the building in time,

thereby notifying about the emergency situation, giving people the opportunity to evacuate urgently and proceed to extinguish the fire.

6. Emergency call system and emergency alarms. This system allows to minimize the risks of assumptions of terrorist attacks and to provide effective complex protection and control through integration of security subsystems into a whole.

7. System of monitoring the housing sector. The system, in particular, helps to control the condition of engineering networks of water supply.

8. Positioning of vehicles. The determination of the emergency services transport moving trajectory, detection of changing the movements of traffic, detection of conditions preventing transport to rich the AS-DPR.

The use of these systems hardware-software complex of technical means "Safe city" will significantly reduce the probability of some event (see table. 2).

Table 2 – The probability of events based on conducted activities

№	The initial event	The probability
1	Violation of periodicity of repair works	$1 * 10^{-4}$
2	Water blooming	$1 * 10^{-6}$
3	The scarcity of water	$1 * 10^{-6}$
4	Meteorological dangerous phenomenon	$1 * 10^{-7}$
5	Drought	$1 * 10^{-6}$
6	Distraction of a worker	0,001
7	Negligence of staff	$1 * 10^{-3}$
8	The presence of aggressive impurities	$1 * 10^{-6}$
9	Error the starting position of the system	$1 * 10^{-3}$
10	Worker could be drunk	$1 * 10^{-6}$
11	Faulty of valves	$1 * 10^{-4}$
12	The order to open the valve wasn't not receive	$1 * 10^{-4}$
13	The defects obtained during the transportation of pipes	$1 * 10^{-3}$
14	A high concentration of H_2 in the air	$1 * 10^{-7}$
15	The explosion of the gas mixture	$1 * 10^{-7}$
16	Fire work close to generators	$1 * 10^{-6}$

Proposed activities APK "Safe city" will help to reduce the risk of events as "the Lack of water on settings which are needed water in the production" in 38 times (see table 3).

The results of the quantitative analysis of the possible consequences of the introduction of hardware-software complex of "Safe city" will allow achieve considerable decrease in risks of emergency situations on industrial objects in Kazan.

Table 3 – Emergency situations, the most likely sources of their occurrence and their probability

№	The reasons of accidents	The probability before using APK "Safe city"	The probability after introduction APK "Safe city"
1	Violation of the instructions by the stuff	0,013	0,001
2	failure of equipment at the water Intake	0,002	0,0006
3	Failure of signal transmission's means because of failure of the water level sensor for water Intake, failure of the water level control or decrease the signal transmission by interference	0,04	0,001
4	Valve regulating water flow is closed, due to failure of valves or if the instruction at valve opening is not received	0,097	0,0002
5	The water didn't received the boiler because of the valve regulating the water supply is closed or failure of the water feeding pump	0,099	0,0004
6	Technogenic causes of the accident at the water Intake	0,003	0,001
7	The technogenic reason of accident is in the intake pipe	0,102	0,0003
8	Sagging of the pipeline due to the falling of the soil into the pipeline or lack of cleaning piles from snow	0,011	0,001
9	The accident at the water Intake because of natural, biological, social and technogenic reason	0,103	0,0002
10	The accident at the CHPP-2 due to water hammer or hydraulic structures if the CHP remains without power due to the explosion, collapse of metal structures, illiterate approach to outage of equipment or damage to and failure of the hardware itself	0,055	0,003
11	The lack of water where it is necessary	0,153	0,004

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SUSTAINABILITY AND ENVIRONMENTAL GAMES

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ABSTRACT

Applying serious games in the teaching process of environmental sustainability, is an up-to-date method. The serious games used for teaching, in order to become sustainable learning tools, have to meet some criteria like Avedon and Sutton-Smith's (1971) and Kirkpatrick's (1994). It was found that serious games are innovative tools for raising environmental sustainability, as they engage students to exchange ideas and help them to actively cooperate in order to experience real life situations. Serious games are innovative tools for raising environmental awareness and consciousness, because they offer fun, engage students in exchanging ideas about sustainability, facilitate active cooperation between students, show real life situations and materialize their dreams for building a sustainable environment.

Key words: sustainability, environmental sustainability, serious games, teaching

1. INTRODUCTION

Many publications on sustainability and technical development, are focusing on the ability to find solutions in which technology, social commitment and sustainability are well balanced. Sustainability, refers to the ability of a system to survive, where all parties of the system consider and take care of quality of life without creating problems to future generations (Morelli, 2011, Lopez, et al, 2014, Allier Forment et al, 2015). Environmental sustainability, according to Morelli (2011) '*…could be defined as a condition of balance, resilience, and interconnectedness that allows human society to satisfy its needs*..'. Sustainable development, as stated by WCED (1987) "*is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs*".

During the Bologna Process in 2005, at Bergen, EEC ministers stated that "*Our contribution to achieving education for all should be based on the principle*

of sustainable development in accordance with the ongoing international work on developing guidelines for quality provision of cross-border higher education". So, sustainability is a lifelong learning process, which refers to a new vision of education, linking the present with the future, where all people live well (UNESCO, 2005, Liarakou, et al, 2007; Reckien & Eisenack, 2013). The Decade of 'Education for Sustainable Development' started under the auspices of UNESCO in 2005, and recently, many educators are interested in the way students apprehend the sustainable development (Hilty, Lohmann & Huang, 2011).

Universities play always, a very prominent role in the development of social responsibility in environmental issues and sustainability. In this arrangement, new teaching methods and practical applications of sustainable development are encouraged (Van Weenen, 2000, Velazquez, et al, 2005). Nowadays, university students, are aware of environmental sustainability, climate change, pollution, and most of these subjects are part of their undergraduate curriculum (Sabah A., et al 2003). University professors, use active pedagogy of teaching, using up-to-date technological tools. Amongst these teaching tools, digital games are very promising as they can enhance students' creativity and consequently can change their behaviors for environmental issues (Hilty et al., 2011, Dyskolia et al., 2012, Pange, 2016). Additionally, digital games for environmental issues support students' knowledge in complex issues by means of a highly interactive way, and they become, effective and innovative tools that intensely engage them in the learning process (Gajus-Lankamer, 2004, Liarakou et al., 2011; Reckien & Eisenack, 2013, Lekka et al., 2015). In serious games students play and adjust their behavior by developing important skills such as problem solving, critical and strategic thinking and at the same time have the opportunity to understand complex issues like environment, sustainability and planning for the future (Goncharova, 2012, Ghilardi-Lopes et al., 2013, Tanenbaum, Antle & Robinson, 2013, Wu, et al ., 2015, Madani, Pierce & Mirchi, 2017, Madani et al., 2017).

In supporting environmental sustainability, educators, can integrate games in their teaching process using digital games. These games for teaching, have to meet some criteria. There are many lists of different criteria for games evaluation. A well-documented list of criteria for games evaluation was suggested by Avedon and Sutton-Smith (1971). These criteria are divided in three categories. In the first category are the criteria related to the *game process* (purpose, results, rules, procedure for action), on the other category are the criteria related to the *environment of the game* (physical settings and environmental requirements, required equipment) and in the last category are the criteria related to the *activities of players* (participants, roles, required abilities and skills, interaction). Analytically, according to the criteria of Avedon and Sutton-Smith (1971), the parameters used for evaluation of serious games are listed below.

<u>Purpose</u>

The term of purpose in serious games is referred to the eventual aim of the game apart from entertainment intended by the designer of the game (Djaouti, Alvarez & Jessel, 2011).

<u>Results</u>

‘Results’ mean, the values assigned to the outcome of the action. The results of the games refer to what experience have the players in real-life simulations and in our case if they are aware on environmental problems.

Participants

That term refers to the minimum or maximum number of participants need for the game, for action. In each game there is a required number of participants needed for action (Avedon & Sutton-Smith, 1971).

Roles of participants

Each participant in a game has a specific role, and it is indicated as function or status (Avedon & Sutton-Smith, 1971).

Rules governing action

Serious games are played in accordance with specific rules. This means that there are fixed principles that determine standards for behavior. Rules are related with the terms of challenge, goals and action and how these are formalized in the context of the game.

Required abilities and skills

According to Avedon and Sutton-Smith (1971) the required abilities and skills refer to the cognitive procedures, the sensory-motor domain that includes movement and motor skills and the affective domain that includes the emotions of the player during the game. (ie the player must know how to use a computer).

Physical setting and environmental requirements

In “physical setting and environmental requirements”, Avedon and Sutton-Smith(1971) refer to the usual environment needed for the game.

Required equipment

With the term “equipment” Avedon and Sutton-Smith (1971) mean all the artifacts that are necessary to be used during the game.

Procedure for action

Each game has different steps during play, and it is tested where a specific procedure is required in order to reach the desirable results.

Interaction

Within each game we examine if there are characteristic of interactivity.

Later, Kirkpatrick (1994), have suggested another model concerning the effectiveness of a training activity, using serious games. This is a four-level model as it is presented in Table (1).

Table 1 – Kirckpatrick’s levels of training evaluation

Level 1	*Reaction*
Level 2	*Learning*
Level 3	*Behavior*
Level 4	*Results*

According to this model, Level 1 evaluates the responding of the participants about the training process, Level 2 assesses learners' knowledge, skills and attitudes, Level 3 measures the degree to which participants are able to apply what they have learned into practice and Level 4 evaluates the objective outcomes.

The aim of this study is to present four serious environmental games, the scope of the game and what issues of sustainability and environmental awareness these games can raise, in relation to the criteria of Avedon and Sutton-Smith's (1971) and Kirkpatrick's (1994) models.

2. MATERIALS & METHODS

Four serious online games concerning environmental issues are randomly selected as a pilot study for teaching environmental sustainability. They are evaluated using the criteria of Avedon and Sutton-Smith's and Kirkpatrick's, afterwards.

Namely the games are:

- Sim City 4 (http://www.simcity.com/, https://en.wikipedia.org/wiki/SimCity)
- Electrocity (http://www.electrocity.co.nz/)
- Plan It Green (http://www.primarygames.com/holidays/earth_day/games/planitgreen/)
- World Without Oil (WWO) *(http://writerguy.com/wwo/metahome.htm)*

Especially, Sim City 4 is a commercial city management game with 3D-graphics where the player has to develop and organize his/her own city trying not to make it an inhospitable place for its citizens. Electrocity and Plan It Green are two educational city-management games, designed especially for primary school students in order to disseminate them with ecological and environmental issues. WWO, is a serious game about energy and safety. In WWO a current global oil shock causes multiple economic, social and environmental consequences. WWO can also be described as an alternate reality game (ARG, http://www.avantgame.com/ McGonigal_ARG_Austin Game Conference_Oct2005_abbr.ppt).

3. RESULTS

THE EVALUATION OF FOUR SERIOUS GAMES ACCORDING TO AVEDON AND SUTTON-SMITH'S CRITERIA

In this pilot study, three city management games (Sim City 4, Electrocity, Plant It Green) and an alternate reality game (WWO) are analyzed according to Avedon and Sutton-Smith's criteria for games.

The results of the evaluation of all games for teaching and learning environmental sustainability are presented in Table 2.

Table 2 - The elements of Avedon and Sutton-Smith in the examined games

	Game			
Criteria	***Sim City 4***	***Electrocity***	***Plan It Green***	***WWO***
Purpose	City development/ happiness of the citizens	City development/ with minor environmental impact	Development of a "green" city	Presents a Solution for a realistic disastrous scenario
Results	The player must learn how to manage a city. The game offers skills for development of environmental sustainability	The player must develop environmental consciousness. The game offers skills for development of environmental sustainability	The player must develop environmental consciousness. The game offers skills for development of environmental sustainability	The player must develop environmental consciousness. The game offers skills for development of environmental sustainability
Participants	Individual, and multi-player mode	Individual players	Individual, and teams of players	Individual players
Roles	Mayor	Mayor	Mayor	Citizen
Rules	No specific rules	No specific rules	No specific rules	No specific rules
Required abilities	Knowledge of computer use, knowledge of environmental terms			
Physical settings	No physical settings were needed			
Required equipment	Internet Access (optional)	Internet Access	Internet Access	Internet Access, blog
Procedure	The player has to create a city from the beginning, gain achievements and follow missions.	The player has to create a city from the beginning	The player has to turn the city into eco-friendly and follow missions	The player has to watch the weekly journal and express opinions
Interaction	individual, and combined	individual, and combined	individual	individual, and intragroup

In our case, for all four games, no physical settings and environmental requirements are needed. Especially, according to this analysis, three of them have been created mainly to develop environmental consciousness (Electrocity, Plant It Green, WWO) and the other one, was a game dealing more with environmental issues of a city.

In these games the players have to act as the Mayor of the town (Sim City 4, Electrocity, Plant It Green) or as a citizen who tries to find a realistic solutions about a global sustainability problem (WWO). The role of the Mayor, in the game is an important one, so the player has to think in a sustainable way how the city will remain clean and without pollution in the future. This supports the suggestion that games can play an important role in promoting environmental sustainability to players. Additionally, all these games include useful training material for teachers to teach environmental sustainability as they show real life situations.

EVALUATION OF THE FOUR SERIOUS GAMES ACCORDING TO KIRKPATRICK'S LEVELS

The four games are assessed according to Kirkpatrick's criteria, in respect of reaction, learning of environmental terms, changing learners' behavior in environmental sustainability and development of environmental consciousness.

Table 3 – Evaluation according to Kirkpatrick's criteria

Level	**Game**			
	Sim City 4	***Electrocity***	***Plan It Green***	***WWO***
1.**Reaction**	All games engage and motivate students to learn through entertainment. They offer enthusiasm and satisfaction, to players. In some cases they offer suspense.			
2.**Learning**	Familiarization with environmental issues. Especially, all four games familiarize the students with the terms of recycling, energy efficiency, solar-and-wind energy, waste-and-water management, coal-and-gas prospecting and extraction-and-oil dependence.			
3.**Behavior**	Gives opportunities to players to change their behavior for environmental issues through these games.			
4. **Results**	According to the level of accomplishment, the games develop environmental consciousness to the players and change the behavior of the players.			

These levels of evaluation are listed below as: reaction, learning, behavior and results. The results for each game are presented in Table 3.

4. DISCUSSION AND CONCLUSIONS

Environmental sustainability is an important topic to be introduced at university undergraduate level using serious games. The current study shows that teachers can benefit of the free online serious games for teaching sustainability and especially environmental sustainability because, all these online serious games promote player's creativity, develop analytical skills for environmental sustainability and improve environmental consciousness. The main issue is to evaluate them according to a set of criteria, of effectiveness, before their application to the learning process. The criteria of Avedon and Sutton-Smith (1971) and Kirkpatrick (1994) provide enough information about the purpose of the game, the results of the game the underlying rules, the procedure for action of the player, the physical settings, the environmental requirements, the required equipment, the roles of the participants, the required abilities and skills, and also the interaction in between players.

In conclusion, serious games are innovative tools for raising environmental awareness and consciousness, because they offer fun, engage students in exchanging ideas about sustainability, facilitate active cooperation between students, show real life situations and materialize their dreams for building a sustainable environment.

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COMPUTER MODELLING OF PHYSICAL PROCESSES USUNG FOR MUFFLERS DESIGN

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ABSTRACT

This article is dedicated to the construction of the virtual muffler of the high powered ICE exhaust. Among the studied before experimental modelling mufflers, the prototype model was chosen that satisfied the engineers with its acoustic parameters. A scale-up from the prototype model to the virtual muffler of the high powered ICE – a full-sized construction – was made, with the chambers number determination, the set of modules specification, the inlet and outlet mutual bracing. During the designing the numerical modelling of gas dynamic processes of the exhaust gases escape was made, as well as the numerical study of the virtual muffler construction's natural frequencies for the structural members' choice, providing the sufficient toughness and the vibration parameters cut.

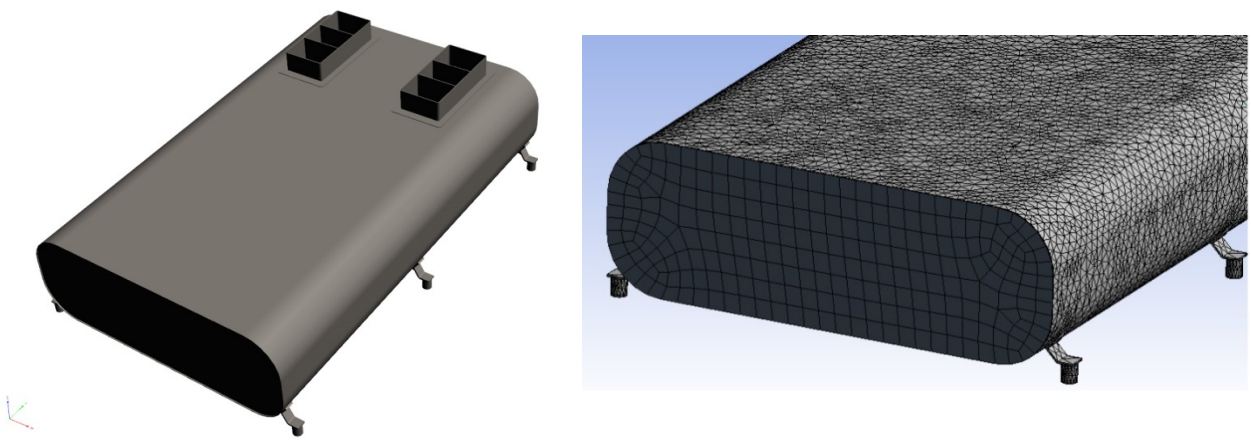
Key words: mufflers, modeling, gas dynamic processes

At designing the high powered internal combustion engines (ICE) exhaust noise mufflers (will conventionally take the ICE of 1 MW and more power as such) the development process usually needs multiple expensive field tests because of the lack of study of the relations between the gas dynamic processes in the exhaust paths and muffler's vibration and acoustic parameters. The numerical modelling of the gas dynamics of the high speed and temperature exhaust gases flow processes, as well as the oscillating processes, arising in the muffler's members, allows essentially cheapening and cutting the muffler's design development time. The objective of creation of the high powered ICE mufflers with the minimized parameters of the members' vibration is crucial.

During the modernization of the source design of the mainline locomotive's diesel generator (DG) exhaust system noise muffler, which unacceptably fast broke because of the high vibration levels, the authors obtained the volumes of the bending vibration natural frequencies of the muffler's shell and the distribution pattern of the exhaust gases dynamic properties for different ICE operational modes by the numerical modelling methods. This allowed multi parametric optimization of the muffler's design, including the backup pressure created by it, as well as reaching the great virtual muffler's design hardness increase by introduction of the members initiating the exhaust gases flow in the muffler linearization. The designing of the full-size virtual muffler construction was preceded by the choice of the prototype model among a great number of the experimentally studied model mufflers before at BSTU «VOENMEH» named after D.F. Ustinov [1].

The most difficult is to determine the acoustic properties and, in particular, the acoustic effectiveness of the designed muffler by the numerical methods, that is why the experimental data usage is expedient. A scale-up from the prototype model to the virtual high-powered ICE muffler was made by the authors, with the specification of the major modules set, the chambers number determination, the in and out openings mutual bracing. During the designing the numerical investigations of the mufflers models' natural frequencies and the modules choice, providing the necessary design hardness and the vibration parameters from the exhaust gases affect decrease, were made. The modernization was conducted by the changes to the virtual muffler design introduction during the numerical multi parametric optimization.

The physical configuration of the source blow off noise muffler is provided in the fig. 1. The exhaust gas from the diesel generator flows to the muffler's chamber through the round in section pipe underneath, and then, flowing through the muffler's chamber, enters the atmosphere through two upper exhaust stacks with the outlet summed area 1.5 times more than the inlet area.



a) b)

Figure 1 - a) Locomotive muffler's physical configuration; b) Segment of finite-element computing grid

The modelling of the source muffler tridimensional solid model was made, the segment of which is provided in the fig. 1 b. The computing grid contained 101 957 nodes. The computing modelling is the simultaneous equations solution itself:

$$[m]\frac{d^2}{dt^2}\{U\}+[C]\frac{d}{dt}\{U\}+[K]\{U\}=\{P(t)\}+\{P^q(t)\}+\{P^g\} \quad (1)$$

Where t-time, $[m]$- model's masses matrix, $[C]$-damping matrix, $[K]$- the finite element model stiffness matrix, $\{U\}$- nodal displacements vector, $\{P\}$- the general vector of the specified outer nodal forces, $\{P^q\}$- the general vector of the specified outer nodal forces, equal to the distributed surface forces, $\{P^g\}$- the general vector of the outer nodal forces, equal to the distributed mass forces.

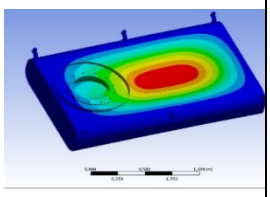
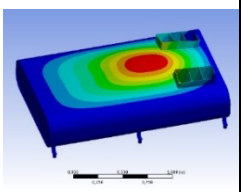
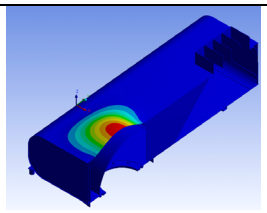
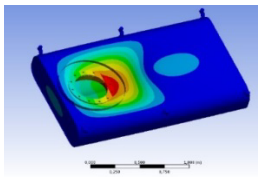
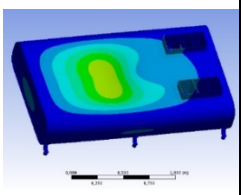
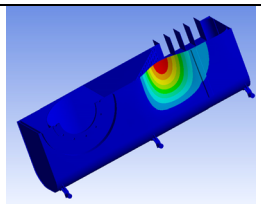
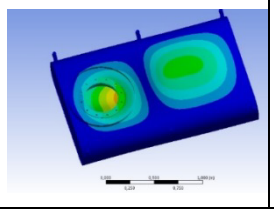
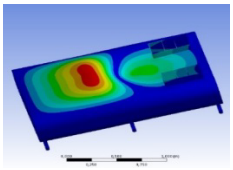
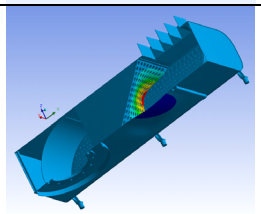
By means of a calculation the volumes of the natural frequencies of the bending vibration for the source model were obtained, provided in the table 1, column 2. The columns 4 and 5 provide the view of the first three natural frequencies forms, as the visualization of the vibration displacement ranges for the developed geometric model at these frequencies.

The areas of the design vibration displacement with the calculated volumes are marked in the pictures by different colors: from the minimal (blue color) to the maximum (red color). The visualization provides the vivid qualitative view of the muffler's shell members stiff bending deformations parameters distribution and allows determining, in terms of the fatigue limit, the most dangerous areas layout.

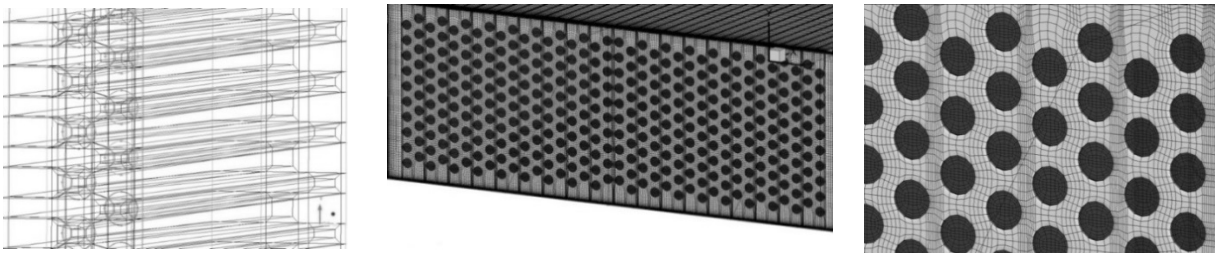
To reach a great shift of the design natural frequencies to the higher volumes by increasing the design stiffness at impossibility of the walls thickness increasing is possible by introduction of the additional modules. It was decided to provide the numerical optimization of the design on the two-chamber virtual muffler's with a single perforated baffle plate.

The introduced elements for the muffler's design stiffness increase at the same time should positively affect the gas dynamics view of the gases flow. The computing modelling of the exhaust gases flow was made in the CFD software suit of the "extra" class by the control volume approach and is the three dimensional Navier-Stokes Reynolds-averaged simultaneous equations solution [2]. The simultaneous equations closure is carried out by connection of the Menter shears two-parameter model $k-\omega \quad SST$. The solution was done in the steady position by the settling principle.

Table 1 – Natural frequencies of the standard and modernized mufflers design with the natural frequencies forms visualization

Item of the Personal Form	Muffler's Models Natural Frequency, Hz		The Natural Frequencies Forms Visualization (the Vibration Displacement Ranges of the Geometric Model):		
	Standard	Modernized	Standard muffler		Modernized muffler
1	2	3	4	5	6
1	27	45			
2	39	60			
3	46	73			

The computing grid (fig. 2) for the conducted calculations contained 200 000 nodes. For the correct computing of the gas dynamics parameters the fine grid to the design walls in the boundary layer was made. The computational domain is taken as consisting from the ½ of the muffler's chamber taking into account the accepted supposition of the flow symmetry regarding the middle place. The boundary conditions are the following: the gas inflow condition with the bulk flow corresponding to the DG (diesel generator) typical operational modes is established at the inlet boundary.



a) b) c)

Figure 2 – Block-structured computing grid: a) block structure near the holes of the baffle plate; b) a segment of computing grid; c) the enlarged view of the computing grid near the perforations.

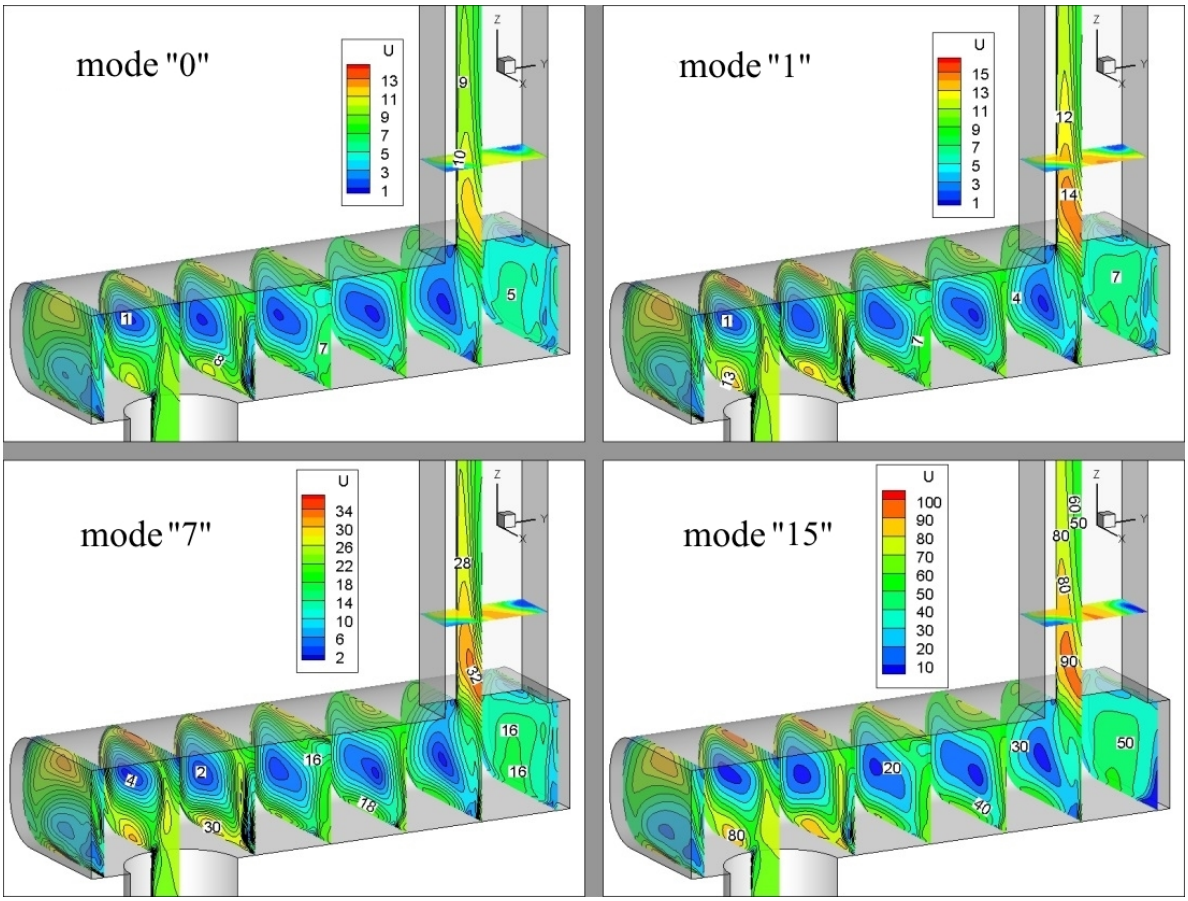
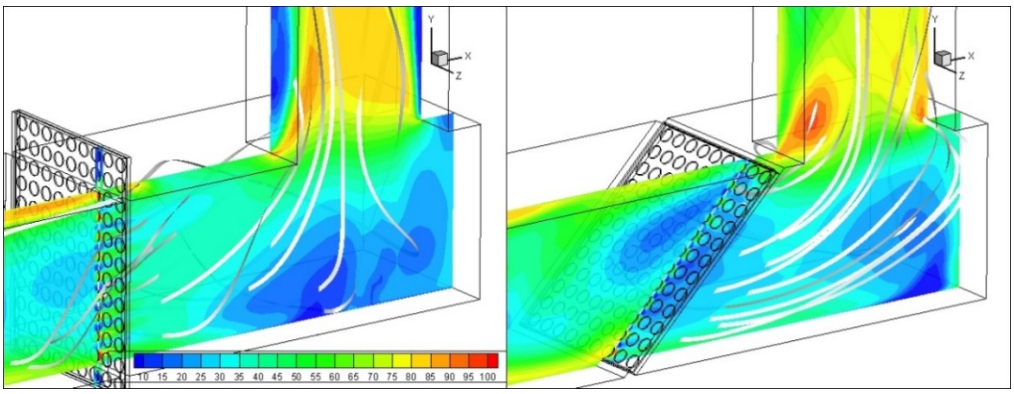


Figure 3 – The views of the velocity modulus distribution, m/sec

The gas temperature is taken as 675 K. The static pressure of 0 atm gauge condition modes is established at the outlet boundary. The view of one of the exhaust gas dynamics parameters – the velocity modulus – distribution in different cross-sections of the standard muffler is provided in the fig. 3. The views of the velocity modulus distribution are provided for four studied DG operational modes.

The modernized muffler's design optimization scheme can be studied on the example of investigation of the perforated baffle setting angle effect on the backup pressure volume and the gas flow degree of uniformity inside of the virtual muffler. The perforated muffler can be set inside of the chamber at different angles to the flow direction (fig. 4). Basing on the computing modelling of the exhaust gases flow in the muffler's chamber the parametrical investigation of the setting angle effect on the back pressure volume and the gas flow degree of uniformity was conducted. The investigations of the effect on the specified factors of the baffle location and its flowing through area were made. The energy losses, spent by the flow for supporting of the created vortex flow, lead to the resistance and back pressure volume increase that negatively affects the virtual muffler's effectiveness parameters and the real muffler's operational reliability. The existence of so high flow nonuniformity with a vivid flow unsteady vortex structure can serve as additional sources of the acoustic pulsation and vibration stresses on the real design walls.



a) b)

Figure 4 – The speed and flow lines distribution in one of the investigated planes of the exhaust gases flow at setting the separating plate cross flow (a) or at 45° angle (b)

The comparative analysis of the exhaust flow gases in the virtual muffler's chamber at different setting versions of the separating baffle was done in accordance to the view of the flow lines dimensional distribution. As it is seen from the image 4, the separating baffle, set cross flow of the exhaust gases, creates the essential tridimensional vortex flow on the back side with the circulation areas. The setting angle, optimal in the conditions of this design and the operational mode, is of the 30° volume to the lower wall of the chamber. The separating baffle through flow area volume was optimized. The necessity of the outlet opening area enlargement was also analyzed. The effect on the flow parameters of other introduced modules was similarly studied.

As a result of the conducted virtual design analysis, the general conception of the modernized muffler was provided in the fig. 5. The main purpose of the additional modules is: firstly, in the design stiffness increasing, secondly, the exhaust gases flow gas dynamics view «improvement».

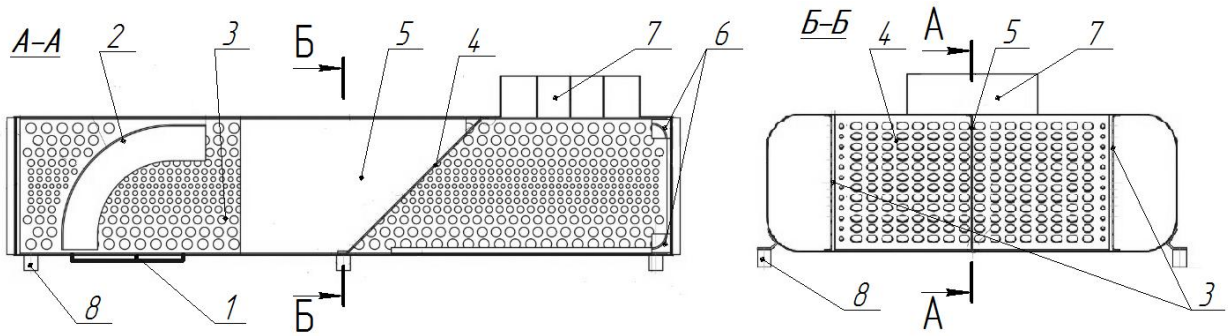
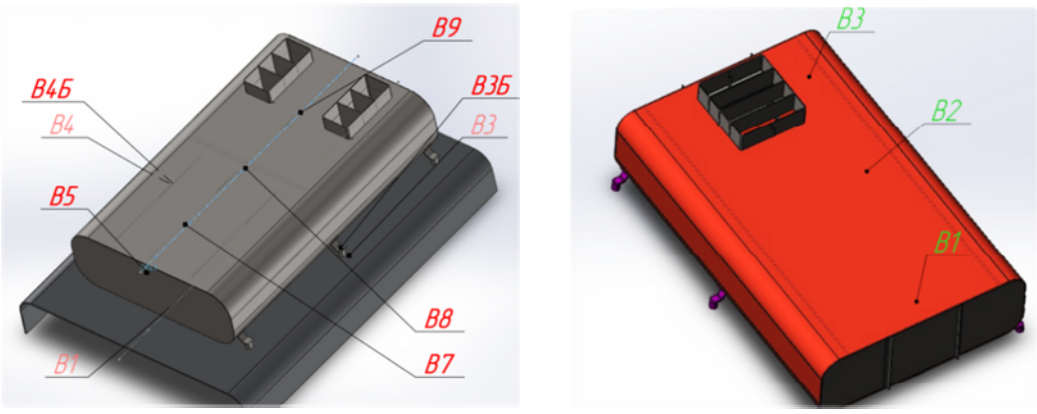


Figure 5 – The sketches of the axial (А-А) and cross (Б-Б) sections of the modernized muffler, where: 1 – the inlet opening flange; 2 – the shaped baffle plate; 3 – the axial plate (2 it.); 4 – the cross perforated baffle; 5 – plate; 6 – dome (2 it.); 7 – outlet pipe; 8 – fastening element (6 it.)

After the design optimization regarding the gas dynamics parameters the calculation of the natural frequencies and the vibration modes of the modernized muffler model was conducted. The natural frequencies of the of the modernized muffler's model, obtained as a result of calculation, are provided in the column 3 table 1. The essential increasing of the natural frequencies, provided in the column 4 comparing to the volumes of the column 3, shows and essential increasing of the modernized design stiffness, comparing to the source one. The 1.5-2 times increasing of the natural frequencies volumes allows preventing the resonances of the shell's bending vibrations. The visualization of the design model's vibration form of the modernized muffler is performed in the column 6, table 1.

After the optimization of the modernized muffler design the test sample was produced for the field test conducting. During the rheostatic tests of the series locomotive the experimental determination of the test muffler acoustic parameters as a part of the exhaust system, the design vibration parameters, exhaust gases flow gas dynamics properties was conducted [3].

Also the measurement points of the shell's members vibration signal of the source and modernized muffler are shown in the image 6.



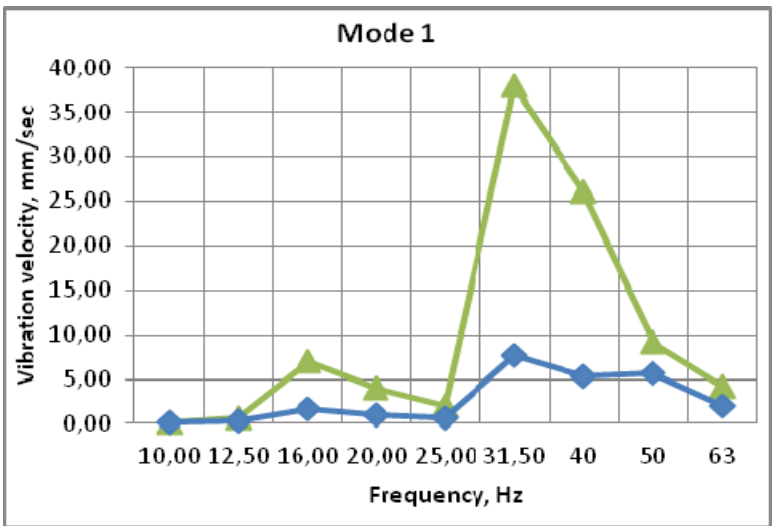
a) b)

Figure 6 – Measurement points of the shell's members' vibration signal location: a) source design; b) modernized

During the experimental investigations of the modernized muffler the measurements of the following parameters were conducted: the sound-pressure level SPL, dB, sound level SL, dBA, of the locomotive exhaust system with the installed modernized muffler (comparing to the source design); vibration acceleration (vibration speed, vibration displacement) or the adverse measurement points on the modernized muffler shell (comparing to the source design); the modernized muffler's backup pressure volumes.

The acoustic effectiveness of the modernized muffler was 9 dBA increased and became 14 dBA (10-20 dBA in the middle- and high-frequency range).

The comparative data of the vibration velocity provided in fig. 7.



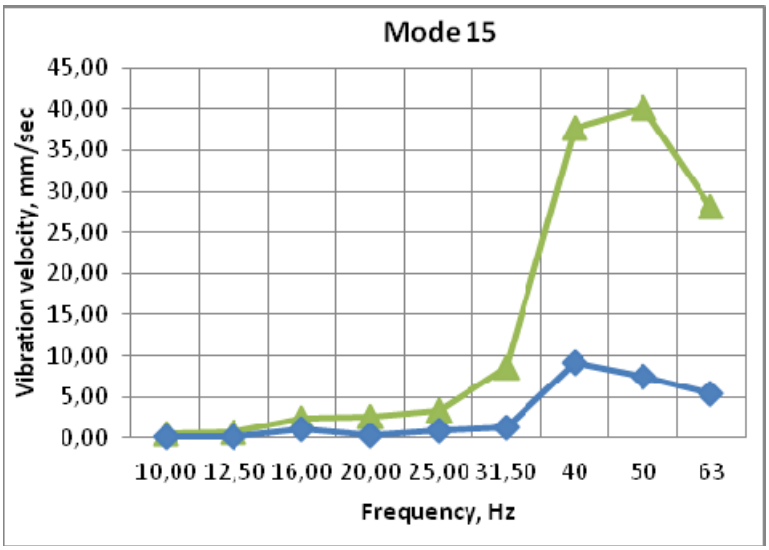


Figure 7 – The vibration speed volumes at the measurement points at the outlet opening of the mufflers - source (B 9, green line) and modernized (B3, blue line) at the same operational modes

The highest volumes of the vibration displacement were noticed for the standard muffler at the measurement points B7, B8 and B9 in the direction of the axe Z, and for the modernized muffler at the points B1, B2 and B3, appropriately, in the same direction at all DG operational modes (fig. 6). The degree of the vibration displacement volume reduction for the dangerous zones of the modernized muffler, comparing to the standard one, was from 10 to 25 times for the most adverse points at the modes of the high power. The reduction of the vibration displacement absolute volumes for all the measurement points on the modernized muffler's shell, compring to the source one, was noticed at all DG operational modes 2-3 times averagely.

The created by the modernized muffler measured back pressure did not exceed the limited volume (4.9 kPa) at all locomotive engine's operational modes.

CONCLUSIONS

The field observation of the muffler design, created by using the results of computing modelling of the exhaust gases flow gas dynamics and the vibration processes, arising in the muffler's design members, performed: the effectiveness of the modernized muffler 9 dB increased (comparing to the standard one), the vibration was 10-25 times reduced (for the separate shell points, and in average 2-3 times for all) without the increasing of the backup pressure. This testifies the expediency of the physical processes computing modelling approaches usage during the designing of new noise mufflers and optimization of the existing designs.

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FROM "REVIVAL OF THE VOLGA" TO THE "IMPROVEMENT OF THE VOLGA": COMPARING THE TARGET FEDERAL PROGRAMS PASSPORTS

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ABSTRACT

The passports of two federal programs aimed at solving key tasks to reduce both anthropogenic impact and the discharge of polluted waste water as well as the liquidation of the accumulated environmental damage, which threatens the water objects of the Volga river basin are compared. The solution of global environmental problems, environmental problems in Russia, in the Volga Basin, the achievement of sustainable development and environmental safety of the territories is impossible without the foundation of the basics of environmental management culture, without the training of environmental specialists of the highest and current level. This poses the problem of improving environmental education in a number of the most important strategic problems of the country's development.

Key words: environmental damage, river basin, federal programs.

1. INTRODUCTION

Ecology as an interdisciplinary field of knowledge unites the main provisions of classical biological, landscape, applied ecology and human ecology. The solution of the global environmental problems that humanity faced in the second half of the twentieth century, achievement of sustainable development goals and environmental safety of the territories is impossible without a constructive system approach to the solution of numerous environmental management tasks, without profound scientific study of all aspects of interaction in the system "Nature - Man", without laying the foundations of the ecological culture of the population. Brilliant examples of the "ecologization" of the natural sciences can serve the ideas about the *biosphere* and the *noosphere*, offered by probably the last encyclopedist of the twentieth century Academician V.I. Vernadsky as well as the notion of *universal evolutionism* by Academician N.N. Moiseyev.

President of the Russian Federation V.V. Putin on January 5, 2016, Putin signed Decree № 7 making 2017 the Year of Ecology in the Rusian Federation. In his annual address to the Federal Assembly (December 1, 2016), the president instructed the cabinet of ministers to prepare programs of preservation of Russia's unique nature symbols. "The next year, 2017, has been declared the Year of Ecology. I instruct the government to prepare programs for the preservation of unique nature symbols of Russia, such as the Volga River (*We emphasize, the Volga is in the first place- Author's note*), Lake Baikal, Altai's Teletskoye Lake", Putin said. (List of instructions of President of the Russian Federation V.V. Putin dated December 5, 2016 No. Pr-2346). The prime minister of the Russian Federation Dmitry Medvedev on December 8, 2016, made his assignment No. DM-P13-7461 to the Ministry of Natural Resources of Russia to prepare and submit to the Government of the Russian Federation the passport of the priority project directed to preservation and prevention of pollution of the Volga River ("Improvement of the Volga") within the framework of the strategic development of the Russian Federation "Ecology". These instructions were fulfilled, and such a Passport was presented to Dmitry Medvedev on August 8, 2017 at the meeting on preservation, prevention of pollution and rational use of the Volga River within the Improvement of Volga project in Volgograd. The project purpose (Passport for 2017-2025) is to reduce amount of the polluted sewage dumped to the Volga by nine times, to liquidate the most dangerous objects of the saved-up ecological harm, to provide preservation of a biodiversity and to preserve the unique system of the Volga river basin.

2. A FEW WORDS ABOUT THE VOLGA RIVER BASIN

The Volga River (*Rā*, Itil) is a great Russian river which has long served not only as the wet nurse of the people, but has also become a consolidating pivot in the history of the Russian state, its symbol. For centuries, the emerging balance between natural processes in such a vast basin as the Volga (1.36 million km^2, two territories of France or the three of Sweden) and directly in the Volga River (length is over 3.5 thousand km) was disturbed by the regulation of its runoff. The

construction of a large number of dams and industrial facilities not only led to the creation of a "powerful energy-transport-irrigation economic complex of the Volga Basin" for the development of large industrial units, including some electric power production (for example, electrochemistry and electrometallurgy) "(m more detailed references can be found in the monograph [1]), as was mentioned in the Resolution of the November 1934 session of the USSR Academy of Sciences devoted to the problem of the Volga-Caspian Sea, but also led to significant losses in flow rate, which naturally led to significant changes in aquatic and terrestrial ecosystems.

As a result of hydro-construction (eight hydro-electric stations of the Volga-Kama Cascade of dams were built, see Table 1), more than 2 million hectares of highly productive flood lands were flooded (including more than 1 million hectares of arable land, hayfields and pastures; total of 65 million hectares of arable land and 75 million hectares of forest were located in the Volga Basin by the early 1960s), about 650,000 people, 290 settlements, 35,500 households and almost 7,000 community buildings were moved from the reservoir zone. At the same time, the total electricity production was about 50 billion kWh per year (the potential reserves of the water resources of the rivers of the Volga Basin are estimated at about 100 billion kWh per year [2, p. 19]). In other words, one square meter of the flooded fertile land "gives" 2.5 kWh of electricity per year (of course, this is a rough estimate, but it also indicates the extremely irrational nature of the use of these territories for energy purposes).

Table 1 - Some characteristics of reservoirs of the Volga

Reservoir	**Years of reservoir filling**	**L**	**S**	**SG**	**V**	**W**	**N**
Ivan'kovskoe	1937	145	41	327	1,12	0,1	19,5
Uglichskoe	1940	136	59	249	1,24	0,2	24,6
Rybinskoe	1940-1949	250**	143	4550	25,42	0,9	116,7
Gor'kovskoe	1955-1957	448	221	1591	8,82	1,5	47,7
Cheboksarskoe*	1982-1985	340	594	2190	13,80	3,3	42,7
Kujbyshevskoe	1955-1957	484	1187	5900[5]*	58,00	19,8	150,0
Saratovskoe	1967-1968	348	1266	1831	12,37	5,3	25,3
Volgogradskoe	1958-1960	546	1332	3117	31,45	10,9	50,0
All reservoirs of the Volga-Kama Cascade		3000	1360	20700	143,8	49	642,9

Notes. L – length (km); S – catchment area (thousand km^2); SG – mirror area (km2); V – the total volume (km^3); W – electricity generation (billion kWh per year); N – resettled residents (thousand people); * – design NRL (normal retaining level); ** – length from Uglichskaya to Sheksna dam.

After the construction of the reservoirs of the Volga-Kama Cascade, all the "mud" from the catchment area is being washed away for a dozens of years during the spring floods (not by any ecological principles) and during summer and autumn rain floods (industry and agriculture in the Volga Basin give a significant part of all of Russia's output and, correspondingly, the anthropogenic load on the region is proportional to this): annually up to 20% of all sewage waters of Russia are dumped into the basin, in the atmosphere of densely populated cities in the Volga region, nearly 30% of all harmful substances released in Russia are emitted annually; 26 "peaceful" nuclear explosions were conducted on the territory of the Volga Basin (in order to solve the problems of the national economy of the country) – almost 20% of all nuclear explosions produced in Russia. All this, in the end, falls into the water. The Lower Volga (7.6% of the water runoff) is the least loaded with wastewater; for the Middle Volga, the total load is 9.2%, for the Lower Volga - 9.4%. A consequence of such chronic loads has become a steady contamination of water and bottom sediments (for more details see: [1, 3]).

The sizes of dangerous pollution zones formed in the places of discharges of large industrial centers can reach several kilometers, in the epicenters of these zones the concentration of chemicals can exceed the background indicators and MPCs by tens of times, there is an intensive accumulation of pollutants in the bottom sediments; there is a disturbance in the structure and functioning of the hydrobiocenoses. The Volga River, in comparison with other major Russian rivers, is subject to the greatest anthropogenic load from sewage (Table 2). At the same time, the differential load on the Volga for individual pollutants is 4-28 times higher than for the Ob, and 7-196 times for the Yenisei.

Table 2 - Distribution of the anthropogenic load along the main rivers of Russia

River basin	**Area, thousand km^2**	**River flow, km^3/year**	**Wastewater volume, km^3/year**	**Wastewater loading, %**
The Volga	1360	254	18,1	7,1
The Ob	2990	404	6,7	1,7
The Yenisei	2580	630	3,2	0,5
The Lena	2490	532	0,12	0,02

We can judge the decrease in the productivity of the river in catching fish amount. According to the data of 1948-1950, the Volga River basin within the Kuibyshev Reservoir was a fishing area where the average annual fish production was 22.8 thousand centners or about 24 kg per 1 hectare of water surface. After 50 years, this estimate decreased more than 3 times - 7.3 kg / ha.

The population of the basin according to the latest All-Russia population census is 38.5%, that is, it is the most densely populated region of the country. Over the past 15 years, the population of Russia has declined by almost 3 million people, while in the Volga Basin it has not changed and is now almost 56 million

people. Paraphrasing the great M.V. Lomonosov, we can say that "Russia's power will grow with the Volga region."

All this shows that the region of the Volga Basin continues to be have *most* pressing *environmental issues* in Russia.

3. HISTORICAL BACKGROUND

Resolution of the Central Committee of the CPSU and the Council of Ministers of the USSR "On measures to prevent pollution of the Volga and Ural river basins by untreated sewage" dated March 13, 1972 No. 177 and its implementation (positively estimated by many specialists) allowed to stabilize the situation with pollution by intensive construction of purification facilities. Considering the importance of the Volga Basin in the formation of the new Russian Federation, its leading role in the development of culture, education, science, health, the Government of the Russian Federation, by order of April 23, 1994 No. 574-r adopted a decision to develop and implement the Federal target program “Sanitation of ecological situation on the Volga River and its tributaries, the Volga basin natural complexes restoration and degradation prevention for the period up to 2010” (" Revival of the Volga "), which was approved by Decrees of the Government of the Russian Federation No. 95 of February 2, 1996 and April 24, 1998, No. 414. We will not dwell on the success of this program (this kind of analysis is a matter of a separate study); it is important to emphasize that the program "Revival of the Volga" has already ended even officially (up to 2010).

The Government shows concern about the environmental issues of the Volga about once every 20-25 years. On November 20, 2013 Vladimir Putin held a meeting of the Security Council on national security in environmental protection and natural resources use. Here are a few quotes from his opening speech (http://en.kremlin.ru/events/president/news/19655):

- «We should admit frankly that environmental security issues were on the sidelines of state attention for a long time. So-called ‘dirty’ technology dominated in many industry sectors, and this is often still the case today. Insufficient funding was made available for re-cultivating land, restoring forests, and building treatment facilities and landfills for waste management»;
- «Expert assessments suggest that at least 15 percent of Russia’s territory is in unsatisfactory environmental condition»;
- «To be honest, we spend relatively little money as a share of GDP on all of these activities…. I can tell you that it is only 0.8 percent. This is nothing compared with countries with developed economies»;
- «I think that we should move swiftly to draft and adopt the National Environmental Security Strategy. It should assess the external and internal threats in this area and set the threshold security indicators»;
- «We must take fundamental and practical research in ecology and environmental protection to a new level. We need to know how the climate is going to change and what risks are involved. We need scientifically based forecasts

of the state of our natural resources and development outlook for our country's environmental situation and the likely transformations to ecosystems as a result of natural and manmade influences. ... Without this kind of information it is hard to evaluate real threats to environmental security and draw up long-term measures to neutralize them».

The authors have written about the need to develop a new program in the rank not lower than the "National Project" several times [4-7].

4. COMPARING THE PASSPORTS OF THE PROGRAMS

Let us compare two Federal target programs: the previous one - "Sanitation of ecological situation on the Volga River and its tributaries, the Volga basin natural complexes restoration and degradation prevention for the period up to 2010" ("Revival of the Volga "), [8] and current one - the priority Improvement of the Volga project [9]. (Table 3).

Table 3 - Comparison of program passports

Passport sections of the program	**«Revival of the Volga»**	**«Improvement of the Volga»**
State customer	Committee of the Russian Federation for Water Management	Government of the RF
Primary developer	Nizhny Novgorod State Architecture and Construction Academy; Engineering Center for Water Management, Melioration and Ecology "Soyuzvodproekt"; Water Problems Institute of RAS	Ministry of Natural Resources and Ecology of the Russian Federation
Deadlines	1996-2010 (15 years)	2017-2025 (9 years)
The most important targets and expected results of the Program implementation		
In the field of legal, regulatory and economic support	development and adoption of laws of the Russian Federation (including the "Law of the Volga River", the Water Code of the Russian Federation, "On Fishing and the Protection of Fish Stocks", etc.); adoption of resolutions and normative acts (including the "Regulations on water protection zones of water bodies", "On measures to improve the environmental education of the population", "On the establishment of a unified water management system in the Volga River basin during the flood period", etc.).	within the framework of the Foundation for the Promotion of Housing Reform, create a unit that stimulates the implementation of investment projects for housing and communal services in the field of wastewater treatment in order to preserve and prevent pollution of water bodies.
In the field of water management	providing the population with potable water of appropriate quality; reduction of specific water consumption by 15-20%;	implement a system of measures aimed at the rational use of water resources and the sustainable operation of the

	20-30% reduction in the volume of water abstraction from natural sources; Reduction by 30-40% of drinking water consumption for industrial needs; completion of certification of small rivers; cessation of discharge of untreated domestic and industrial wastewater; arrangement of reservoirs, strengthening of shores, reduction of areas of shallow water by 20-30%, etc.	water management complex of the Lower Volga, the preservation of the unique system of the Volga-Akhtuba floodplain •reconstruction (modernization) and construction of treatment facilities at no less than 200 enterprises - major polluters in 17 regions of the Russian Federation; reduction of no less than 80% of the discharge of contaminated sewage from the Volga Basin to be cleaned (up to 10%); watering the river Akhtuba in the low-level period up to 100 m^3 / s; clearing and restoration of water bodies of the Volga river basin (1,171 km).
Inventory of objects of negative impact		form, rank and categorize lists of objects of negative impact on the environment.
In the field of industrial production	20-25% reduction in the specific consumption of natural and energy resources; reduction to the level of regulatory requirements of industrial wastewater pollution and gas emissions.	
In the field of agriculture	providing the population with ecologically clean food products; establishment of certification centers for food products and licensed production (priority in the organization of control of baby food and imported products).	
In the field of urban ecology	fundamental improvement of the environmental conditions of population living in cities; an increase in the specific area of green plantations per resident to 10 m^2; resettlement of residents from sanitary protection zones; removal of environmentally hazardous production outside the city territories, etc.	
In the field of environmental monitoring	creation of a basin automated system for continuous environmental monitoring of the environment; identification of extreme natural and	install automated systems, laboratories for monitoring the composition, volume of wastewater at sites that have a

	anthropogenic situations and phenomena, etc.	negative impact on the environment of the I and II categories that discharge (drain) wastewater (100%).
In the field of processing and utilization of domestic and industrial waste	creation of a basin information system, data banks on production and consumption wastes and on technologies for their processing with the organization of waste monitoring; completion of waste certification (with special attention to toxic waste); liquidation of unauthorized waste dumps; creation of a network of enterprises for processing domestic and industrial waste, etc.	
In the field of protection of atmospheric air from pollution by gas emissions of industry, heat power engineering, transport	implementation of priority measures to reduce the concentration of toxic gas emissions from industrial enterprises (reduction by 40-50%), energy (30-40%) and transport to the atmosphere of settlements by the standards; provision of compensatory measures for the population living in the areas with high air pollution, etc..	
In the field of radiation and chemical safety	creation of a network of posts for continuous monitoring of the level of radiation and toxic contamination of territories, as an integral part of the basin system of environmental monitoring; construction in the Volga basin a repository for the disposal of environmentally hazardous waste, etc.	
In the field of forestry, flora and fauna, specially protected natural areas	creation of a cadastre of forest resources, flora and fauna, specially protected natural areas; completion at the federal and territorial levels of the formation of a unified network of specially protected natural areas as a natural framework of the Volga River Basin; increase in forest cover to the minimum required areas in low forest areas of the Russian Federation; •30-40% reduction in the volume of wood waste produced.	approve and implement a program for maintaining and restoring the biodiversity of the Volga River
Preservation of the unique system of the Volga-Akhtuba floodplain		carry out dredging on a number of fish canals; provide clearing of 200 km of spawning canals of fish vessels; complete construction and

		commission and put into operation hydraulic engineering facilities for additional watering of the Volga-Akhtuba floodplain etc.
In the field of fisheries	comprehensive hydrobiological assessment of the current state of rivers in the Volga River Basin; scientific justification for expanding the scale of natural reproduction of the river semi-migratory and migratory fish species; ensuring the regulation of the hydrological regimes of reservoirs to create favorable conditions for spawning, feeding of juveniles and increasing the productivity of fish; establishment of a network of hatcheries, organization of freshwater sturgeon farming, pasture fisheries in the reservoirs of the Volga-Kama cascade,	
In the field of environmental education and training	creation of a continuous environmental education system in the Volga Basin in order to achieve sustainable development; completion of the development of a program for the continuous formation of an environmental culture of the individual for educational institutions of all levels; creation of a network of environmental summer schools for schoolchildren of grades 5-7 on the basis of health institutions etc.	develop and implement a set of information and communication measures at the federal and regional level aimed at developing principles of careful attitude to water resources among citizens (involving the volunteer movement);
Funding		
Costs for the implementation of the Program, including:	176.28 trillion. rub. (pricing for 1994) or ~ $ 79.151 billion.	245.8214 billion rubles. (pricing for 2017) or ~ $ 4.214 billion.
•federal budget	15,6%	46,1%
• budgets of RF subjects	20,2%	17,3%
• other sources	64,2%	36,6%
Costs by type of work:		
•building	90,8%	83,8%
•designing	8,0%	
• research and development	1,0%	0,9%
• other costs	0,2%	15,3%

Table 3 is quite descriptive and does not require detailed commentary. We should only note that the new program is less complex and more local (it is 20 times "cheaper" [although it is 1.5 times shorter in terms of time] and is clearly oriented, mainly, to the construction of treatment facilities and the improvement of

environmental situation on the Lower Volga). Register of opportunities for a new project [9, c. 21] suggests that as a result of the implementation of the "Improvement of the Volga" Program, one can expect:

- improvement of the state of water bodies throughout Russia (the possibility of replicating the Program for the conservation of other water bodies);
- improvement of the health of the population;
- replenishment of aquatic biological resources;
- development of tourism and recreation;
- development of small-sized navigation.

The developers of the Program consider the main risks (with a high probability of occurrence) to be the following [9, p. 20]:

- reduction of the state financing of the project due to the unstable macroeconomic situation;
- low quality of design and construction of facilities (it is proposed to establish an institute for pre-project analysis, quality control of construction and subsequent operation);
- low investment activity due to the benefits of fines for investment activity (it is necessary to develop new flexible and effective financial instruments to support and stimulate the business to participate in projects to improve the environmental situation, which cannot be solved within one very local program).

5. CONCLUSIONS

In general, the Government's next attempt to "cut the Gordian knot" of the problems of the Volga River Basin can only be welcomed. The project's passport provides for the development and implementation of a set of measures to ensure the rational use of water resources and the sustainable operation of the Volga water management complex. As academic and high school natural scientists, we particularly note the points of the program in the field of environmental education. In the Constitution of the Russian Federation the Article 42 (Everyone shall have the right to favorable environment, reliable information about its state and for a restitution of damage inflicted on his health and property by ecological transgressions.) adjoins the Article 43 (Everyone shall have the right to education). In the context of the present work, it is symptomatic. The solution of global environmental problems, environmental problems in Russia, in the Volga Basin, the achievement of sustainable development and environmental safety of the territories is impossible without the foundation of the basics of environmental management culture, without the training of environmental specialists of the highest and current level. This poses the problem of improving environmental education in a number of the most important strategic problems of the country's development.

Any program for its implementation requires only two conditions. At the same time, funding is the second one. The first is the actual intent to implement

this program. Let's hope that all of us have such intent. The Volga has done so much for Russia that we in turn can also try a little for the Volga.

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PHYTOSOZOLOGICAL STUDY OF NATURE MONUMENTS FOR THE DETERMINATION OF THE ENVIRONMENTAL STATUS OF PROTECTED AREAS

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ABSTRACT

The following study was carried out in Samara region and it sets a goal on the basis of a number of phytosozological criteria characterizing the vegetation cover to determine the ecological status of the protected natural area (PNA). Phytosozological assessment of nature monuments of regional importance in Samara region allows to build a rating of the conservation value of these objects, which in its essence is equated with the ecological status of the NPA. The obtained results are sufficient to make managerial decisions to optimize the system of nature monuments, increase the level of its representativeness and ecological status.

Key words: protected natural area, nature monuments, determination

By ecological status we mean a set of natural and social values and parameters that allow the natural and territorial complexes to fulfill their functions to the maximum. Following Aija Mellumathe [1], the function of the PNA is understood as an appointment, a specific activity and a role in a more general system. V.E. Boreyko [2] distinguishes quite a few such values for the PNA: storage and accumulation of wildlife values (museum function); recreational and educational; inspirational; scientific; function of protection of cultural values; function of treasure, fetish and symbol; moral; unconscious; economic; environmental protection, etc.

Our research [3-5] on the phytosozological assessment of the protected natural areas of Samara region implies that the proposed method allows obtaining

qualitative information on the degree of study of the protected area, demonstration (reference value), the correspondence of the protected area to the environmental objectives, to assess anthropo-tolerance, species and cenotic diversity, the degree of transformation and the restoration potential of the protected complex.

The proposed phytosozological criteria partially or completely coincide with those of other authors [1, 2] on the ecological status of protected natural areas.

The obtained phytosozological assessments of the PNA of Samara region which are part of the ecological status of objects according to the laws of synergetics [6] bear new properties when they are considered in comparative landscape (natural-territorial), natural-zonal and even administrative relations. Let's give some examples.

Example 1. Representativeness of the PNA. In Samara region, according to the state register of protected areas of regional importance [7] there are 214 natural monuments. On average, the administrative unit (27 municipal districts and 3 urban districts) account for 6.7 protected areas and ranges from 2 (Koshkinsky district) to 13 (Volzhsky district). Thus, one can speak about the uneven spatial distribution of the PNA.

A different picture is obtained when analyzing the distribution of the PNA in landscape areas. Monuments of nature are absent in the South Syzran and Bugulma landscape areas; they are very few in the Melekess-Stavropol one. The maximum number of protected areas is in the Soksky (85), Syrtov (52) and Sviyago-Usinsk (31) landscape areas [8, 9]. Thus, the system of protected areas of Samara region does not cover the entire landscape diversity of the region, which undoubtedly reduces its effectiveness.

Example 2. The study of the protected area of Samara Region. This is the most important phytosozological indicator, directly related to other criteria of ecological status. The indicator of "exploration" is directly dependent on the landscape diversity of the protected area and the occupied area.

It is not a secret that the study of protected areas is not systematic, but random and is determined by the personal interests of the researcher. Taking into account this circumstance and a small number of professional specialists capable of organizing these works, on the whole, the level of study is rather low. Many protected natural areas in Samara region have not been studied.

Example 3. Floristic diversity of Samara region. This is perhaps the most important integral indicator, depending on the diversity of landscape-ecological conditions, the occupied area and, in part, on the degree of study.

In this respect (the NPA with a high level of floristic diversity) the largest number of natural monuments are in the following districts: Bolsheglushitsky (Stone log number 1, 2, 3, River Origins Big Irgiz; Beam pantry and stow Gryzlov - desert steppes), Elkhovskoye (Mount Lysaja and Mount Zelenaja) Isaklinsky (Isaklinsky upland forest and lake Molochka) Kamishlinski (Mount Karatal Chagyl), Kinel (Krasnosamarsky pine) Pohvistnevskogo (Podbelskie bottomland oaks; Pohvistnevskie suburban oak forests; Yatmanskie broad-leaved forests, mountain Kopeika) Syzran (Gremyachiy; Malousinskie upland pine and oaks, Racheysky boron)., Shigonski (Murano cowberry, Murano lake, Levashovskaya

forest-steppe, Gurjev ravine), etc. Unfortunately, it should be stated that about 25% of the regional PNA has low floristic diversity.

Phytosozological assessment of nature monuments of regional importance in Samara region [3] allows to build a rating of the conservation value of these objects, which in its essence is equated with the ecological status of the NPA. The head part of the rating (№ 1-50) is presented below:

1-2 - Rachein taiga; Guryev ravine.
3 - Lake Molochka.
4 - Gryzl - Desert steppe.
5-6 - Cretaceous forests of the southern part of the Sengileev Upland; The Muran forest.
7 - Levashovskaya forest-steppe.
8 – Baulk Kladavaya.
9 - Sernovodskiy shihan.
10 - Podval'skie terraces.
11-13 - Origins of the Big Irgiz River; Murano cranberries; The Murano Lakes.
14-15 - Rachey Bor; Moss swamp.
16-17 - Mount Kopeyka; Seven keys.
18-21 - Stone logs No. 1, 2, 3; Mount Zelenaya; Isaklinskaya upland forest-steppe; Ramensky Forest Cottage.
22 - Mount Lysaya (Koshkinsky district).
23 - Maytugan solonetses.
24-25 - Mount Karatal Chagyl; Ulyanovsk-Baytugan interfluve; Usilovo swamp.
26-29 - The Koshkinsky Baulk; The tract Mulin Dol; Hypnous swamp; Mount Visokaya.
30-31 - Popov's garden; The Irgiz floodplain.
32-33 - Krasnosamar pine forest; Chubovskaya steppe.
34 - Rachey rocks.
35-37 - Kutuluksky Yary; Gostevsky shihan; The falconry of the mountain and the shore between Studen and Koptev ravines.
38 - Sister fossils.
39-42 - Stone dol; Mount Red; Mountain Lysaya (Krasnoyarsk region) Domashkinskaya forest-steppe.
43 - Ravine the Ridge.
44-46 - The Tsar's Mound; Abdulzavodskaya oak forest; Yatman broad-leaved forests.
47-48 - Forest steppe in the upper reaches of the river Amanak; Mountains on the river Kazachka.
49-50 - Vyazovsky feather grass steppe; Malousinskie upland pine and oak forests.

It is likely that the ongoing research on the study of the plant world of the NPA in Samara region will provide new data and the proposed rating should change. Nevertheless, the obtained results are sufficient to make managerial decisions to optimize the system of nature monuments, increase the level of its representativeness and ecological status.

Among of the urgent measures, we recommend those responsible for the preservation of landscape and biological diversity - Samara Region Government and relevant departments to:
- develop and approve a special program or a set of measures (with mandatory funding) to study the current state of the protected natural areas of the region, paying special attention to biological diversity;
- to carry out a number of studies on the optimization of regional specially protected natural areas by expanding the area of existing NPAs and formalizing the new ones that have a high level of landscape and biological diversity.

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LEACHING OF REFRACTORY ORE WITH ULTRA-FINE GOLD BY THE ELECTRO-PHOTO ACTIVATED SOLUTIONS

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ABSTRACT

Theoretical substantiation of leaching of clustered ultra-fine gold by the electro-photo activated (PEA) cyanide and chloride solutions is given in the article. Active clusters of water and the clustered reagent complexes are formed in the process of dissolution of active forms of oxygen in this medium. These active clusters have the defining role in gold leaching: possible processes of transformation of clustered gold in mineral substance. The interaction of clustered components of the electro-photo activated leach solution with clustered atoms of ultra-fine gold takes place. Realization of environmental problems of cyanide increases the actuality of research of gold recovery by reducing of it consumption and using of alternative lixiviants, such as activated chloride hypochlorite solution. The results of pilot-plant and laboratory research of gold leaching and by cyanic and chloride-hypochlorite photo-electro activated solutions are given in the article.

Key words: ultra-fine gold, cluster chemical reactions, active clusters, lixiviation of metals, electro-photo activation of leach solution

1. INTRODUCTION

Most of the gold is extracted from refractory ores now, and direct cyanidation cannot efficiently recover gold from such ores. Thus the problem of winning precious metals from troublesome ores is attracting all aspects of applied mineral research and development. Furthermore, there is a general interest in reducing of cyanide consumption by using active forms of oxygen for the

formation of hydrated clustered in water faze of leach solution [1, 2] or replacing cyanide by lixiviants which are nontoxic and environmentally safe [3].

1.1. Cluster mode of occurrence of ultra-fine gold

Researches of many domestic and foreign geologists and geochemists revealed that gold and platinum metals concentrate in ore minerals both in the mode of micron and submicroscopic inclusions, coating and in ultra-fine, chemically bound mode of occurrence [4–6]. Ultra-fine mode of occurrence of these metals in mineral substance is generally presented by poly-element or mono-element clusters bound with element sulfur. These compounds (particularly with gold) are described by the formula Au_nS_m. It is supposed that "nuclear" part is presented by monoelement gold compounds and the "external coating" consists of sulfur atoms in these cluster compounds. Existence of bi-element gold-sulfur compounds in ores is proved by both the electron microscopy pictures and by the significant amount of experiments with simulated colloidal gold solutions and sulfur-containing reducer [4]. Nano-gold is rather wide-spread in the weathering crust of deposits of gold-sulfide and gold-sulfide-quartz formations. The main types of nano-gold forms are individual particles and their aggregates of various configurations situated at the hollows of surface micro- and nano-relief of placer gold grains. Nano-gold is extracted from sulfides during the process of their chemical alteration and transition to hydroxides of iron. Then nano-gold particles precipitate in the surface of placer gold grains due to their huge surface energy or under influence of natural amalgamation process [5].

Both silicium and sulfur have high extent of geochemical affinity with gold. The fact of clustering of silicon with hydrogen and alkali metals was established experimentally. Clusters are presented by silicon fullerene-similar compounds with incapsulated hydrogen and alkali metal atoms: H_nSi_m, Na_nSi_m, K_nSi_m, Rb_nSi_m, Cs_nSi_m [6].

The existence of bi-element clusters of gold and silicon (Au_nSi_m) is possible in gold-quartz and gold-sulfide-quartz ores. Similar gold-carbon nanostructures (Au_nC_m) could be formed in carbonaceous shale in the process of biogeochemical recycling. It is necessary to provide the access of oxidizers and complex-forming compounds for the extraction of cluster gold mode of occurrence from ores. These compounds first react with the "external capsule" (sulfur, silicium, carbon, etc.);the second stage is the reaction the "nuclear" part (gold).As atoms of "external capsule" elements are also clustered, bounded "nuclear" gold clusters can be leached to the solution keeping bound with "external capsule" elements. Further dissolution of gold clusters takes place by declustering of such structures and by formation of complex compound with cyanide, halogens, etc. It is necessary to provide both formation of a soluble complex of a "capsulate part" of gold clusters and complex with their clustered "nuclear" gold part for leaching of cluster mode of occurrence of ultra-fine gold. For the solution of these tasks lixiviants should contain oxidizers and complex-forming compounds. And these reagent complexes have to be in a hydrated cluster form.

Formation of hydrated clustered chemically active complexes can be provided with various methods of processing of lixiviant solutions. Presence of active forms of oxygen is the main condition for the formation of hydrated clustered chemically active complexes.

1.2. Theoretical aspects of cluster structure of water

The theoretical and experimental proof of cluster structure of water is one of the most considerable achievements in this sphere. The presence clusters in water is experimentally proved [1] and theoretically substantiated [2]. Clusters are compacted molecular structures characterized by high binding energy. Clustering of water is accompanied by formation of hydrogen bonds (O–H) between water molecules and one-element bonds (H–H, O–O).Usually the clustering of water molecules consists in the hydration of dissolved solid or gas molecules/atom. The most intensive clustering takes place in oxygen-saturated hydrated layer. This fact is explained by the formation of O–O bonds. According to the theory of Prof. V.L. Voyeykov (Moscow State University), the dissolved oxygen is reduced into water by oxidation of hydrogen atoms [7]. Presence of radical and an ion - radical forms of oxygen significantly intensify this process. In the process of reduction of active oxygen by water, electromagnetic quantum is released. It activates one of the nearest water molecules. This molecule becomes a source of electron for other molecule of the dissolved oxygen. Thus, process of activation of water molecules and the dissolved oxygen is characterized as a chain reaction [7].

The process of reduction of dissolved oxygen in water is accompanied by the oxidation of water molecules. It enhances the probability of their dissociation. The positively charged ions-protons are formed in this process. They become electron acceptors for dissolved anions and transfer them to the condition of active radicals. Hydroxyl ions are reduced to radicals. Complex-forming ions, for example CN^{-}, are transformed to a radical form –CN*. CN* radicals transform into ionic form. If the water cluster is created around a molecule or an ion of the dissolved compound, including several oxygen atoms with O–O bonds, produced protons and hydroxyl ions create a metastable system of clustered ions. Such clustered ion systems actively interact with complex-forming ions. This interaction combines them in the joint hydrated cluster. These clustered systems of hydrogen and hydroxyl-ions stimulate the collective electronic shells of cluster inclusions (including gold) when contacting with mineral substance.

The formation of compounds containing clustered atoms of oxygen in aqueous solutions is provided by the processes of transformation of H–O to O–O bonds. This transformation is realized by the saturation of an aqueous solution by active UV-radiated oxygen. Molecular oxygen is generated by water electrolysis; it is UV-transformed to atomic state and ozone [8, 9]. Presence of atomic oxygen and ozone promotes H–O to O–O bonds transformation.

The choice of lixiviant is caused by the element composition of a “coated” part of a gold cluster. Clustered chloride complexes can be used both for dissolution of “coated” structures (for example sulfide) and for gold complexing.

These complexes can be synthesized by sodium chloride electrolysis. Hypochlorous acid (HClO) and perhypochlorous acid $(H_2Cl_4O_4)*nH_2O$ are produced in anode region; sodium hipochlorite (NaClO) is formed in inter-electrode space. Extremely active oxidizers are produced in the process of UV–radiation of the water-gas emulsion formed at electrolysis. These oxidizers are atomic oxygen, atomic chloride, superoxide radical ion (O^{*-}), ozone (O_3), hydroxyl radical (OH*), hypochlorite radical (ClO*). Clustered hydrated complexes are produced at electro-photochemical processing of aqueous solutions of lixiviant. These complexes are highly active in relation to a coated part of a gold cluster.

1.3. Mechanism of gold leaching by electro-photo activated solutions

Complex polymer (clustered) structures are more effective then single hydrated anions (nH_2O*CN^-) or radicals (nH_2O*CN*) for dissolution of a "nuclear" part of gold clusters because of stimulated interaction between the collective electronic shells of it clusters and clustered inclusions (including gold) when contacting with mineral substance. Interaction between gold cluster and hydrated complex, containing complex-forming substance and oxygen, can be demonstrated by the reaction of 3-atomic gold cluster and potassium ferrocyanide:

$$Au_3+K_4(Fe(CN)_6)nH_2O*mO=HAu_3(CN)_6+4KOH+Fe(OH)_3+(n-4)H_2O*(m-3)O, \quad (1)$$

Cluster formed as a result of NaCN hydratation can be presented by the following formula: $m[(CN^*)(OH^-H^+)CN^- nH_2O^*(Na^+)OH^-]$.

The collective protons and hydroxyl ions transform CN^- ions to reactive metastable CN* radicals and stimulate electronic shells of gold clusters, providing the possibility of chemical interaction. The gold clusters, formed by this way, can be described by the formula: $[nAu*m(CN)_2]^{n-} kH_2O$.

Similar to cyanide solution, cluster reactions can take place with chloride-based complexes:

$$nAu + m[H_2Cl_4O_{4*}(OH^-H^+)H_2O] = nAu*m[Cl_4(OH)_4]^-*H_2O^+mO = n*[AuCl_4]^-*2(m-n)Cl_2*2mH_2O*3mO, \quad (2)$$

The decrease of concentration of "free" cyanide ions (determined by titration) proves the formation of clusters in electro-photo activated solution. This provides reduce it consumption in leaching process. The some growth of cyanide ions concentration is observed after the first hour after electro-photo activation of solution. The growth of concentration of the oxidized forms of sodium cyanide (CNO^-) in pregnant solution is not observed. This fact proves absence of oxidation process.

2. MATERIALS

Comparative experiments on electro-photo activated leaching of ultra-fine gold from refractory ores by cyanide and chloride solutions were carried out for ore and different alluvial recourses. The material for research is primary ore of Pogromnoe deposit (Trans-Baikal Territory). The ore is characterized with the minimum sulfide minerals and the organic carbon content. The comparison of effectiveness of cyanide and chloride complexes will be the most objective as their barren interaction with other components of ore will be minimal. Gold in ores of this field is presented by mainly ultra-fine size. The target metal is finely dessiminated in the quartz and silica-alumina minerals (metasomatic minerals). Sulfide minerals (2.5-3%) are presented in ore generally by pyrrhotine (gold content does not exceed 10 g/t).

3. METHOD OF PREPARATION OF ELECTRO-PHOTOCHEMICAL ACTIVE LEACH SOLUTIONS

Electro-photochemical activated (PEA) solutions of different lixiviants were prepared by electrolysis with the following UV-radiation.

1. Electro-photochemical activated NaCN solution was prepared by water electro-activation by electrolysis (U=15 B, I= 5-7 A), UV-radiation and sodium cyanide (NaCN) addition. NaCN concentration for agglomeration (pelletization) was 1 g/l and its concentration for column leaching (pilot studies) was 0.3 g/l.
2. Chloride-hypochlorite leach solution was prepared by electrolysis of NaCl solution (c_0(NaCl) = 20 g/l). Hydrochloric acid (HCl) was added to the solution on the final stage of electrolysis. Obtained solution was UV-radiated then. Chloride-hypochlorite photo-electro activated solution was used for laboratory tests.

4. EXPERIMENTAL PROCEDURE OF CYANIDE LEACHING (PILOT STUDIES)

Column leaching was applied for low-sulphidic primary gold ore of Pogromnoe deposit (Aprelkovo mine). Ore preparation for the experiments included crushing to an average size –10 mm and agglomeration (pelletizing). Ore saturation for pelletizing was done with the electro-photoactivated and standard solutions of sodium cyanide (not activated according existing technology). Sodium cyanide concentration for pelletizing was 1 g/l for all percolation columns. Sodium cyanide concentration for leaching process was 0.3 g/l for all percolation columns. One sample weight for each percolator was 100 kg. Pelletized ore was staying in percolators for 3 days. Ore pellets hardened and diffusion stage of gold leaching was realized.

Standard solution of sodium cyanide (1 g/l for agglomeration and 0.3 g/l for irrigation) was not activated anyway (percolation column N°.1). Photo-electrochemical preparation of sodium cyanide solution (1 g/l for agglomeration and 0.3 g/l for irrigation) was carried out by method of subsequent electrolysis and

UV–radiation of base solution, following by reagent addition (percolation columns N°. 2 and N° 3). Leach solution for the irrigation of ore of percolation column N°. 2 was preliminary air saturated. Percolation column N°.3 was irrigated by leach solution without preliminary air saturation. Hydrogen dioxide was added to sodium cyanide solution as an oxidizer in a percolation column N°. 4.

Pregnant solutions from each percolation column pass to separate sorption column. Flow-sheet diagram of experimental procedure of cyanide leaching (photo-electro activated and excising technology) is shown in fig. 1.

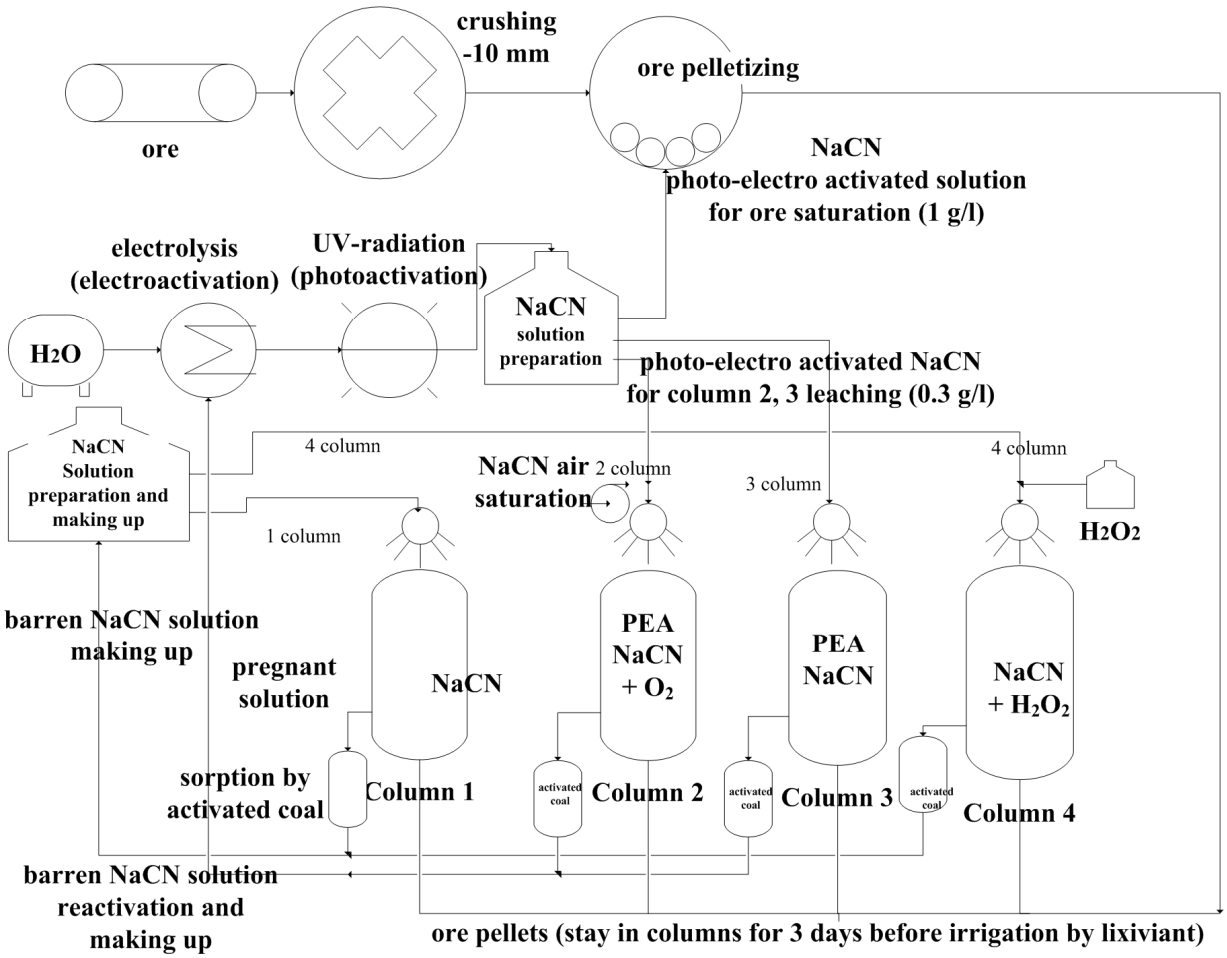

Figure 1 – Flow-sheet diagram of electro-photo activated (PEA) and standard (existing technology) cyanide leaching (pilot-plant test)

An irrigation of ore was carried out by standard cyanide solutions (column 1), prepared electro-photo activated leach solutions (columns 2 and 3); cyanide - hydrogen dioxide solutions (column 4). Concentration of sodium cyanide was 0.3 g/l both for first cycle and reactivated barren solutions [9].

The diffusion-convective stage of leaching was lasting for 40 days for each sample. Pregnant leach solution was collected, sampled and analyzed for gold (by AAS) and sodium cyanide content (by titration). Pregnant leach solution was absorbed by the activated carbon (80 g/100 kg column). After a gold sorption barren solution was made up with the necessary reagents. Cyanide and cyanide-peroxide (columns 1 and 4) leach solutions were made up till initial concentration

and returned for the column irrigation. Photo-electro activated leach solutions (columns 2 and 3) were processed in the photo-electrochemical reactor (before addition of sodium cyanide till initial concentration 0.3 g/l). Results are given in (fig. 2).

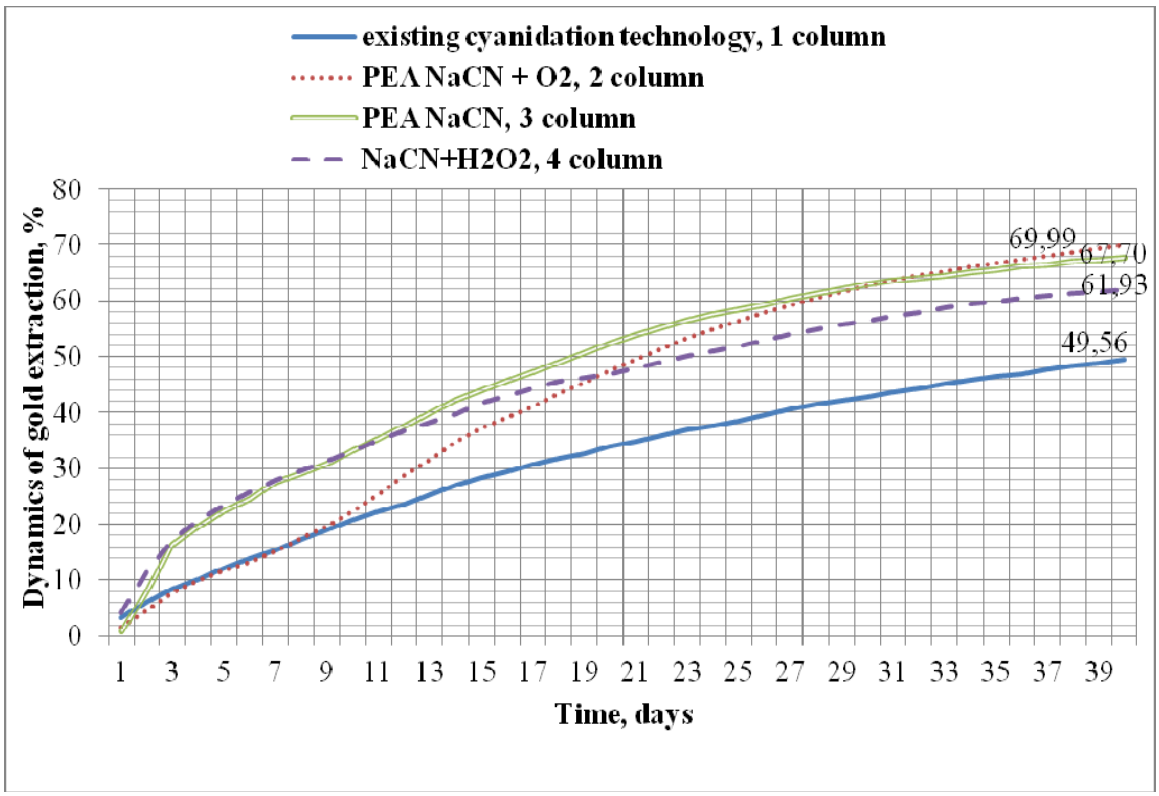

Figure 2 - Dynamics of Au extraction in pilot plant research (No. 2, 3, 4 - experimental percolation columns, No. 1 –standard technology)

The maximum increase of gold recovery is 20.4 % (column No.2 – PEA+O_2 NaCN) in comparison with existing technology (column No. 1 – NaCN). 18.1 % increase of gold recovery is observed for photo-electro activated column leaching (column No.3 – PEA NaCN) in comparison with existing technology (column No. 1 – NaCN).The increase of gold extraction is 12.4 % for a peroxide–cyanide leach solution (column No. 4, NaCN + H_2O_2) in comparison with existing cyanidation technology. It was established that cyanide consumption may be reduced to 0.2 g/l. This fact is important in ecological and economical sense.

5. CHLORIDE HYPOCHLORITE GOLD LEACHING

Nowadays, due to the realization of environmental problems of cyanide, there is a worldwide quest to find viable alternatives to cyanide. One of the alternatives is a chloride solution with an appropriate oxidizing agent [10-13]. Baghalha provides a complete review of both advantages and difficulties connected with chloride hypochlorite gold leaching.

In all halogen-based leaching processes for gold, high-oxidation conditions are required. The general equation describing the reaction of gold with chlorine or bromine is as follows:

$$2\ Au + 3\ X_2 + 2\ X^- = 2\ AuX_4^-, \qquad (3)$$

where X=Cl, Br

The complex $AuCl_2^-$ is formed initially and is rapidly oxidized to $AuCl_4^-$ [11, 12].

Typical conditions used in leaching gold with halides are characterized with low pH < 3 and chlorine concentration within 5-10 g/l [13].

Presence of chloride ions saves from passivation of gold surfaces during chlorination. Mineev G.G. [14, 15] considers that gold recovery depends on pH of the solution. Low pH (pH≈3) provides dissolution of oxide films on the gold surface [15].

The major disadvantage of the chlorine–chloride system is the high reactivity of chlorine in reaction with sulfide and gangue carbonate minerals. As a result, only high grade materials may be treated by chlorine–chloride system economically.

As the dissolved gold complex is unstable and reprecipitates on contact with a reductant such as sulfidic materials or metals, application of the chloride-chlorine systems is limited to extraction of gold from oxidized materials. Attempts have been made to reduce the reactivity of sulfides in halide systems using compounds such as flotation collectors used to coat sulfides [16]. Preliminary oxidizing roasting of ore concentrates can be a solution of the problem of the increased reactivity of sulfides [14-16].

High silver contents in ores may dissolve slowly under certain conditions in low-chloride solutions because of the formation of a passivating film of insoluble silver chloride [17, 18]. Consequently, higher concentrations of chloride in solution are required to solubilize the relatively insoluble silver chloride. Therefore, the chloride system may not be ideally suited to treatment of ores in which silver is of primary value.

Pogromnoe deposit ore samples were used for percolation leaching experiments. Reference and activated gold leaching experiments were carried out by chloride-hypochlorite solutions in small laboratory percolators (5 kg).

1. Chloride-hypochlorite leach solution prepared by electrolysis of NaCl solution (c_0(NaCl) = 20 g/l) was used in reference leaching experiment (without UV-radiation of electrolysis solution).

2. Chloride-hypochlorite leach solution prepared by NaCl electrolysis (c_0(NaCl) = 20 g/l) and UV-radiated (photo-electro activation of solution) was used in reference activated gold leaching.

Ore samples were saturated by photo-electro activated chloride-hypochlorite solution and pelletized. Pelletized ore was staying for 3 days in percolators without irrigation. Ore has been irrigated with leach chloride-hypochlorite solution for 10 days (reagent consumption was 300 ml/kg*day). Pregnant leach solution was analyzed for gold content and the gold was adsorbed from pregnant leach solution

with activated coal. Gold-saturated coal was analyzed by assay method. Data of gold-saturated coal analysis confirmed the effectiveness of the activated gold leaching.

The activated (PEA) chloride-hypochlorite gold leaching provided 78.9 % gold recovery to pregnant leach solution and 93.4 % to activated coal. Reference (not photo-activated) chloride-hypochlorite gold leaching is characterized by 48.8% gold extraction to the solution and 65.7 % to coal.

6. CONCLUSIONS

Laboratory research of chloride-hypochlorite column leaching demonstrated that the activated method provided 78.9 % gold recovery to pregnant leach solution (93.4 % to activated coal). The reference chloride-hypochlorite column leaching provided 48.8% and 65.7% respectively. Experiment duration was 10 days, increase of gold recovery with activated leaching method is 30.1 %.

Laboratory research of photo-electro activated cyanide column leaching provides 20.4 % maximum increase of gold recovery. Photo-electro activated air saturated NaCN (column No. 2) provides 69.9% gold recovery in comparison with 49.5% recovery for the existing technology (column No. 1 – NaCN).

18.1 % increase of gold recovery is observed for photo-electro activated column leaching (column No. 3 – PEA NaCN) in comparison with existing technology (column No. 1 – NaCN).The increase of gold extraction is 12.4 % for a peroxide–cyanide leach solution (column No. 4, NaCN + H_2O_2) in comparison with standard cyanidation. Experiment duration was 40 days.

Chloride-hypochlorite photo-electro activated solution can provide higher level of gold recovery with shorter process duration in comparison with cyanide. Final conclusion regarding the choice of leach solution has to be done on the basis of technical and economic calculations.

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SIXTH INTERNATIONAL ENVIRONMENTAL CONGRESS ELPIT-2017

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PILOT STUDIES OF PROCESS OF THERMAL DRYING OF THE SUGAR BEET PULP

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ABSTRACT

Authors have considered the principle of operation of the mobile plant designed on the basis of the dryer ES600. Pilot studies on the basis of FSBEI HE "KGEU" on drying of a beet press are conducted. The laboratory analysis of initial raw materials and products of processing at various operating modes of drying installation is carried out. Regularities of change of value of humidity of the dried-up beet press depending on an operating mode of drying installation are revealed. The data obtained during the pilot studies helped to define an optimum operation mode. Also on the basis of the experimental data adjustment of the developed mathematical model of the material balance of processing of waste of beet sugar production for the purpose of support of its adequacy is carried out.

Key words: sugar beet pulp, thermal drying, sugar beet industry.

The plan of research provided conducting pilot studies for determination of parameters of work of installation and on confirmation of the developed mathematical model. Pilot studies are conducted on industrial mobile installation. Laboratory measurements of a product of processing are taken in the accredited ecology-chemical laboratory.

The main goal of conducting pilot studies consists in receiving during the experiment of data on the basis of which it is possible to judge adequacy of mathematical model and to make the corresponding changes [1, 2]. For ensuring accuracy of mathematical model and assessment of her adequacy pilot studies were

conducted at different operating modes of installation and different humidity of a beet press.

Pilot studies of drying of a beet press are conducted from November 10 to November 16, 2016 on the basis of the FSBEI HE "Kazan state power engineering university". Laboratory measurements are taken on the basis of testing laboratory of "TsLATI on RT" branch of Federal State Budgetary Institution "TsLATI po PFO" (No. POCC RU.0001.517624)

As experimental installation the industrial mobile ES600 installation developed and constructed by the VOMM Impianti e Processi S.p.A company is chosen (A method for the solid state polymerization of polyethylene terephthalate. ITMI20030048 (A1). 2004-07-16). Installation is intended for the thermal drying of organic waste.

Installation is placed on base 40 of a foot container. It includes: the control unit of the dryer ES600, the dryer ES600, the screw for withdrawal giving, the bunker for withdrawal, the oil heat exchanger, a diesel copper, a cyclone, the condenser cooler. In addition for production pellet from the dried-up press the FT-300 installation was used. The appearance of the installation is shown in figures 1, 2 and 3.

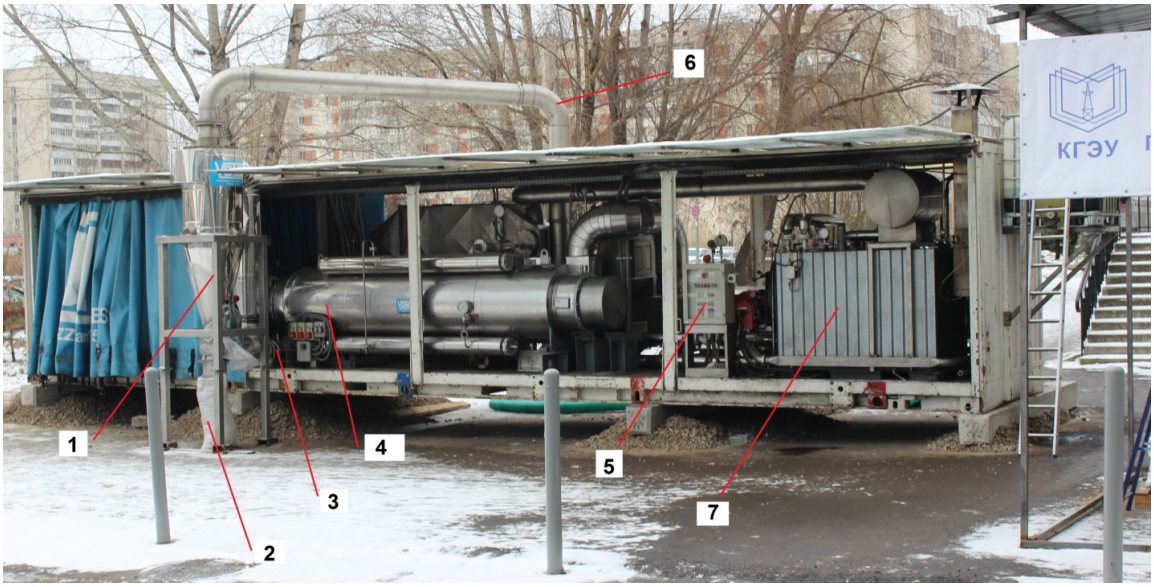

Figure 1 - Industrial mobile installation (front view)

Principle of operation of the mobile industrial installation: control box 11 realizes installation start, the diesel boiler 7 by means of the panel 5 turns on further, in the heat exchanger 7 there is a heating of diathermic oil which warms further air in the heat exchanger 12 and moves in "shirt" (interpipe space) of the working camera of drying installation 4, on the screw 9 there is a submission of a crude beet press in the bunker 8, further the crude press comes to the working camera of the dryer 4 where under the influence of a shaft with blades it is discarded on walls of the working camera (the "shirt" warmed by thermal oil) a flow of heated air the dry beet press is carried out from the working camera of the

dryer on a pipe 3 during a cyclone 1 where the crude press separates from a flow of heated humid air and gets to a bag 2, moisture from a flow of air is carried away on a pipe 6 and is condensed in the condenser 10, air returns for heating to the heat exchanger 12.

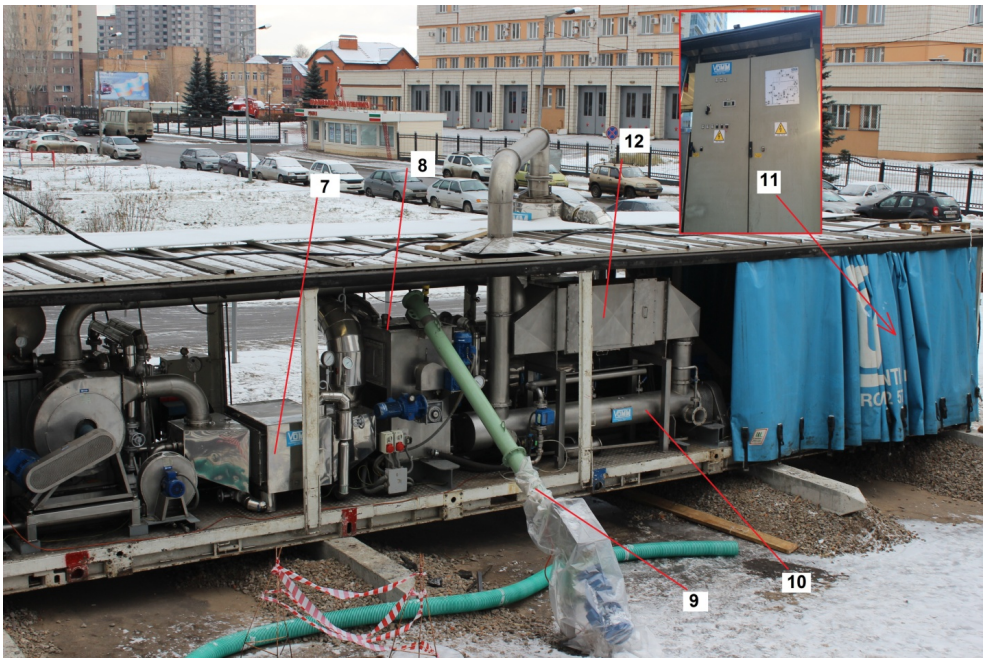

Figure 2 - Industrial mobile installation (back view)

Figure 3 - The installation for pellets FT-300

Drying installation of ES600 represents the horizontal cylinder in which the second cylinder of a little smaller diameter is located, thus the interpipe space in which a countercurrent concerning the dried-up raw materials diathermic oil for heating of a wall of the internal cylinder moves is created ("shirt" is created). The internal cylinder is a working volume of the turbo dryer, in it the shaft with blades which rotation allows to distribute uniformly raw materials on a heated wall of the working camera that provides uniformity and heating intensity of particles of raw materials is located. In the same direction, as raw materials heated blowing-off air which carries out the dried-up raw materials from drying installation moves.

In control box the notebook with the specialized software set on it for monitoring and monitoring of all processes on installation is placed, connection is carried out by means of COM of RS-232 port. The operation mode of installation can be regulated due to change of rotational speed of a shaft with blades in the working camera of installation ES600, change of temperature of thermal oil. Temperature of blowing-off air during the experiment was 200 °C.

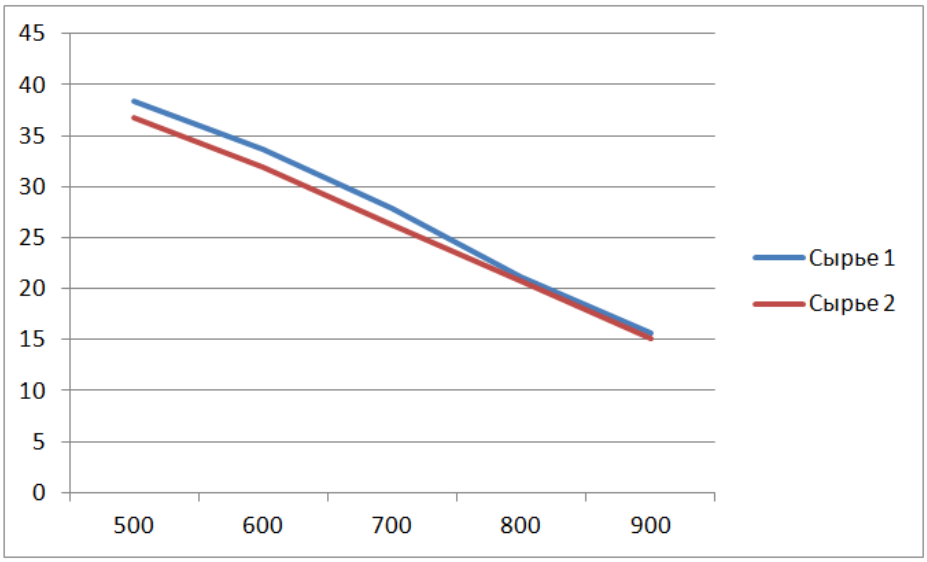

Figure 3 - Dependence of humidity of the dried-up press on the speed of rotation of a shaft at a temperature of diathermic oil of 200 ° C. On ordinate axis values of humidity, on abscissa axis revolutions per minute are specified.

The operating mode of installation included:

1. change of speed of rotation of a shaft with shovels in the range from 500 to 900 revolutions per minute, the interval of change of rotation has made 100 revolutions per minute;
2. change of temperature of diathermic oil in range from 200 to 240 ° C at an interval of 20 °C.

The plan of pilot studies was definition of influence of an operating mode of drying installation on the received humidity of a beet press. Pilot studies are conducted on two types of raw materials from two different beet sugar plants. Raw materials 1 from the first plant are a crude beet press, raw materials 2 from the second plant is the pressed beet press after the press beet pulp of installations

(mechanical dehydration). The initial humidity of both types of raw materials is defined according to PND F 16.1:2.2:2.3:3.58-08, the humidity of raw materials 1 was 92%, raw materials of 2 - 84%.

Results of pilot studies taking into account all possible operating modes of installation for both types of raw materials are given in a type of charts in figures 3-5.

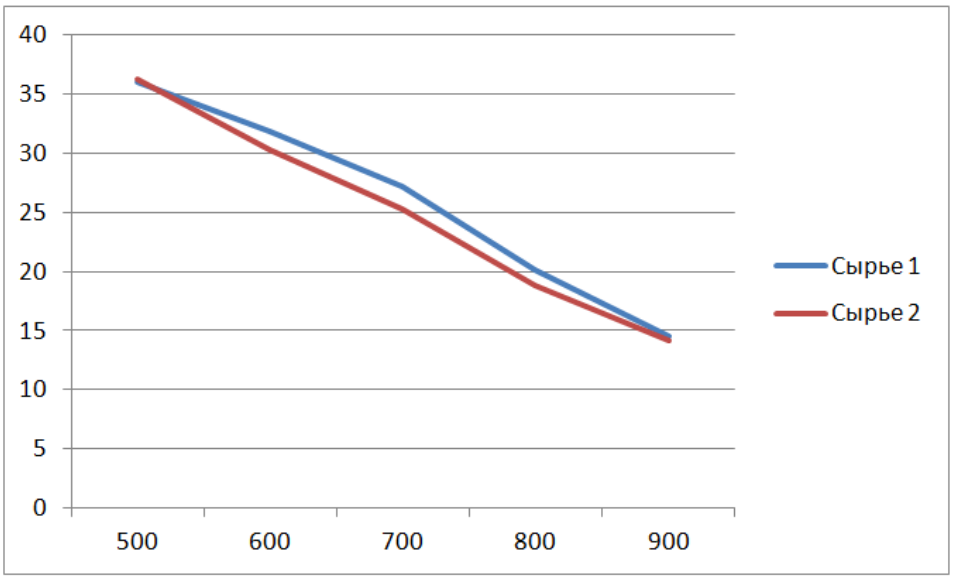

Figure 4 - Dependence of humidity of the dried-up press on the speed of rotation of a shaft at a temperature of diathermic oil of 220 ° C. On ordinate axis values of humidity, on abscissa axis revolutions per minute are specified.

In figures 4-5 on the basis of experimental data the charts displaying dependence of humidity of the dried-up press on the speed of rotation of a shaft of the drying ES600 installation and temperature of diathermic oil are constructed.

During the pilot studies it turned out to dry up the crude and pressed beet press to humidity of 12,5 and 13% respectively. It was succeeded to reveal the parameter which is most influencing efficiency of drying, shaft speed was it. Shaft speed defines the time spent of raw materials in the working camera of drying installation, than frequency is higher, that time is more. During the experiment the time spent of raw materials in the working camera made from 30 to 50 seconds.

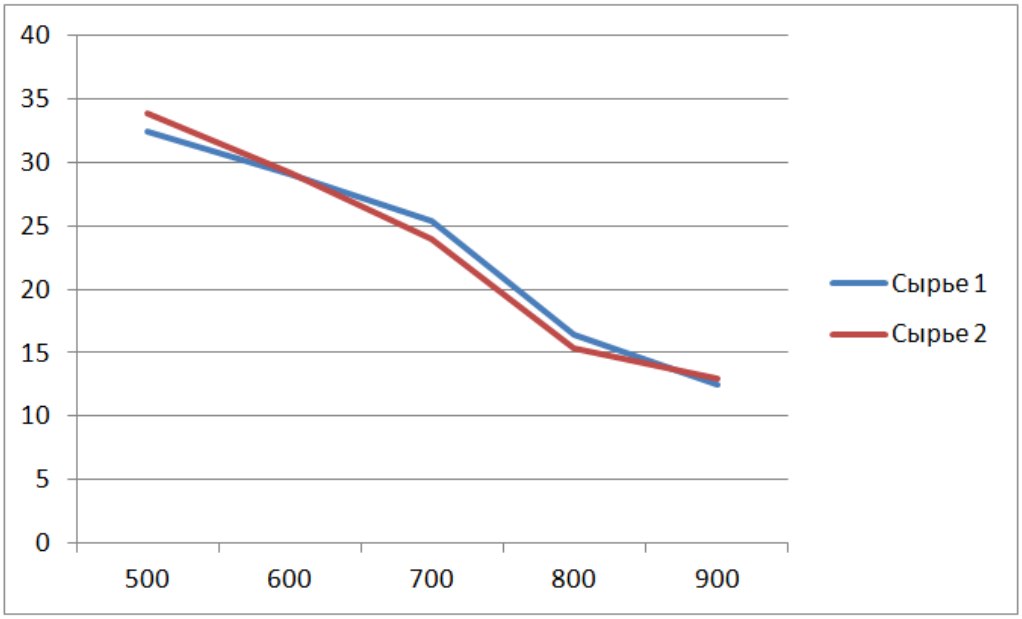

Figure 5 - Dependence of humidity of the dried-up press on the speed of rotation of a shaft at a temperature of diathermic oil of 240 ° C. On ordinate axis values of humidity, on abscissa axis revolutions per minute are specified.

The dried-up press received during thermal drying is presented in the figure 6.

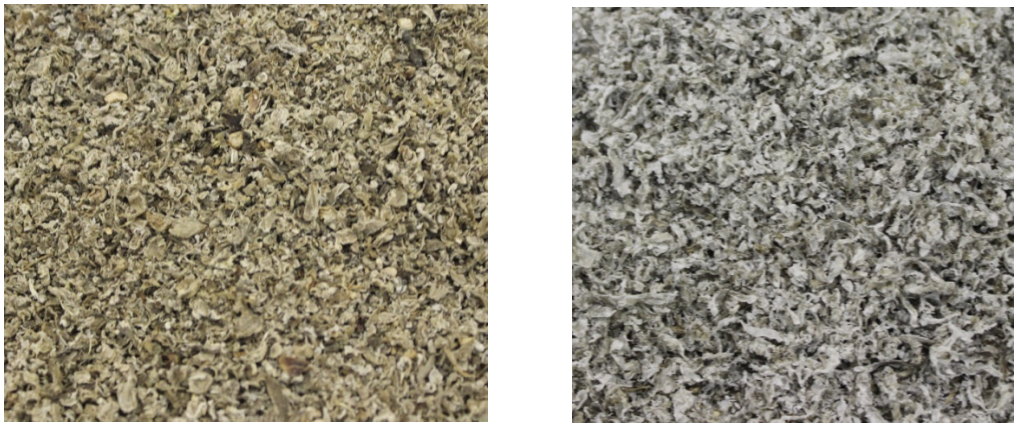

Figure 6 - The dried-up press:
at the left - raw materials 1, on the right - raw materials 2

During the further experiment on the pellets of the received press on the FT-300 installation it was succeeded to receive pellets with a diameter about 6-8 mm and 25-35 mm long, pellets are represented in the figure 7. By results of laboratory researches the humidity pellet has decreased by 1-1,5% concerning the dried-up raw materials and was 11-12%.

Figure 7 - Pellets from a beet press

The data obtained during the pilot studies helped to define an optimum operation mode of drying installation of ES600, 900 revolutions per minute - shaft speed with blades, temperature of diathermic oil - 240 ° C, temperature of blowing-off air - 200 ° C. Also on the basis of the experimental data adjustment of the developed mathematical model of the material balance of processing of waste of beet sugar production for the purpose of support of its adequacy is carried out.

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COMBINED BIOLOGICAL AND REAGENT WASTEWATER TREATMENT PROCESSES

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ABSTRACT

According to the results of laboratory researches, practical and industrial tests new data has been received regarding biological and reagent types of municipal and domestic wastewater treatment processes which are combined in the course of time and space. So, the reagent agent dosage has been determined which allows to provide with treated water quality standards and stable cultivation of activated sludge microorganisms in aeration tanks in complex, the qualitative and quantitative dependence patterns have been revealed between the size of reagent agents complexes and microbe aggregates diameter (activated sludge floccules). The original methodology has been proposed for assessment of microbial community in the course of cultivation using variety of indicators including biological diversity, enzymatic and respiratory activity of microorganisms as well as operational characteristics of activated sludge. On the basis of biological wastewater treatment plant operated by "Chistopol-Vodokanal" JSC practical and industrial tests of combined biological and reagent wastewater treatment process were successfully carried out. Based on results analysis for the tests which were conducted the efficiency has been demonstrated for biological process of carbon, nitrogen, phosphorus compounds and suspension particles treatment of municipal and domestic wastewater with using VTA Biokat P500 reagent.

Keywords: wastewater treatment, activated sludge, reagent preparation

Wastewaters treatment continues to be an important problem of our time, the solution of which is related to the development of biotechnologies for the

decontamination of wastewater in biooxidation and biotransformation processes of their components.

In the aspect of wastewater treatment, it is a matter of cultivation of mixed microbial communities of activated sludge or biofilms that consume waste water components as nutrient substrates, thereby removing them from wastewater. The main product of bioconversion of waste water components is biologically purified water, the by-product - is biomass of activated sludge or biofilm.

In addition to carbon in the wastewaters composition there are two main biogenic elements - nitrogen (N) and phosphorus (P), the presence of which is constantly registered in municipal or close to them domestic waste water.

Present domestic treatment plants don't often ensure balanced development of the main groups of microorganisms-destructors of wastewaters components, don't meet modern requirements for treated water, and in many cases cause organic contamination of natural waters, especially by biogenic elements (nitrogen and phosphorus), thereby causing eutrophication of water bodies.

An equally important problem of the activated sludge microbiocenosis exploitation in biological treatment plants is to ensure its stable separation from purified water by sedimentation. Deterioration of sedimentation leads to operating troubles of secondary settling tanks, removal of activated sludge biomass from the purification system and reduction of its concentration in the aeration tank. The productivity of treatment plant is reduced, and the quality of wastewater treatment is deteriorating.

The aim of the work was a comprehensive study of the process of complex biological and reagent treatment of municipal wastewater for effective cultivation of the activated sludge microbiocenosis.

As objects of researches were examined microbial communities of activated sludge from biological wastewater treatment plants of Chistopol city and Kazan city, as well as reagent preparations: complex coagulant and flocculant VTA Biokat P500, complex coagulant VTA Nanofloc A644, coagulant $Al_2(SO_4)_3 \times 18H_2O$ and coagulant $FeCl_3 \times 6H_2O$.

Microscopy of the activated sludge was carried out by crushed drop method using the LOMO Micomed BO-1 optical microscope with DCM 310 photo-ocular. Samples of the activated sludgewere analyzed with an increase of × 150, × 600, × 1000. For the morphological analysis of the activated sludge, microscopy of its samples was carried out using a confocal laser scanning microscope OLYMPUS LEXT 4000 on the basis of the Center for Collective Use "Nanomaterials and Nanotechnologies" of the KNRTU. In the present work the state of activated sludge was assessed by the species diversity of organisms in the process of pilot-industrial testing.

Respiratory activity of the activated sludge microorganisms was calculated according oxygen consuming rate by the biomass per unit time. Dehydrogenase activity of activated sludge microorganisms was determined by standard photometric method, based on triphenyl tetrazolium chloride reduction involving dehydrogenases of biological systems to triphenyl formazan soluble in ethanol. For studies sizes of nanoparticles in the reagents and reagents solutions by the method

of dynamic light dispersion was used laser nanoparticles analyzer «Malvern Zetasizer Nano " (United Kingdom). Quantitative determination of the biological oxygen demand (BOD_5), ammonium ions, nitrite, nitrate, sulfate and phosphate ions, compounds of mobile phosphorus by the Kirsanov method, the phosphorus in the sludge by the weight molybdenium Lorentz method, was performed according to standard procedures. Chemical oxygen demand (COD) was determined by bichromate oxidation, dissolved oxygen concentration - by Winkler method, as well as using the portable Oxygen UlabSX 716. The experimental results were processed using STATISTICA 5.5 and MS Microsoft Excel software package.

The reagent VTA Biokat P 500 was implemented into experimental mediums at dose of 10, 20, 30, 50, 100 and 500 µl /dm^3, the reagent wasn't taken into control system. The periodical cultivation for microbial community of activated sludge was conducted within 4 hours promoting concentration of dissolved oxygen in all mediums in the amount of not less than 2 mg/dm^3. The dose of activated sludge by weight was about 2 g/dm^3. In compliance with the results of the first stage of laboratory researches the dosage of VTA Biokat P500 reagent in the amount of 50 µl /dm^3 was determined which didn't affect significant inhibiting of activated sludge organisms but promoted to increase the activity of oxidation-reduction enzymes (dehydrogenase) (Figure1) [1].

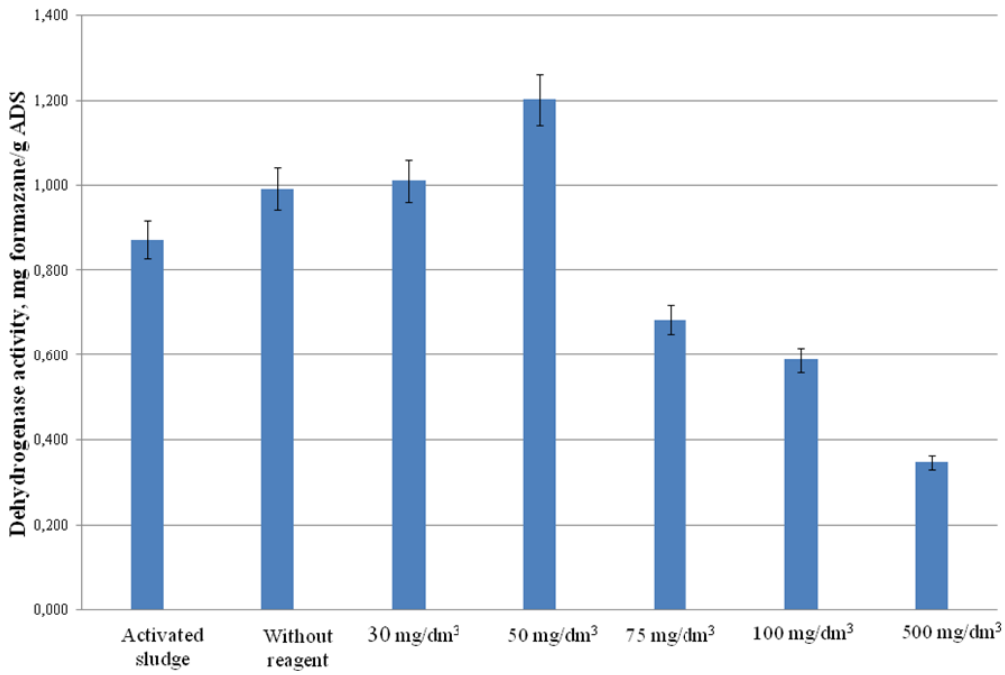


Figure 1 – Dehydrogenase microorganisms activity in mediums with various reagent concentrations

Besides that, the selected dosage enables to increase the efficiency of nitrification process by 41% compared with traditional biological treatment. The increase in efficiency was recorded for removing phosphate by 76 %, organic

substances-by 46 %, nitrogen compounds - by 30 % from wastewater compared with traditional biological treatment.

The respiratory activity of activated sludge microorganisms was researched to assess test reagent efficiency in the course of cultivation in synthetic wastewater solution for improving dissolved oxygen mass exchange in conditions of oxygen limitation. At initial stage the synthetic wastewater solution was saturated with oxygen within 30-60 minutes. Just before experiment the activated sludge suspension in the amount of about 2 g/dm^3 related to dry substance biomass was taken into synthetic wastewater. The Biokat P500 reagent in the amount of 50 µl /dm^3 was taken into control system. At the same time the control experiment was conducted without adding reagent. According to obtained results the biomass in these systems consumed at average by 6,7 % less dissolved oxygen than in control systems.[2].

For detailed research of activated sludge flocs size dependence in the presence of VTA Biokat P500 reagent in system the reagent particles size was researched in solutions of various concentration. The results which are presented in Table 1 indicate significant dispersion in samples of 10 and 100 µl /dm^3 dosage [3].

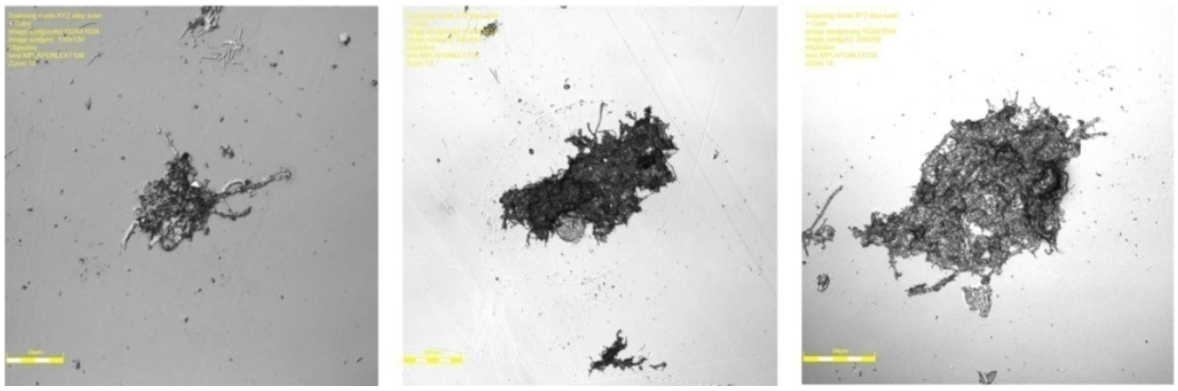
Table 1 – Particles size and volume distribution in reagent solutions

Tested Sample	Particles share of certain size in sample	
	Average size (diameter), nm	Share, %
BiokatP500 10 µl /dm^3	316,4	50,0
	33,17	43,5
	13,71	6,5
Biokat P500 50 µl /dm^3	35,6	100
Biokat P500 100 µl /dm^3	18,49	73,1
	86,31	26,9

The samples of 50 µl /dm^3 dosage had absolute homogeneity and for them all the reagent particles were of 36 nm size.

It's obvious that the size of reagent particles in solution determine aggregating and size of forming sludge flocs. The morphology of activated sludge flocs was explored to reveal this dependence with using coagulant-flocculant VTA Biokat P500 compared to coagulant VTA Nanofloc A644 as well as with the samples of activated sludge in system without reagent.

The obtained results state significant enlargement of activated sludge flocs in sample with VTA Nanofloc A644 reagent compared to sample without reagent and with reagent VTA Biokat P500 (Figure 2, Table 2).



a b c

Figure 2 - Microscopic picture of activated sludge flocs
(a - without reagent, b – VTA Biokat P500, c – VTA Nanofloc A644, ×400);
calibration scale corresponds to 100 μm

Table 2 – Activated sludge flocs size

Sample	Flocs size, micrometers	Average size of flocs, micrometers
Without reagent	65,0-100,0	98,0
Biokat P500	150,0-360,0	125,0
Nanofloc A644	117,0-816,0	304,0

As it was described before [4], there is a linear dependence between the size of activated sludge flocs and the activated sludge ability for biological oxidation when the critical size of floc is 250 micrometers while oxygen into flocs weight transfer coefficient decreases rapidly. Thus it is pointed out that the solution with VTA Biokat P500 reagent operating concentration of 50 μl /dm^3 differs in the homogenity of particles size that results in the formation of activated sludge flocs size which is favorable for biological oxidation processes and acceptable sedimentation.

Based on obtained results the practical and industrial tests were carried out at municipal biological wastewater treatment plant (BWWTP) in Chistopol city to assess the efficiency of VTA Biokat P500 reagent for treating wastewater and investigate pointedly how the reagent affects the microbiocenosis of active sludge.

The practical and industrial tests took more than 50 days. In the course of all the period of tests the analysis of activated sludge condition was conducted periodically 1-2 times per week as well as within several following weeks. VTA Biokat P500 reagent consumption was from 3 dm^3/h to 8 dm^3/h (on average 5 dm^3/h) with dosage directly into test aerologic tank for one from four independent treatment stages. Another treatment system stage was control and was used for comparison with test system.

The consumption of incoming wastewater into each stage was 104 m^3/h on average (~2500 m^3/day); so the specific reagent flow rate was from 0,000029 to 0,000077 m^3/m^3 wastewater.

As a result of the pilot-industrial tests of VTA Biokat P500 reagent on BWWTP in Chistopol city, an increase of the efficiency of organic substances removal from wastewater according BOD and COD, suspended solids, phosphates, nitrites was observed with their normative content in purified water [5]. It has been experimentally proved that a prolonged presence (more than 50 days) and the accumulation of a reagent in a biological purification system in conditions of it's directly introduced into an aeration tank to remove phosphates and other wastewater components does not adversely affect the course of biological processes associated with enzymatic transformation and respiration.

A comparative evaluation of the efficiency of the microbial wastewater components biooxidation processes with the use of reagent preparations was carried out in the laboratory [6]. The dose of activated sludge by the weight was about 2 g / dm^3 on a dry matter basis. Biokat P500 solutions were added to one of the laboratory aeration tanks in the amount of 50 µl / dm^3, in two others - $AL_2(SO_4)_3$ in an amount of 30 mg / dm^3 and $FeCl_3$ in the amount of 57 mg / dm^3. The fourth aeration tank was a control without application of a reagent preparation. Samples of wastewater and biomass were selected for analysis at the initial moment of time, after 1 and 4 hours of cultivation.

From the obtained results, it follows that the efficiency of the combined biological treatment using VTA Biokat P500 to remove phosphates is higher by 14% and 5% compared to the use of aluminum sulfate and ferric chloride, respectively. The removal of organic substances in a similar manner proceeds more efficiency by 18% in a medium with VTA Biokat P500 in comparison with other reagents (Figure 3).

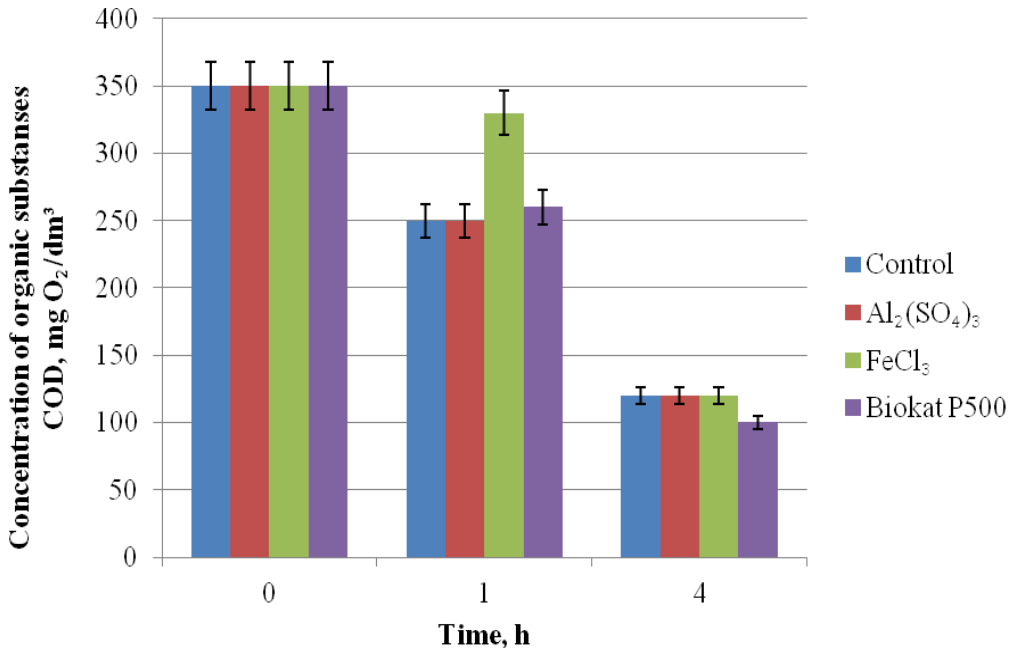


Figure 3 – Biological oxidation of organic substances in the course of cultivation

The efficiency of nitrification processes was assessed by the calculation of nitrification coefficient K_N (Table 3).

Table 3 - Balanced ratio of nitrogen forms in the course of cultivation

Probe	**Amount of removed $N\text{-}NH_4^+$, mg/dm^3**		**K_N**
	Total	Autotrophic oxidation	
Control	11,07	3,93	0,35
$Al_2(SO_4)_3$	11,29	7,32	0,70
$FeCl_3$	11,14	1,24	0,086
Biokat P500	**11,61**	**8,65**	**0,77**

The results of the nitrification coefficient (K_N) calculation showed that microbiocenosis of the activated sludge in the medium with the Biokat P500 reagent has the greatest nitrifying activity.

It has been experimentally revealed that the efficiency of simultaneous in-time and in-space biological and reagent treatment of municipal wastewater using VTA Biokat P500 reagent to remove phosphates is higher by 14% and 5%, COD by 18%, nitrogen of ammonium - by 25% and 10% compared to the use of aluminum sulfate and ferric chloride, respectively. As a result of studying the processes of activated sludge microorganisms cultivation in the presence of the complex reagent VTA Biokat P500, pointed out an increase in the efficiency of removal of phosphate ions from wastewater by 76%, organic substances by 46%, nitrogen compounds by 30% compared to conventional biological treatment.

Thus, based on the results of a complex assessment of processes of biological oxidation and biotransformation of wastewater components in the technology of their combined biological and reagent treatment, the dosage of VTA Biokat P500 reagent equal to 50 µl / dm^3 was determined [7]. It was noted that the chosen dosage of the innovative reagent does not exert a pronounced inhibition of activated sludge organisms in the technology of biological treatment of municipal wastewater. Moreover, it has been shown that the use of the VTA Biokat P500 reagent in this dosage promotes the activity of redox enzymes (dehydrogenases) in the processes of microbiocenosis cultivation in aeration tanks, provides an increase in the efficiency of the nitrification process by more than 40% compared to conventional biological treatment [8]. Separately, the processes of aggregation (flocculation) in the presence of a reagent VTA Biokat P500 were investigated. It was noted that a solution with a working reagent concentration of 50 µl / dm^3 differs in the homogeneity of the particle sizes, which in turn causes the formation of activated sludge flocs favorable for biooxidation and satisfactory sedimentation.

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PHOTOCATALITYCAL METHOD AND EQUIPMENT FOR PURIFICATION OF WATER WASTE CONTAMINATED WITH PHENOL TO THRESHOLD LIMIT VALUE

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ABSTRACT

Phenol is one of the most toxic pollutants. It has genotoxicity, neurotoxicity, reproductive and developmental toxicity, chronic toxicity and carcinogenicity properties. Phenol pollution of natural bodies is one of the most important ecological problems of modern industry. In the present work we described the photocatalytic method of purification of water waste of petrochemical factories against phenol. Photocatalysis is one of the most promising methods of water decontamination, which allows to purify water against phenol without formation of byproduct by using photocatalysts. Photocatalyst is semiconductor materials, with active surface. Electromagnetic radiation interacts with surface of photocatalyst, promotes moving of electrons from valence band to conductive band.

In the present work we described the method of water purifiction is based on photocatalysis process in the presence of zinc oxide nanoparticles under visible and UV irradiation. Organization of photocatalytic equipment is described. We showed that faceting of zinc oxide nanopartiles allows to increase activity of photocatalyst. Faceting zinc oxide nanoparticles can purify of water under visible light. It is shown that photocatalysis promotes to fully oxidize phenol to nontoxic substances and has great promise of implementation to industrial water purification.

Key words: photocatalysts, water purification, zinc oxide, visible light, water waste

1. INTRODUCTION

One of the most important ecological problem of modern industry is pollution of wastewater with toxic contaminant including phenol [1]. Phenol is very toxic pollutant, it has genotoxicity, neurotoxicity, reproductive and developmental toxicity, chronic toxicity and carcinogenicity properties (1 g of phenol poisons 1000 tons of water) [2,3]. Pollution of industrial effluent with phenol is most often finds at wood-working, petrochemical plants, production of plastics, paint manufacture, coke-chemical industry and other [4].

Threshold limit value of phenol in domestic water is 0.001 ppm, for drinking water TLM is 0,5 ppb [5].

Traditional purification methods of wastewater from phenol and it derivatives are extraction, sorption, oxidation, hydrolysis, biological purification and others [6-8]. But at the present time all these methods not allows to purify water to TLM and problem of creation new approaches of water treatment is relevant. Photocatalysis is one of the most promising methods of water decontamination, which allows to clean water from phenol without formation of byproduct by using semiconductor materials, photocatalysts. Usually photocatalyst is metal oxide such as zinc oxide or titanium dioxide. Electromagnetic radiation interacts with surface of photocatalyst, promotes moving of electrons from valence band to conductive band. Active radicals arise on the surface of photocatalyst, which take place in chemical decomposition of organic pollutants.

Creation of equipment for photocatalysis process, which allows to realize purification in industrial, is also very crucial aspect. Using nanoparticles of photocatalyst as suspension permits use all surface area for achieving maximum purify effect.

In laboratory "Nanocatalysts and functional materials" (Togliatti State University) we have developed photocatalyst based on ZnO, researched it properties and manufactured trial equipment for implementation of experiments and find the favorable conditions for developing the most effective technology of purification sewerage from phenol. Figure 1 shows scheme and image of developed equipment. This equipment can significantly facilitate for engineers, technologists, designers the task of search and setup purification process of water waste from phenol at the each plant.

The principle of operation of this installation is based on changing the speed or stirring of chemical reactions under the action of light in the presence of substances (photocatalysts) that absorb quantum of light and participate in the chemical transformations of the participants in the reaction, repeatedly entering with them into intermediate interactions and regenerating their chemical composition after each cycle of such interactions.

It is shown that zinc oxide can exhibit high photocatalytic activity in the reaction of complete decomposition of phenol to carbon dioxide and water under the influence of visible light. The presented design of a photocatalytic reactor,

which is a prototype of an industrial plant, allows for photocatalytic studies of nanopowders under both visible and UV lirradiation.

2. EQUIPMENT FOR RESEARCH OF PHOTOCATALYSTS

Equipment consists of several elements:

- Ultrasound bath "Sapphire 0.5 L" for dispersing of photocatalytic powder (fig.1, pos. 1),
- Power supply unit (fig.1, pos. 2),
- Funnel (fig.1, pos. 3),
- UV-lamp (fig.1, pos. 4),
- Protective cover (fig.1, pos. 5),
- Capacitive reactor, volume 5 L (fig.1, pos. 6),
- Air compressor "EHEIM air pump 200" (fig.1, pos. 7),
- Ozonizer "Groza" (fig.1, pos. 8),
- Peristaltic pump "BT100-2J"(fig.1, pos. 9),
- Magnet stirrer "Ulab US500A" (fig. 1, pos. 10),
- Vessel for clean water (fig. 1, pos. 11).

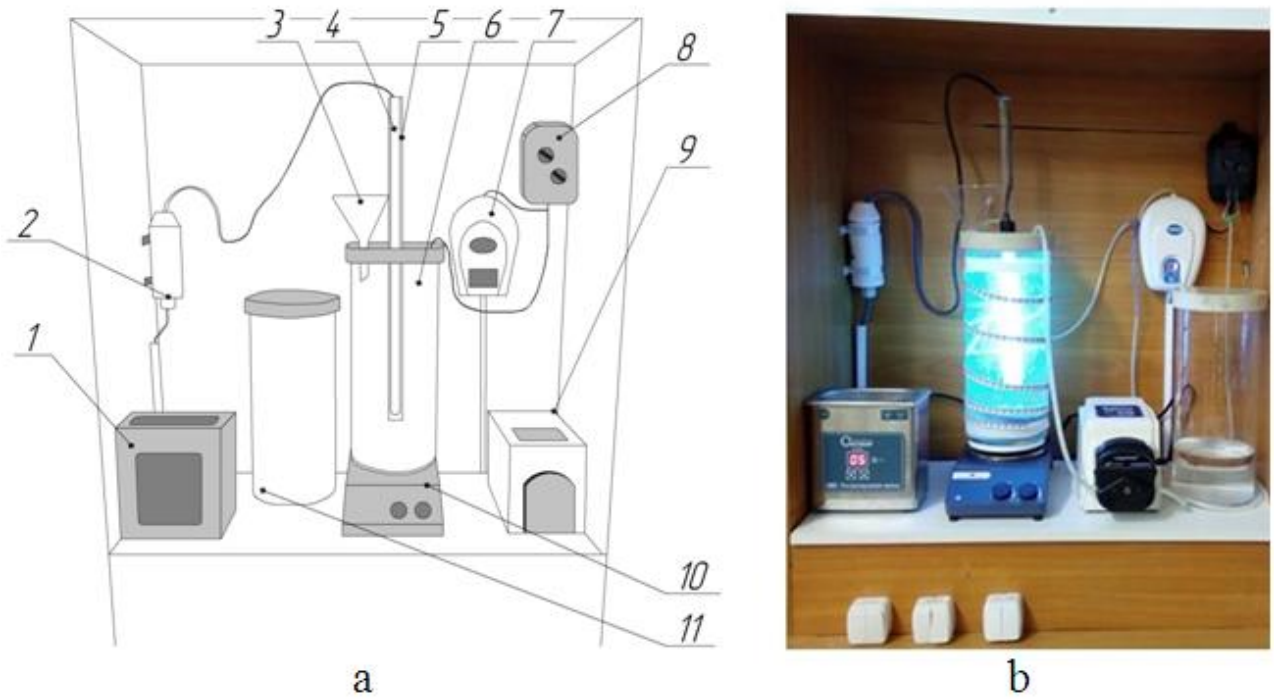

Figure 1 - Scheme (a) and image (b) of developed photocatalytic equipment

The supply of water and dispersed particles of the photocatalyst to the capacitive reactor is provided with a funnel (Figure 1, pos. 3). The protective casing was used in two types: quartz and light filter, which allows to study photocatalysts in both ultraviolet and visible electromagnetic radiation.

The trial equipment is connected to the power supply. Then photocatalyst is preparing by dispersing the powder in the test liquid using an ultrasonic bath (Figure 1, pos.1) for 10 minutes. At this time, a contaminated working fluid is moved through the funnel (Figure 1, pos. 3) into the reaction vessel (Fig. 1, pos. 6). Next the photocatalyst is also loaded through a funnel into a reaction vessel. A magnetic stirrer is activated (Figure 1, pos. 10). Then, it is necessary to close the protective cabinet to achieve sorption equilibrium, on the next stage switch on the radiation source (Figure 1, pos. 4 or 12) and load the air-ozone mixture from the ozonizer (Figure 1, pos. 7) and the air compressor (Figure 1, pos. 8) necessary for the photocatalysis process. At the end of this time, the power source of the lamp, ozonizer, and compressor is switched off on the instrument panel. At this stage, you can open the protective cabinet and start the pump (Figure 1, pos. 9) to release the reaction vessel and transfer the liquid to the vessel (Figure 1, pos. 11) for purified water.

Such a design of the photocatalytic reactor provides the possibility of full-scale studies of the photocatalytic activity of powders of various materials on one device, working out regimes and necessary parameters for specific photocatalytic materials and types of contamination of fluids that require purification.

3. SYNTHESIS OF NANOPARTICLES ZNO BY HYDROTHERMAL METHOD

Hydrothermal method implies fabrication by several stages. Synthesis was processed by chemical reaction the water/ethylene glycol solution. At first, 250 ml of ethylene glycol (EG) was dissolved in 750 ml of distilled water (W). Resulting mixture was stirred to appearance homogeneous solution by mechanical stirrer. Next, 50 mM of salt including Zn2+ ions was dissolved in EG/W solution to preparing the true solution. To obtain samples of different shapes, we used zinc salts of different acids: zinc chloride, zinc nitrate, zinc acetate. Then, prepared solution was heated to 70°C with constant stirring. On the next stage 42.1 g of potassium hydroxide was added to stirring solution. Solution temperature was maintained about 70°C. Prepared solution was stirred at 70°C during 1.5 hour. On completion reaction time stirred was stopped and nanoparticles were fell onto bottom of the flask. Spent solution was poured off, sediment of nanopartilces was washed water. Nanoparticles were dispersed in distilled water by ultrasound bath and then separated by centrifuge at 6000 rpm. Described wash procedure was repeated several times to complete removing synthesis by-products. On the last stage nanoparticle powder was dried in desiccators at 105°C to remove water.

4. CHARACTERISTICS OF OBTAINED NANOPARTICLES

Resulting powders were deposited onto silicon oxide plated and studied by scanning electron microscopes (SEMs), CarlZeiss Sigma, Germany. Also those samples were performed with a X-ray diffraction (XRD), Shimadzu XRD 7000,

Japan, to determine they structure. Chemical composition of nanoparticles was studied with energy dispersive X-ray fluorescence spectrometer EDX 8000 Shimadzu, Japan. Distributed of nanoparticle size was measured with laser analyzer Sald 2300 Shimadzu, Japan. Figure 2 and Table 1 show characteristics of obtained ZnO nanoparticles. Nanoparticles have hexagonal crystal structure of wurtzite, space group P63mc, chemical composition of nanoparticles is ZnO.

5. RESEARCH OF PHOTOCATALYTIC PROPERTIES

Research of photocatalytic properties was implemented by chemical decomposition of phenol dissolved in water. Phenol concentration was analyzed with spectrofluorophotometer RF-6000, Japan; spectrophotometer Promecolab PE-5400 UV, Russia and Gas Chromatograph-Mass Spectrometer GCMS-QP2010Ultra every hours during one day. Zinc concentration after photocatalytic tests was determined with Atomic Absorption Spectrophotometers AA-7000, Japan.

At first, we research changing of phenol concentration in water without nanoparticles at constant stirring in dark, under visible light and under UV irradiation (fig. 3a). The initial concentration of phenol was 10 ppm. All three series of experiments were performed at room temperature, each experiment was repeated more than five times.

Table 1 - Characteristics of obtained ZnO nanoparticles

Parameter		Faceted particles	Non-faceted particles
Power color		White	Beige
Medium size of particles, nm		321	570
Shapes		Faceted wires	Plates
Specific surface area, m^2		31	21
Crystallite size, nm		23	32
Lattice constant, Å	a	3.247	3.252
	c	5.205	5.211
Mineral name		Zincite	
Space group		P63mc	
Crystal structure		Hexagonal	
Potassium mass concentration, %	EDX	0.0	1.2
	SEM	0.0	2.8
Band gap, эВ		3.2	3.3

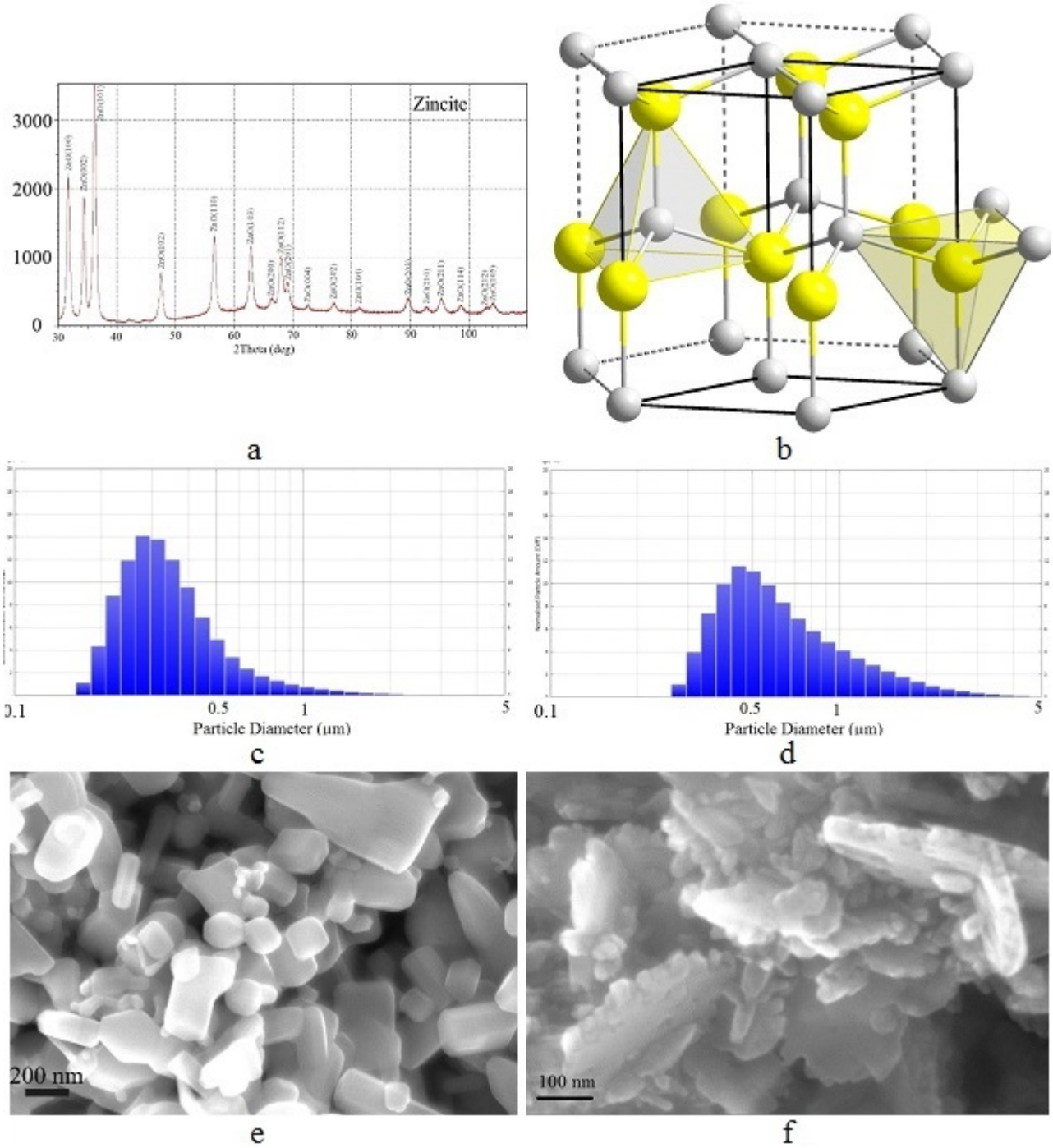

Figure 2 - Characteristics of obtained ZnO nanoparticles
(a) XRD, (b) Structure of primitive cell, (c) distributed of faceted nanoparticle size, (d) distributed of non-faceted nanoparticle size, (e) SEM images of faceted nanoparticles, (f) SEM images of non-faceted nanoparticles

To study the change of phenol concentration under visible light, a yellow light filter was used in the form of a protective casing for a UV lamp, which does not allow passage of ultraviolet rays. Then all nanoparticles were studied for sorption capacity. The ZnO nanoparticles were dispersed in water containing phenol at a concentration of 10 ppm (Fig. 3b,e).

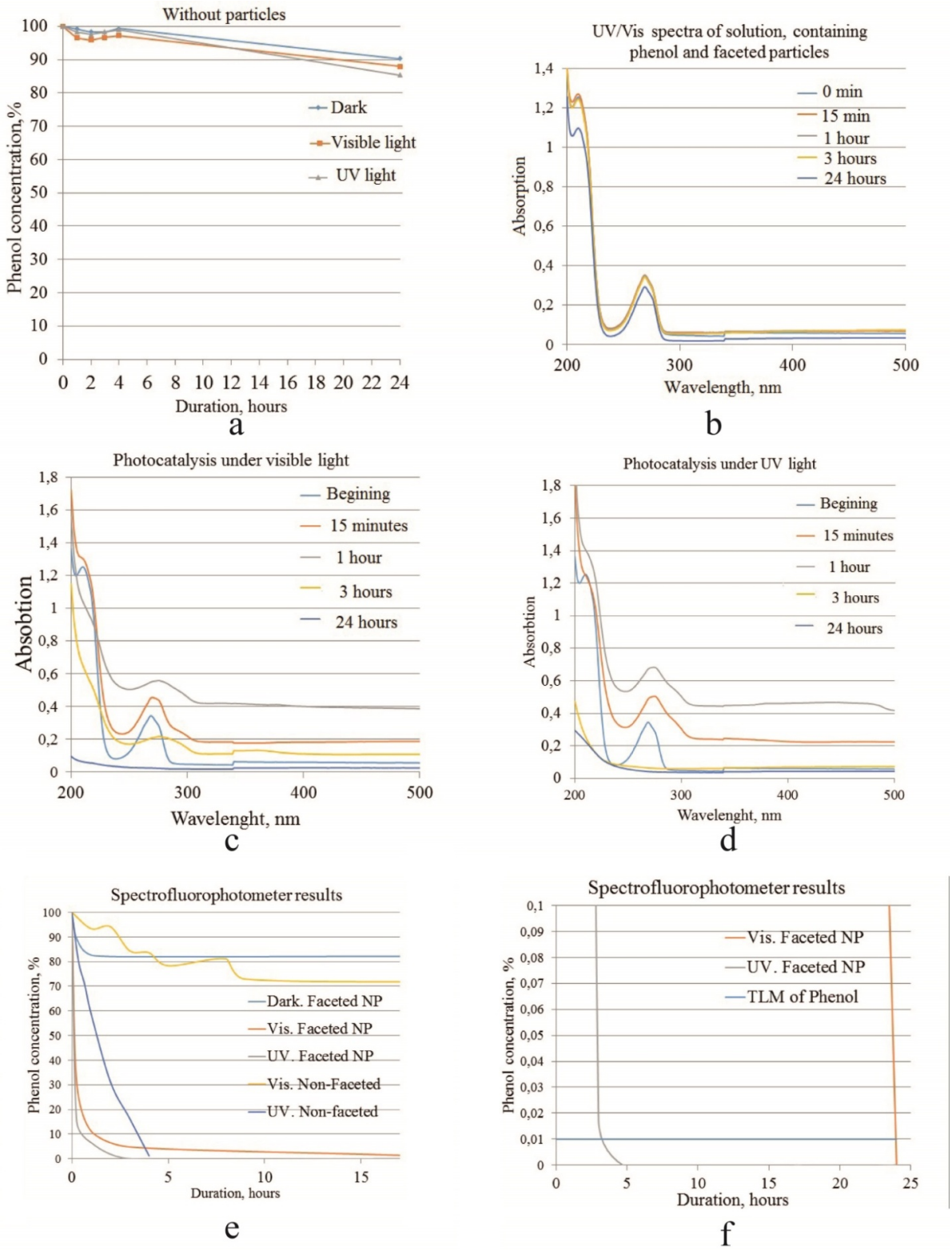

Figure 3 - Kinetics of changing of phenol concentration in the presence of ZnO particles

(a) without particles, (b) UV/Vis spectra of solution in the dark, (c) UV/Vis spectra of solution in the presence of faceted particles under visible light, (d) UV/Vis spectra of solution in the presence of faceted particles UV light, (e,f) spectrofluorophotometer results

The solution was mixed on a magnetic stirrer, in the dark. Each hour 5 ml of solution was sampled and centrifuged for nanoparticle precipitate. Next, were studied photocatalytic activity of ZnO nanopowders under UV (Figures 3c and 3d). The concentration of phenol was 10 ppm. The irradiation was carried out with a mercury fluorescent lamp with a wavelength of 365 nm Wonder-Light GPH303T5L / 4P M1-2T-14. One series of samples was irradiated with UV light, the second was irradiated with a UV lamp through a light filter.

Results of testing with Gas Chromatograph-Mass Spectrometer show that phenol concentration was reduced and by-products are absent (fig. 4)

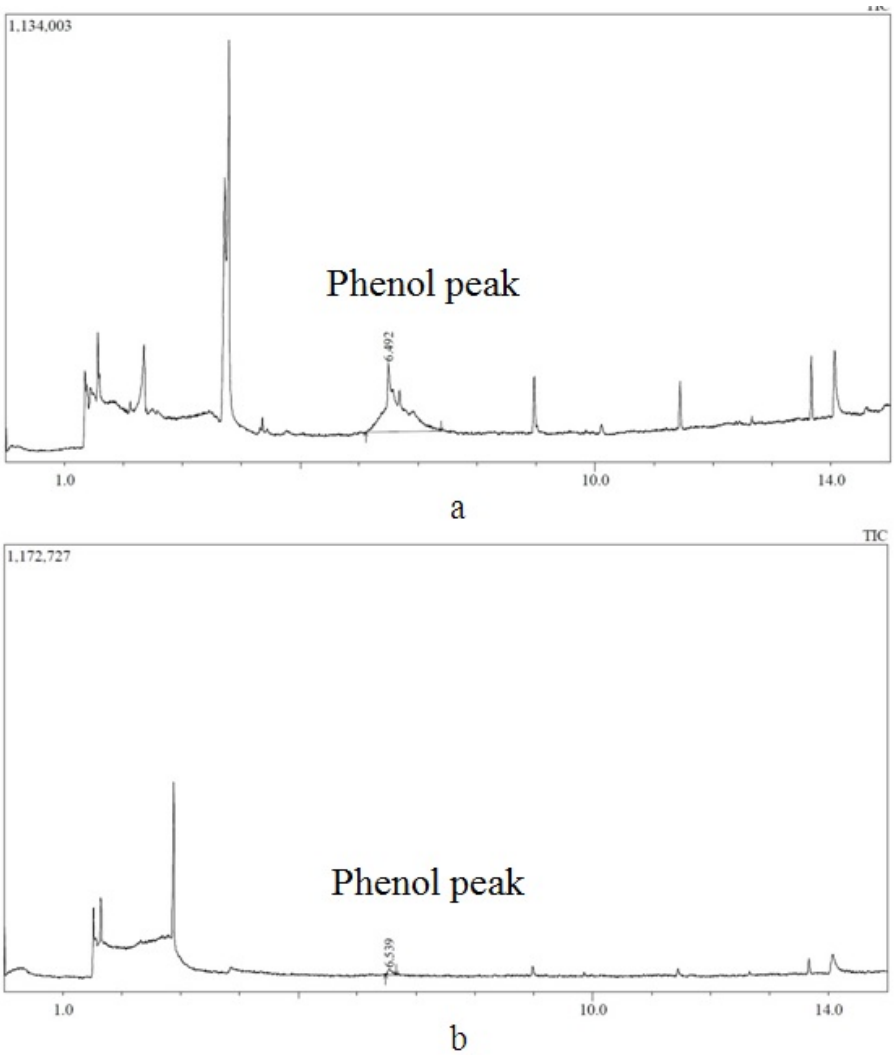

Figure 4 - Results of testing with Gas Chromatograph-Mass Spectrometer (a) until photocatalysis (b) after irradiation with visible light

Spectrophotometry of water showed the disappearance of the characteristic peaks of phenol, the emergence of new and, ultimately, a drop in optical density to values close to zero. The data of the three methods of investigation are consistent and allow us to state that phenol decomposition occurred before CO_2 and H_2O.

Figure 3a shows the decrease of concentration of phenol in an aqueous solution without nanoparticles with stirring by a magnetic stirrer in three different cases: in the dark, under the influence of visible light and under the influence of

UV light. The decrease in concentration in all three cases was slightly different. After 2 hours the concentration of phenol partially fell, but after it increased to its original value. Probably, this form of the curve is due to the partial sorption of phenol on the walls of the vessel and subsequent desorption. After a day in all three cases the concentration of phenol was about 92% of the original. The difference between the series of experiments did not exceed the deviation within each sample, i.e. the composition of the radiation does not affect the change in the concentration of phenol. A partial drop in concentration may be caused by evaporation or sorption on the walls.

The curves (Figures 3b and 3e) show the decrease in phenol concentration in the dark, as seen in the figure, ZnO particles sorb on their surface less than 20% phenol, then the phenol concentration does not change during the day.

Under the influence of UV light, the phenol decomposition proceeds for several hours (Fig. 3d). The concentration of zinc in water after photocatalysis was about 2 ppm. The mass of nanoparticles during the photocatalysis was 1 g per l, therefore about 0.2% of zinc from the loaded photocatalysis remains in the water. In what form the zinc remains in the water is not clear. It is likely that in the case of ZnO in water, after the photocatalysis, fraction of small particles or zinc compounds remain. In the future, this issue will be studied in detail.

Irradiation of a phenol solution containing dispersed ZnO nanoparticles was also performed by visible light through a light filter that transmits visible spectrum radiation. ZnO nanoparticles, which have a facet, exhibit photocatalytic activity under the influence of both visible and ultraviolet light. Particles without faceting are only active under the influence of ultraviolet radiation.

CONCLUSIONS

1. Hydrothermal method of synthesis of ZnO nanoparticles allows the creation of photocatalysts active in the visible range of electromagnetic radiation.
2. It is shown that ZnO, which has a facet, can exhibit photocatalytic activity under visible light in the phenol decomposition reaction.
3. A pilot equipment has been developed that allows the research and testing of photocatalysts and purification and purification of wastewater from phenol to regulatory requirements.

ACKNOWLEGEMENTS

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3D MODEL STRUCTURAL REPRESENTATION BY B.I.M. PROCESS

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ABSTRACT

The B.I.M. helps the owner, the architect and the contractor, to carry out a complete project under different points of view. It provides the functionality of the spaces, and make it virtually ready for a long time. The B.I.M. has an added value. In fact, it creates a unique platform like a knowledge network able to sharing data in real time among different professionals.
The interaction between the structural, the functional and the aesthetic elements into modern design software, represents a serious challenge for many graphic programs, but B.I.M. differs from the others one thanks to its ability to compare and interchange data. Structural computation programs have interfaced with graphics programs just after B.I.M. creation.
In this work, will be defined B.I.M. as a sort of interactive platform for sharing design ideas. In the literature, the cases included in the structure models, were not easy comparable because they performed with different tools. With the use of B.I.M. it is possible to create a unique language of dialogue not only between figures involved in the same project, but also between different projects.

Key words: software structure models, graphics programs

1. INTRODUCTION

The B.I.M. as computer aided modeling is an innovative way to manage the project. It takes care of the design from the point of view of the graphics of digital representation in three dimensions and it is a part of the management processes of the model, production and communication analysis (Figure 41).

All building components contain information and they are connected to the parametric data that describe the attributes included in the working process of the model.

If a building component change, all associated data change with it, and as a consequence, the entire related process, at the structural, economic and accounting level. In B.I.M. the work design is organized on several databases that interface and connect together by the operator.

Compared to the traditional procedure for implementing the architectural design, through the use of vectorized lines that geometrically represent the constituent parts of the building, the B.I.M. adds textural and economic attributes to each element, and characterizes the process by sharing information and it is part of the PLM (Product Lifecycle Management). During the development phase of the project, the different professionals involved, with their special skills, contribute to increasing and changing data on the same platform.

This process ensures that there is no loss of data throughout the establishment phase of the project, in addition, it displays the hypothetical scenarios of the model, related to the vulnerability of the building and to the dangerousness of the site.

Introducing the system of B.I.M., means to integrate into a setting up project of architecture, engineering or a design object, a multi-disciplinary approach to facilitate the identification of the spatial geometry, of the surveying, and about the quality and quantity of materials building components.

2. 3D STRUCTURAL DESIGN

To pick up the definition of the General Services Administration (GSA), which in 2007 published this definition of B.I.M.: "Building Information Modeling is the development and use of a multi-faceted computer software data only to document a building design, but to simulate the construction and operation of a new facility or a recapitalized capital (modernized) structure. The resulting Building Information Model is a data-rich, object-based intelligent digital representation and Parametric structure, which sees adapted to the various needs of users can be extracted and analyzed to generate feedback and improvement of the design structure."

With the development of the technology, and the diffusion of information on the networks, has increased the need to enlarge the knowledge in the field of the digital design.

To create a 3D structural model for a building with B.I.M., means getting the ability to create an intelligent multiple dimensions design.

Beyond how many changes are made during the design phase of the building, the various constituent elements remain consistent and coordinated among themselves. This does not happens by using CAD in 2 D.

The established connections between the different skills, make more complete the developing process of building design. This speeds the decision-

making stage because the model displays various scenarios and eliminates eventually mistakes.

The design process becomes manageable when it involves the quantification of feedback, and gives the possibility of finding design solutions that could not be achieved with prototypes that would be too expensive.

The experimental use of B.I.M., in structural field, is considered in this research.

3. PARAMETRIC VISUALIZATION

With the B.I.M. the changing rule of the belonging elements does not change the object itself, in fact, changing in axonometric, perspective, planning and section, the visualization of a project is automatically modified by the first change.

In contrast, with CAD, each modified element entails a series of successive changes. According to B.I.M methodology, a building plan requires clear rules to be underpinned. For example, the A rule defines and constrains the height of the building, the B rule constrains the volume can be realized, the C rule defines the parameters of seismic safety, the D rule limits of 5 cm the brick cladding of the whole building, a.s.o... If the designer collides with the rules, laid down in advance in the program, he is notified.

The parameters of the project are, for example, the geometrical dimensions of a building. All these data collaborate in writing parametric modeling of the building, in which, each element belongs to a determine category.

To date, the market of computerized graphics does not offer a variety of software that contains parametric and predefined objects (ArchiCAD and Revit Structure).

A decisive step toward the implementation of B.I.M. was done by the so-called modeling procedure. Through this process, B.I.M. has become a kind of multifaceted tool, provided with a plurality of functions. It has become an authentic multifunction instrument, capable of detecting a plurality of data and to provide an innovative structural representation.

B.I.M. is defined as work in progress that overcomes the traditional connotation of tool aimed at creating geometric design, it becomes an advanced multi-layered instrumentation.

A modern instrumentation with a plurality of functions by virtue of which can be "read" in three dimensional and analytical, the structures. By B.I.M. we can identify the connections between a plurality of elements (tubular, walls, windows). It is a skill that allows to capture a variety of useful data to targeted information needs. B.I.M. provides answers about the object linkage.

At the same time, it make possible to understand what type of connection is applicable in a specific context. B.I.M. also allows to check what kind of connections has been used. In this context, B.I.M. is, therefore, specifically applicable to topological structures.

In the scientific (Eastman, 2008), B.I.M. models were defined as programs characterized by parametric components, within which the digital data are

governed by intelligent rules. In addition, these programs permit to earn maximally accurate information, this is an indispensable element in the design, as well as, more generally for the conditions and connotations analysis of a building.

Another element of B.I.M. strength, as already mentioned above, is its ability to bring in automatic the changes made to the project for the entire document.

It should also be considered, that the data provided are rationally grouped and coordinated. This feature allows a plurality of visions and an easier analysis of the same data.

So, B.I.M. appears to be a multifunctional fruit thanks to its ability to link and combine several software in applying to a project.

Applying B.I.M., the designers can adopt specific, fast and synchronized choices.

4. B.I.M. FOR ARCHITECTS AND ENGINEERS

Every active company in the field of construction, air force, and mechanics, at the beginning of its activity, prepares a plan in which locates human resources needs. These figures are involved in the project management, in group works, and ensure the implementation and the success of the project.

The employee training investment is important to integrate the traditional process with the newest B.I.M. In addition to the professional training, the companies take advantage of an additional specialist, who manages the project files complexity.

This solution benefits the training within the company, and increases the quality of the project. With the industrialization process, and the discovery of mechanics, the professional figure of several employees has been replaced by a machine, able to operate more than two workers.

This is not the case of the B.I.M., in fact, it facilitates the procedures in order to include all professionals in the same project. The B.I.M. target is to promote the cooperation among different professionals who work on the same platform to implement the same project. B.I.M. does not aspire to substitute a worker, on the contrary, it involves different professionals to realize a project. They load data in the computers and work with it during the entire modelling process (Figure 46).

The B.I.M. technology can be used both by professionals, architects and engineers, and by public superintendents.

The advantages generated by using B.I.M., are various, as already expressed in the previous chapters.

5. CONCLUSIONS

The parametric display of a three-dimensional digital model of a building is unprecedented compared to the complete and sophisticated B.I.M. Although this methodology comes from the Computer - Aided - Drafting, it is able to present clear advantages.

Widespread in a strong way in the last decade, modelling studied in this research, has led to rise in productivity for construction companies.

The engagement of a contractor to a work transition, by the use of traditional model, to an innovative, has entailed many advantages: saving money previously invested to create a prototypes, and decreasing building mistakes, as a consequence, corporate profits has risen.

Design approach is quite different than the previous. It must be flexible, modifiable and applicable in each single stage. Often, the companies invest in professional training to collect files that are managed by others specialists who work for the same project.

This is a good idea as a new key to change the whole process, and not only the graphics mode. Even the service equipment business is updated: more powerful CPU, more memory support, WAN devices and video conference monitors to promote a greater information interchange among technicians located in different geographical areas.

The analysis of an architectural project involve many disciplines, for this reason, there are more information to manage and store. This is the input to invest in more powerful and complete equipment.

3D CAD models are viewers software and they can still be used for detailing some phases of the project, despite the central role is done by B.I.M. technology. However, this mode, must immediately be the starting point of the basic model.

The 2009 Smart Market report shows that the majority of construction companies have produced positive returns on their investment in B.I.M.

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THE DOOR OF SAINTS: ITALIAN CULTURAL HERITAGE TO BE PROTECTED FROM SEISMIC RISK

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ABSTRACT

The Door of Saints in Capocastello (Italy) and its painting are not well preserved from environmental risks because they are unprotected and continuously exposed to the weathering agents (they have not a coverage and then are exposed under sun, wind, water and snow).
The seismic safety evaluation of this element is a strategic and fundamental topic because the Door is the lower end access in terms of public security of Capocastello. The structural quality assessment of the masonry arch is determined by a first inceptive and in-depth knowledge phase. This is integrated by data and information coming from several architecture and engineering disciplines (structures, survey, history, urbanism, technology, architectural renovation).
The B.I.M. procedure (Building Information Modeling) to create the 3D structural model of the masonry arch necessary for the structural analysis by Midas/GEN software will be described.

Key words: building information modeling, seismic safety, evaluation

1. INTRODUCTION

This paper analyzes the Door of the Saints and its 3d model. The arc is located in Mercogliano that is a town known since the time of the ancient Romans as Mercurianum, then Merculianum. The actual settlement date back to the medieval period. The document dated around the eleventh century is a first evidence that proves their existence at that time.

The structural function of the Door mixes with their specific architectural configuration, creating an interesting element of architectural morphology that is

useful to identify the urban planning to which it belongs and to assess safety and enjoyment of the country itself inside the ancient walls.

The picturesque landscape of Capocastello (Figures 1) was selected for choosing the Door example to analyze. In this town there are both ancient local stone buildings and recent constructions and there is a low range of masonry arc. Only two arcs on four arcs around the roman walls are in a good state of conservation.

The relief and the site survey were drawn to render as faithful as possible to the 3dmodel of the arc, considering all the structural and non-structural elements, to be considered for the future paper on this research.

This means that representation, the ICT and structure disciplines are strongly merged together. This approach also gives rise to a whole of assessments concerning design choices for the heritage conservation which are suitable to preserve masonry arcs for a better use of the surrounding spaces.

This paper, starting from a historical and cultural knowledge phase (Figure 2,3), gets to characterize a representative type of historical arc and to draw its three-dimensional model by using the photo scan method, which is a fundamental step to set up a refined structural model for assessing its safety,

2. THE DOOR HISTORY

On the southern slopes of the Massif feverfew, a 550 meters high, stands the town of Mercogliano. For its landscape features is identified as the "door of feverfew and Irpinia".

It Is a delightful holiday centers surrounded by lush vegetation that holds a wealth of remarkable architectural interest. Particularly distinctive is the Medieval Village, known by the name of Capocastello, where it can, still today, see the ruins of the medieval castle, and the only surviving stretch of the ancient walls that once surrounded the village.

In the past there being born after the Samnite war a Roman colony, the place retained the name of the place where, in fact worshiped the cult of Mercury, to the Middle Ages under the name of "Castrum Mercuriani", hence the current name.

The place, however, until the fifteenth also retains the same coat of arms, the image of the god Mercury. Important testimonies, inscriptions and archaeological finds, evidence of the presence in the territory of Mercogliano of Roman settlements dating from the fourth century and traced back to the Roman colony of Abellinum. At this historical period are ascribed the events of the Christianization of Irpinia, with the Santi Modestino (current patron of Mercogliano and Avellino) Fiorentino and Flavian, who find their death in the Mercogliano area (Figure 4). The real foundation of Mercogliano is due to the last decades of the century VI, in conjunction with the invasion of the Lombards in southern Italy. A colony of refugees from neighboring Abellinum, just to escape the Lombards, occupied the hill of Mercogliano. In a short time a settlement is built that slowly fills up. Mercogliano, Avellino still farmhouse, is mentioned for the first time in a document in 982. The country's development continues in 1000 following the

invasion of the Normans in southern Italy, which began in 1030. At that time it is built Castle. Between 1077 and 1089, reflecting a continuous development, the old house is elevated to the rank of the castle. The country, finally acquires administrative autonomy. Henry of Sarno was the lord of the fortified village in 1136, sub feudal lord of Avellino Rainulfo count. In 1137, under Roger II, who is sieges Mercogliano occupying the castle, began Norman domination. At that time Ruggiero II he shut up in the Castello Matilde, the wife of conte Rainulfo. The feud was then donated by Roger II to Richard de Aquila, also named in the Barons catalog to send to the Holy Land of some knights and squires. To Richard de Aqulia, several years later, they succeeded Ruggiero 1161, and Countess de Pierrone Aquila, 1183, wife of Roger de Castelvetere.

The analyze on the Doord was performed by using a three-dimensional model: this model was developed and shaped starting from a detailed geometrical-architectural representation and by using the photoscan methodology. The model will be integrated by components with precise morphological characteristics and mechanical properties, thus integrating and interfacing all the features of the structural engineering. In the future paper will be show the arc behaviours [1, 2].

The analyzed ancient arc is one example of a broader scientific research that involves the cultural masonry construction and is finalized to draw up an atlas concerning typological features and static and seismic safety of arc of Campania Region architecture.

3. SEISMIC RISK

The conservation is not only an action aimed to the slowdown of the degradation, but also the act of valuing, guaranteeing the assurance of the resources needed. An interdisciplinary approach [6, 7] now allows unifying the professional competences that formerly did not talk to each other, typical of a professional Taylorism, introducing the relationships between professionals who interact and become guarantors of knowledge. The preservation of cultural heritage depends, first, on the nature of the materials of which the buildings are made: for example, bricks have a different behavior from volcanic rocks. But, even if in a different form, on the surface, all the rocks are vulnerable to atmospheric agents (humidity, wind, rain) which accelerates the arc decay. With regard to the static safety issue, and specifically materials and techniques to use, it should be noted that today there is a revival of traditional materials and techniques (Figure 2, 3).

The configuration/conservation design process currently describes the representation–structure binomial, since the information communication technology (ICT) has been introduced in the field of cultural heritage as digital form of communication. In the architectural field, the same digital representation phase is usually carried out to achieve the three-dimensional model, derived from the cloud of points generated by laser scanners or photo scanning (Figure 5).

A naive use of modern materials, giving the illusion of stability to the architectural and archeological heritage without compromising the aesthetic appearance, was the origin of the diffusion of materials for decades considered

"modern", such as concrete, which are instead characterized by a high incompatibility. Modern materials, in fact, have been often the cause of a greater damage, not only to the values of the historicity of buildings, but also to their survival and, paradoxically, their stability, thus worsening the overall static performance. Their use seems to have failed right where it should be strong, that is, effectiveness and durability [3].

The more and more recurrent need to analyze and restrict the seismic risk accelerated the research and the use of valid solutions for improved performance of constructions under earthquakes. Today the choice of materials and techniques, once more modern, is significantly wider, because many new materials have been introduced in the restoration, such as composite materials, whose technology is more or less widespread and established. The choice of material and technique should not be obtained from an ideological vision, based on fundamentalist foreclosure for materials and contemporary techniques, but rather by a careful examination of the characteristics and properties of the building to be restored, its materials, its problems and its structural types. A choice that allows to design the retrofit with moderation, using compatible materials and techniques, to achieve a balanced outcome, in compliance with all the requirements of restoration, not least compatibility, reversibility and recognition of the interventions, and to keep the architectural unity and the meaning of the restored building.

The question, at this point, is whether the characteristics of new materials and new techniques are able to ensure compliance with the above requirements, also in reference to the demand of seismic safety. It is also wonder how a proper restoration can achieve the objective of maximum conservation of tangible and intangible information of buildings in accordance with the preservation of the original static behavior, minimum intervention and maximum reversibility; and then as the use of these materials may help to avoid repeating the error made by the indiscriminate use of reinforced concrete: it was not able to ensure the historical continuity and the expected increase in performance, especially during seismic events, because of its chemical and behavioral (static and mechanical) incompatibility.

To provide a comprehensive answer to these questions, it is increasingly evident the need for an evaluation computer tool that is able to reproduce in detail all the available (multidisciplinary) information and allows users to make multiple comparative evaluations between the different possible solutions [7].

Safeguard means not only prevent that the constructions as arc collapses under seismic event but also that the paintings for example as the fresco placed on the upper portion of this masonry arch and dated back to XI century shows Flaviano, Modestino and Fiorentino Saints appears unharmed by the loss of a cultural pictorial historical representation [4].

4. THREE DIMENSIONALS MODELING

The methodology adopted for developing the model was based on the three-dimensional re-design of the arc, according to the measurements obtained by

conventional digital survey. The virtual model that has material and morphological consistency in each structural component will be finally expanded with the finite element model developed for performing structural analyses.

The architectural model of the Door must reveal the fundamental elements for the realization of a finished structural model. It is necessary not only design its morphological and material consistency but also the study of the connections to the side walls of the same arc.

Each element carries with itself the geometrical, material and mechanical characteristics needed for reproducing size, location and structural behavior, which are at the base of a refined and suitable structural analysis finalized to assess the static and seismic safety of this arc type.

This research work allowed achieving a refined structural model described in the next paper that will let to examine the arc behavior considering all elements and factors contributing both to ensure the structural safety and to represent possible elements of static or seismic risk.

This modelling approach is important for structures such as the one examined in this paper since it also allows considering the conservation status of each stones and non-structural elements and then assessing the consequent influence on safety.

Only a previous and careful knowledge and survey phases can give information about what may happen to arcs that are constantly exposed to atmospheric agents and therefore spoil before than other building elements.

In fact, it is now well established that their functionality and safety degenerates over time and increases more and more the risk of falling parts of the structure. Obviously, it is conceivable the damage that can cause such a situation to both the built heritage and users.

5. CONCLUSIONS

The morphological feature of arc is linked to spatial issues: in the examined case, the Door has an organic vision and it becomes connecting element between the ancient parties of urban planning and the new constructions but also it becomes cutting and division element among each floor on the building façade. Furthermore, it is also a representative element of ancient decoration which renews the importance of the roman sign and reveals outside the active function done within Capocastello.

This paper reports a single step of a wider research that is developing on the static and seismic safety of ancient arcs. Inspired by news events that highlighted the need to critically and systematically evaluate the safety of ancient elements of cultural heritage, especially the ones of masonry arcs and the ones in the historic areas of towns. In the future research it will be developed a methodology that allows defining refined finite element models for structural analyses.

Merging traditional techniques of survey with the most powerful ITC method on B.I.M. platform, it is useful to realize a 3D model that includes all the structural and non-structural elements characterizing the arc type to be studied.

Such a model allows both to quantify the safety and to identify role and influence of each arc element in the structural response for focusing all factors that could constitute risk elements. Furthermore, it also allows considering degradation phenomena of each structural and non-structural elements, as fresco painting and then their influence on structural safety.

The analyses that will be performed in the subsequent research will be confirmation of the 3D model potentiality [5], showing how it allows going beyond the customary procedure for the static verification of the bearing structures of arcs, highlighting the failure risk of the stone which is locally yielded to high stresses. In specific cases these features can lead to collapses for loads lower than those usually estimated by the conventional checking and can be detected only through detailed 3D models including all the arc components.

This modelling approach straightforwardly allows to study and to foreshadow all the possible collapse mechanisms by varying several parameters concerning construction faults, conservation status, loading condition, constraints of structural and non-structural elements.

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FORECAST OF THE VEHICLE FLEET SIZE AND STRUCTURE IN RUSSIAN FEDERATION BY ECOLOGICAL CLASS, A TYPE OF POWER INSTALLATIONS AND A FUEL TYPE FOR THE PERIOD UP TO 2030

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ABSTRACT

The methodology and predictive estimates of vehicle fleet size and structure in Russian Federation for the period up to 2030 according to the ecological class, the type of power installations, the type of fuel used was given, as well as the greenhouse gas emissions and fuel consumption calculated on their basis. To predict the level of motorization, the vehicle fleet used the technique of MADI, a combination known forecasting techniques: logistic multi-factor model, step by step and regulations target methods. Prediction of the structure of the fleet on environmental class was determined by taking into account the disposal of old vehicles and replace them with new ones in accordance with the requirements of Technical regulations “The safety of wheeled vehicles”. Prediction of the structure of the vehicle fleet by type of power plants and fuel type was determined by experts. Forecast greenhouse gas emissions and fuel consumption is made for COPERT.

Key words: cars, power installations, fuel, emissions, greenhouse gases, forecast

1. INTRODUCTION

To justify and implement measures to improve the energy and environmental efficiency both individual vehicles and the industry as a whole, forecast estimates of the number and structure of the fleet, fuel consumption,

greenhouse gas emissions are needed. In the Transport Strategy of the Russian Federation, the Strategy for the development of the automotive industry of the Russian Federation no prognostic evaluation of the size and structure of the vehicle fleet, fuel consumption, greenhouse gas emissions. This makes essential activities to improve the energy and environmental efficiency of individual vehicles, the industry as a whole.

Below are the results of such a predictive assessment according to the developed methodology.

2. APPROACHES TO PREDICTION OF MOTORIZATION LEVEL AND A VEHICLE FLEET SIZE

It is known, that the size of vehicle fleet for a predetermined forecast period is determined by the balance of demand for vehicles (the number of new and used vehicles delivered to the park) and their retirement from the fleet for various reasons in each particular year. The characteristic of demand for vehicles is determined not only by their use as a vehicle (depending on the level of goods and population mobility), but also by aesthetic considerations, prestige, reliability and relative conviction at the car's superiority, availability of parking space and storage and etc. The share of vehicle retirement from the fleet depends on the residual car price, fuel price, fuel efficiency of new cars, incentives for updating the vehicle fleet at the national and regional levels and other factors [1]. In general, goods mobility (the volume of freight and cargo turnover), population mobility (passenger traffic and passenger turnover), transport accessibility of economic, administrative and cultural ties have a significant impact on the socio-economic development of the state, its individual regions and is determined by the motorization level (stage) (the number of passenger car per 1000 inhabitants), which changes the way people live, policy in the field of traffic management, urban planning, etc. (see Table 1).

Table 1 - Characteristics of motorization levels, Number of cars / 1000 inhabitants

Level	Values	Characteristic
I	10 – 30	Emergence of difficulties with the movement organization
	30 – 100	Problems with ensuring the highways throughput
II	100 – 250	Problems associated with the car exploitation, introduction of restrictions on the car use
	250 - 450	New level of the life quality and population mobility (coercion to mobility), development of integrated transport systems, high-speed highway networks
III	Более 450	Level of motorization of economically developed states (territories), implementation of measures to contain mobility

For the prediction of motorization level and a vehicle fleet size is usually used: the method of socio-economic factors accounting, method of extrapolation of time series, that transfer the retrospective period of a vehicle fleet growth rates to the promising (forecast for the "achieved level"), the application of the logistic multi-factor model, the step-by-step method, the regulatory method, a combination of the above methods.

The method of socio-economic factors accounting, based on real car prices by classes, cars fuel efficiency by class, fuel prices, income level, a number of families in each income group and the proportion of unemployed, is known for more than 50 years. "Autostat" mentioned about the development of domestic methodic, but it was not published in the open press.

The method of extrapolation of time series, the implementation scheme of which is shown in Figure 1, is widely used to predict the level of motorization both in our country and abroad.

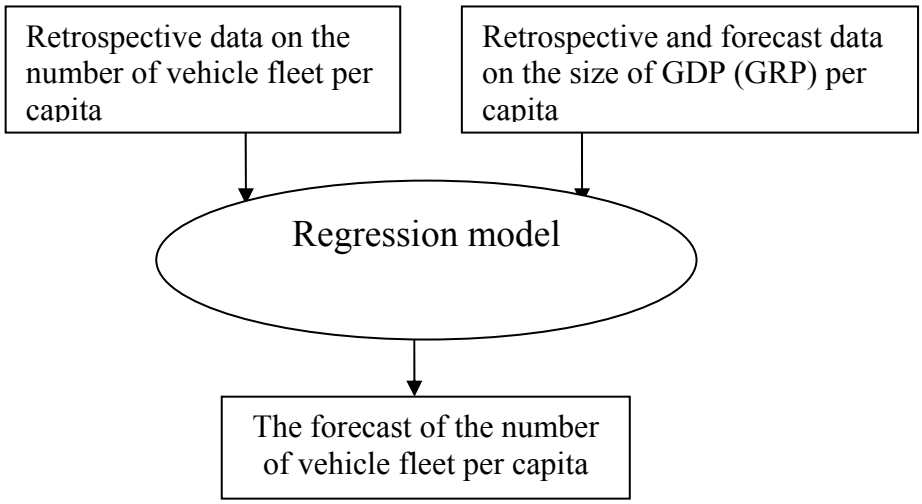


Figure 1 - Scheme of the method for predicting the motorization level by extrapolating time series

An important point is to determine the type of extrapolation of time series, which, most often, is described by the equation of the logistic curve. Meanwhile, the use of the indicator "GDP per capita" to predict the size of vehicle fleet leads to a significant results distortion due to unpredictability of state economic development (crises of the 1990s, 2008-2009, 2014-2015).

The logistical multifactor model is based on the statistical analysis of the motorization level in different countries and regions [2]. It reflects the patterns of the transport system development, combined with the motorization stages (Table 1): at the first stage of development, the scales and rates of motorization are comparatively low; on the second - they are replacing by intensive growth; on the third, the rates slow down significantly and stabilizing (Figure 2). Such a scheme is inherent at diffusion and saturation mechanisms and can be described by an S-shaped curve, or a logistic function of the form P(t):

$$P(t) = \frac{P_p}{1 + ae^{-bt}} \quad (1)$$

Here P(t) - current value of the indicator; Pp - limit value of the indicator, corresponding to the moment of saturation; a, b - coefficients determining the nature of the logistic function for a particular vehicle fleet at a certain stage of development; e - base of natural logarithms; t - time.

When carrying out predictive estimates of the fleet size using this method, the principal point is to consider at least two scenarios of socio-economic development, taking into account the adoption of a certain motorization level as a target.

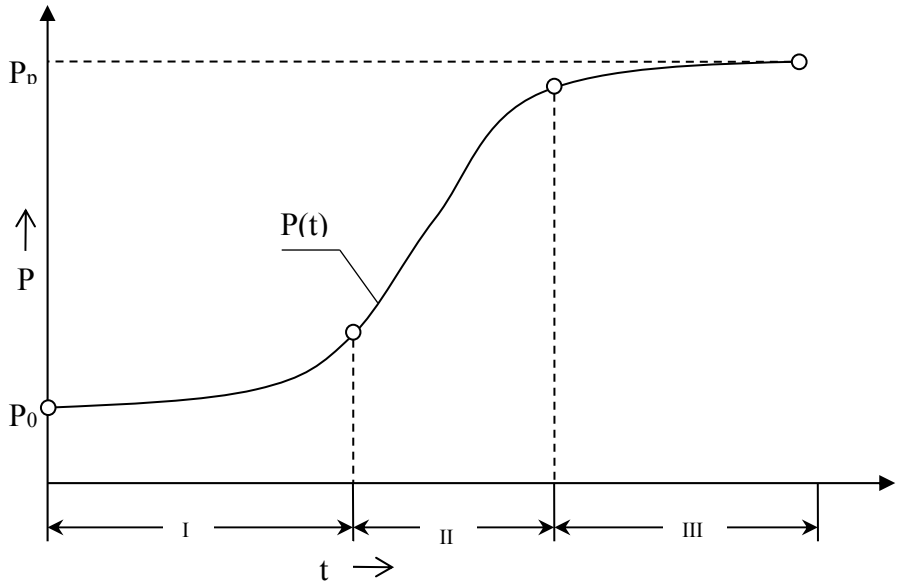


Figure 2 - Type of logistic function and motorization stages

This method is realized in a step-by-step (iterative) estimation of the fleet size, when, for the forecast period, a change in the cars quantity is determined consistently, with a certain constant step, taking into account the supplies and disposals of the vehicles.

To determine the fleet size A_{t+1} by the end of the (i + 1-year, or other periods), it is necessary to know fleet size at the end of the current year A_{t+1} and volumes of vehicles supplies A^P_{t+1} and disposals A^B_{t+1} during the next year [2]:

$$A_{t+1} = A_t + A^P_{t+1} - A^B_{t+1}. \quad (2)$$

The volumes of disposals and supplies determines not only the change in a vehicle fleet size, but also its structure. For example, the termination or reduction

of the fleet replenishment may lead to its aging, reduction in a car number for a given forecast period. For the analysis of trends in fleet change, coefficients are determined:

$$r = \frac{A_{i+1}^{П}}{A_i} \text{ – supply factor; } b = \frac{A_{i+1}^{B}}{A_i} \text{ – disposal factor.}$$

When $r > b$ – vehicle number grows, $A_{i+1} > A_i$ (extended recovery); $r < b$ – vehicle number is reduced, $A_{i+1} < A_i$ ("fleet degradation"); $r = b$ – stable vehicle fleet size, $A_{i+1} \approx A_i$ (simple recovery).

This iterative method is used in the MADI method [3-6].

The size of a vehicle fleet in year t is established by results of solving the differential equation:

$$\frac{dN(t)}{dt} = (1 + at)W - (1 + bt)\lambda \cdot N(t), \tag{3}$$

Here $N(t)$ – the number of vehicle fleet in year t; W – indicator of supplies in to the vehicle fleet; λ – indicator of disposals from the vehicle fleet.

The values of W and λ are determined by formulas

$$W = \frac{N_{pr} + N_{imp} - N_{\exp}}{N_0} = \frac{N_{\sup}}{N_0}, \qquad \lambda = \frac{N_{dis}}{N_0},$$

Here N_{pr}, N_{imp}, N_{exp}, N_{dis} – number of vehicles, produced by the domestic industry, vehicles supplied from abroad, vehicles exported and vehicles withdrawn from the fleet, respectively; N_{sup} – total number of vehicles supplied to the fleet; N_0 – the total number of vehicle fleet.

The value a over a time interval (t - t_0) is defined as

$$a = \frac{N_{\sup} - N_{\sup} \cdot t_0}{N_{\sup} \cdot t_0 (t - t_0)}. \tag{4}$$

In the absence of statistics in exchanges of vehicles supplied and disposed a fleet at any given time, the model is operated by varying the parameters W and λ in the form of a sequence of discrete (divisible by one year) values taken for based on the above assumptions. Along with the evaluation of a fleet age structure, the annual runs are adjusted in each of the age groups, depending on a vehicle's life-span [3, 4].

The forecast of motorization level is usually performed in two scenarios using the *normative-objective method*, which prescribes the establishment of a

normative motorization level value at the end of a forecast period and the adoption of the hypothesis of a change in motorization level in accordance with stage III of the logistic function, shown in Figure 1. An important point in forecast preparing is to analyze the dynamics of motorization level in retrospect with obtaining the appropriate regression equations and extending the ranges of their application for the forecast period.

Forecast estimates of the vehicle fleet size of Russian Federation and individual regions by this method are held at MADI regularly since 1992 [6]. In this forecast of the passenger cars fleet, the upper range limit of changes in motorization level (saturation with passenger cars) for the period up to 2010, the "market" option was 275-300 units / 1000 inh., the lower limit - about 60 units / 1000 inh. (statistics for 1990). The trajectory of the change in the motorization level in this range was adopted the same as the trajectories of motorization levels in European countries in the post-war years and, in particular, Spain in the period from 1970 (61 units / 1000 inh.) to 1990, (276 units / 1000 inh.), which is described by the dependence YH, unit / 1000 inh., with the correlation coefficient $R^2 = 0{,}8391$, the value of the Fisher criterion 3176,4 (least-squares processing) in the form:

$$YH = 42{,}917 + 17{,}09 \cdot t + 0{,}2786 \cdot t^2, \qquad (5)$$

In formula (5) t – prediction period (1 ... 20 years).

As shown by comparison of Rosstat data for 2010 and prediction estimates, made in 1992, error in a forecast results in passenger cars' number was less than 7%. Although the reliability of predictive estimates of the freight vehicles and buses fleet in Russia was lower. The forecast of the vehicle fleets number for some regions, made in the following years, according to this method, yielded more accurate results [6].

Let us consider in more detail the modernized version of the method discussed above, using which *the size and structure of the Russian vehicles fleet for the period until 2030* for two scenarios of the transport system development - inertial and innovative - is estimated.

3. FORECAST OF A VEHICLE FLEET SIZE

Primarily, a block of initial data and assumptions is formed based on the evaluation results of the following indicators:

- population size (demographic projection);
- motorization level;
- dynamics of the vehicle supplies into the fleet and their disposals;
- fleet structure according to the ecological class, type of power installation (PI) and type of fuel used.

The main difficulty of a work at the initial stage is to combine the methodological approaches of different authors performing demographic forecast,

forecast of a motorization level, forecast of a vehicle supplies and disposals into the fleet, forecast of a fleet structure according to the ecological class, type of power installation in terms of assumptions and a forecast period length.

In the development of a forecast, a hypothesis (assumption) was accepted that the motorization level until 2020 will grow linearly at a rate of 3-4% per year, and after 2020 will enter the phase of growth retardation in accordance with shape of the logistic curve (see Figure 1) (its third stage), since will be actively implemented measures to contain motorized mobility. Given that the vehicle fleet consists of passenger cars and light commercial vehicles by more than 90%, this trend is likely to remain for the period until 2030, a density level of trucks and buses per 1000 inhabitants (similar to motorization level) will also not change significantly.

At this, forecast estimates of the production, import and export volumes of new and used passenger cars, trucks and buses were taken into consideration and, consequently, the shipments of vehicles to the fleet of Russian Federation given in the Automobile Industry Development Strategy for the period to 2020 and updated in 2013 and 2017 year for the period until 2030, which takes into account the influence consequences of the crises of 2008-2009, 2014-2015 yrs. on the markets dynamics of different vehicle types and the trends in Russia's socioeconomic development.

An important point is the establishment of a forecast trends in the supply of appropriate vehicle types into the fleet of Russia for the period until 2015-2020 yrs. and 2021-2030 yrs. Herewith only one "agreed base scenario" of supplies is used for both innovative (1) and inertial variants (2) changes in the motorization level. Forecast estimates of the vehicle supplies into the fleet and their disposals for the period up to 2030 are given in Table 2.

Table 2 - The share of vehicle supplies into the fleet and their disposals in 2016 and 2030, %

Vehicle type	Share of vehicle supplies		Share of vehicle disposals	
	2016	2030	2016	2030
Passenger cars	1,1	6,9	1,0	4,5
Trucks	5,1	5,2	5,0	3,5
Buses	3,6	4,7	3,5	3,5

Figure 3 presents the forecast results of a passenger cars quantity for the innovative scenario (the level of motorization 450 units / inh.) and the inertial scenario (400 units / inh.). Also there is presented the average value of a vehicle fleet size at the motorization level of 420 units / inh.

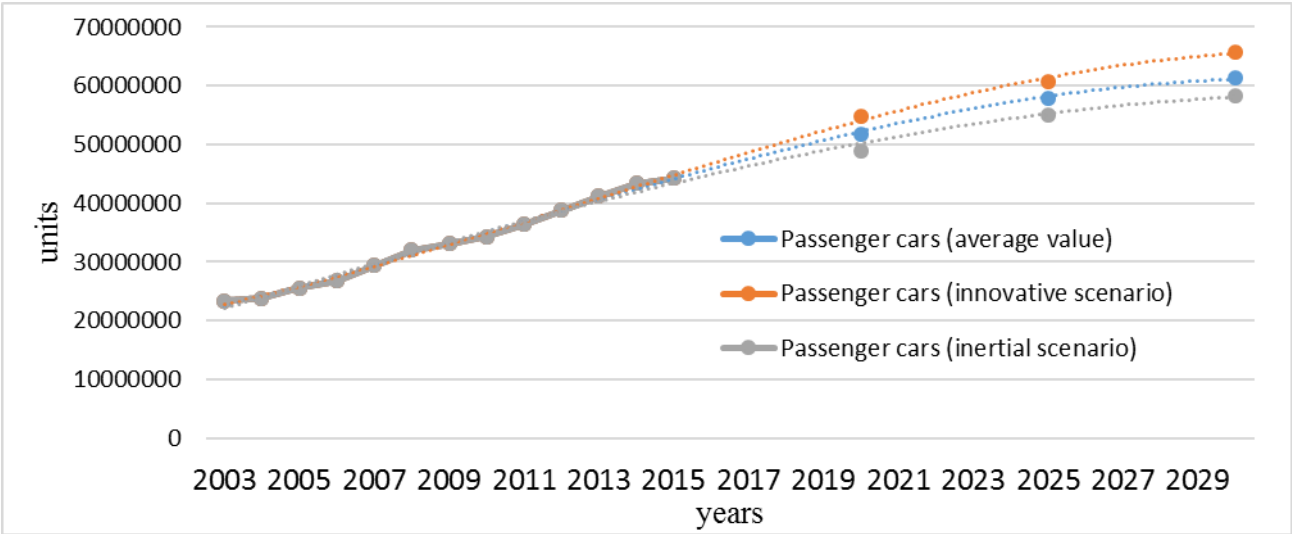


Figure 3 - Forecast of a passenger cars quantity in the RF up to 2030 for different development scenarios, units (at 31.12 of each yr.)

The forecast of a population in Russian Federation for the period under review (145 million people) was taken according to the data of Rosstat (http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/population/demography/#).

It is expected, that the share of vehicle supplies and disposals into the fleet will increase, reaching in 2030 values of 6.9% and 4.5% accordingly for passenger cars. Such a forecast of the dynamics of passenger car disposals envisages the measures implemented to stimulate the vehicle fleet renewal.

Table 3 shows the estimated forecast for passenger cars, trucks and buses quantity in the vehicle fleet of Russian Federation for the period up to 2030, taking into account the volumes of supplies and disposals for the motorization level of 420 units / 1000 units given in Table 2.

Table 3 – Forecast for passenger cars, trucks and buses quantity in the vehicle fleet of Russian Federation for the period up to 2030, th. units

	Passenger cars	Light commercial vehicles	Trucks	Buses	Total
2016	45770,5	2442,9	3820,9	876,1	52910,3
2020	51840,0	2560,0	3840,0	890,0	59130,0
2025	57800,0	2747,0	3953,0	910,0	65410,0
2030	61320,0	2870,0	4130,0	930,0	69250,0

According to the forecast estimates, the vehicle fleet of Russian Federation by 2030 will increase by 30.8% compared to 2016, reaching 69.25 mln. units. At this the number of passenger cars can make up 61.3 mln. units (88.5%), light commercial vehicles - 2.9 mln. units (4.1%), trucks - 4.13 mln. units (6.0%) and buses - 0.9 mln. units (1.3%).

4. FORECAST OF A VEHICLE FLEET STRUCTURE ACCORDING TO THE ECOLOGICAL CLASS

The vehicle fleet formation, taking into account the distribution by ecological classes, is a tool that ensures the natural disposal of obsolete vehicles and, as a result, stimulates the development of market for new vehicles, and increases the energy and environmental efficiency of road transport.

The main current regulator of vehicle fleet saturation of Russia and its individual regions by environmentally preferable vehicles is the Technical Regulations of the Customs Union TR TS 018/2011 "On the safety of wheeled vehicles", which introduced supplies time into the fleet for vehicle of different ecological class (Figure 4).

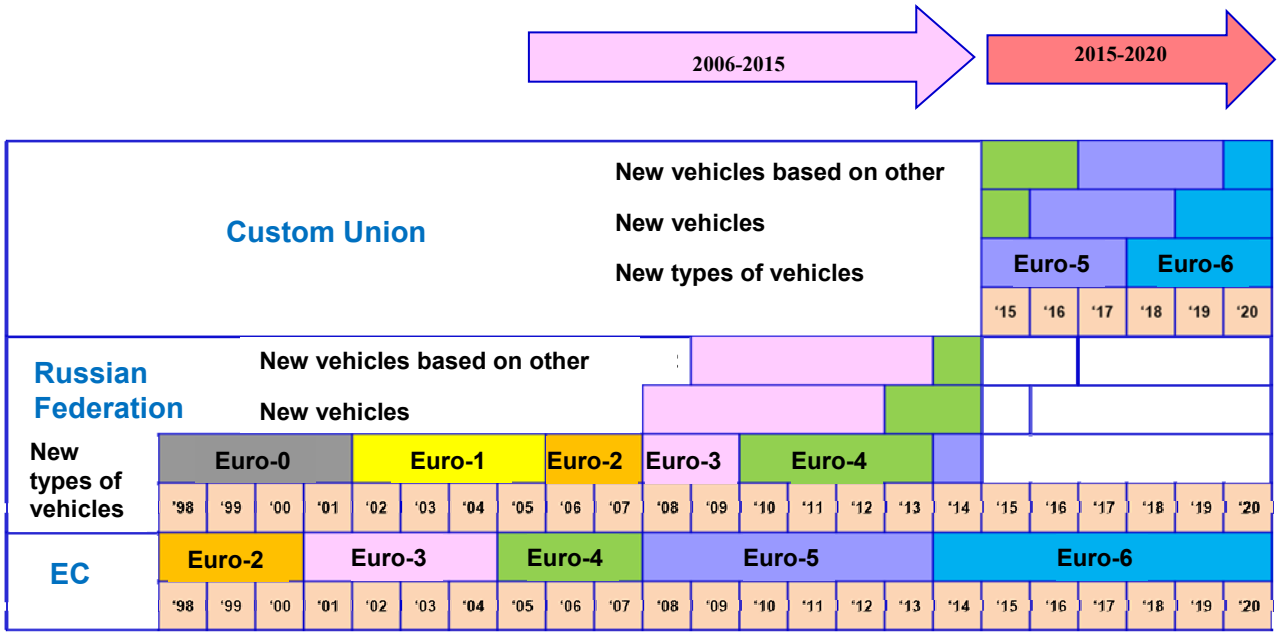


Figure 4 - Dynamics of requirements to the vehicles by ecological class

For number of reasons, the introduction of the ecological class 6 (Euro 6) requirements was postponed to a later date. This circumstance as well as a forecasted number of vehicles that are disposed of and supplied in each year (vehicles of low ecological classes are drop out and vehicles of high classes are supplied) were taken into account when a structure of vehicle fleet by ecological class was forecasted for the period up to 2030 (Figure 5).

The results showed that in the park of passenger cars in 2030 there will remain 9% of vehicles of ecological class Euro-3; the share of vehicles class Euro-4 will be reduced to 26%, class Euro-5 - to 40%, class Euro-6 - will be about 25%. In this forecast, electric vehicles and hybrids are also classified as ecological classes Euro-5 and Euro-6 for vehicles. It is expected, that by 2025 in the passenger car fleet vehicles of low ecological classes (Euro-0...2) will practically

disappear. In LCV fleet by 2023 vehicles of ecological classes Euro-0 and Euro-1 and by 2026 also vehicles of ecological class Euro-2 will practically disappear. By 2027, trucks of ecological classes Euro-0 and Euro-1 will be decommissioned, but the trucks of ecological class Euro-2 will remain in a fleet until 2030; their share in a fleet will be 1%. By 2024 buses of ecological classes Euro-0...2 will be taken out of exploitation. Buses of ecological class Euro-3 will remain in a fleet until 2030; their share will be reduced to 7%.

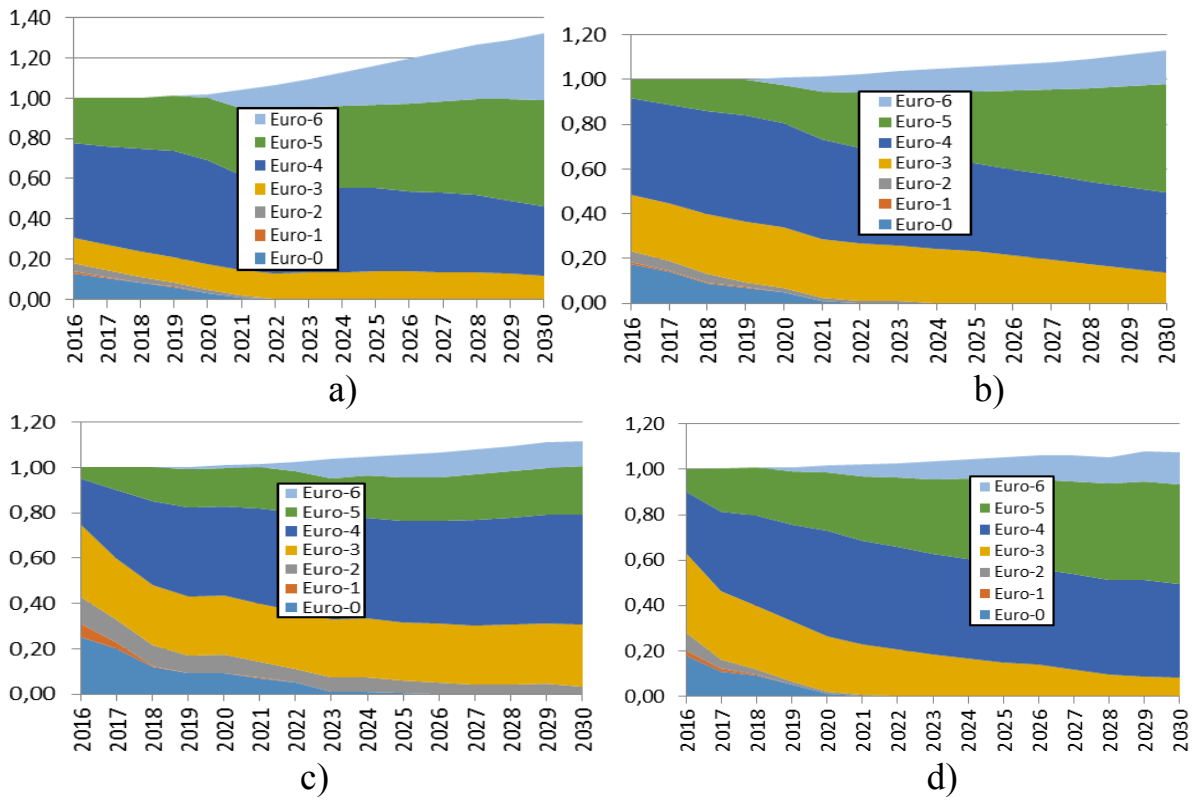


Figure 5 - Forecast of a vehicle fleet structure in Russian Federation by ecological classes until 2030: a) passenger cars, b) light commercial vehicles (LCV); c) trucks (without LCV); d) buses

5. FORECAST OF VEHICLE FLEET STRUCTURE BY POWER INSTALLATION TYPES AND FUEL TYPES

Forecasting of vehicle fleet structure by power installation (PI) type and fuel types is the most difficult task due to the volatility of energy prices, unequal development of renewable energy sources in different countries and regions in relation to vehicles, energy saving measures realization. Among the main trends in the road transport development, which will have an impact on the vehicle fleet structure by PI type:

a) stricter requirements for greenhouse gas emissions and consumption of petroleum fuels;

b) electrification of PI, avoidance of traditional energy sources: use of hybrid power installation, traction motors, fuel cells, expansion of alternative fuels using;

c) autonomous driving and the transition from driver assistance systems to autonomous driving systems;

d) development of transport systems providing for the collection, intelligent processing, analysis and exchange of data, and also using advanced communication capabilities between vehicles, road infrastructure and vehicle, vehicle and a person.

When carrying out the forecast of vehicle fleet structure and size by PI, it was taken into account that the *innovative scenario* for Russian market implies a lagging behind the global growth rates of the share of electric vehicles in sales by an average of 4-5 years. Thus, the share of electric vehicles in sales on Russian market by 2020 can reach 1-1.5% (15-25 ths. cars). The growth rate of electric vehicles sales after 2025 will largely be determined by the development of charging infrastructure in the Russian regions. The development of the *inertial scenario* implies a deviation from the innovative scenario after 2025 and a backlog from the global pessimistic scenario for 6-7 years. By 2025, the share of electric vehicles in sales could be 3-4% (65-85 ths. cars). In our opinion, the most likely scenario for estimating a number of electric vehicles in a fleet until 2030 is the innovative scenario for supplies of these vehicles to 2020 and the inertial one after 2020. As a result, the share of electric cars in a fleet for the period until 2030 may be less than 1%.

Taking into account the foregoing, as well as on the basis of generalization of similar forecasts results made abroad [7-9], expert evaluations of MADI specialists and other organizations, Table 4 shows the results of vehicle fleet forecast by the structure according to the type of PI and the type of fuel.

Table 4 - Forecast of a vehicle fleet structure by power installation (PI) type as of 31.12. at corresponding year

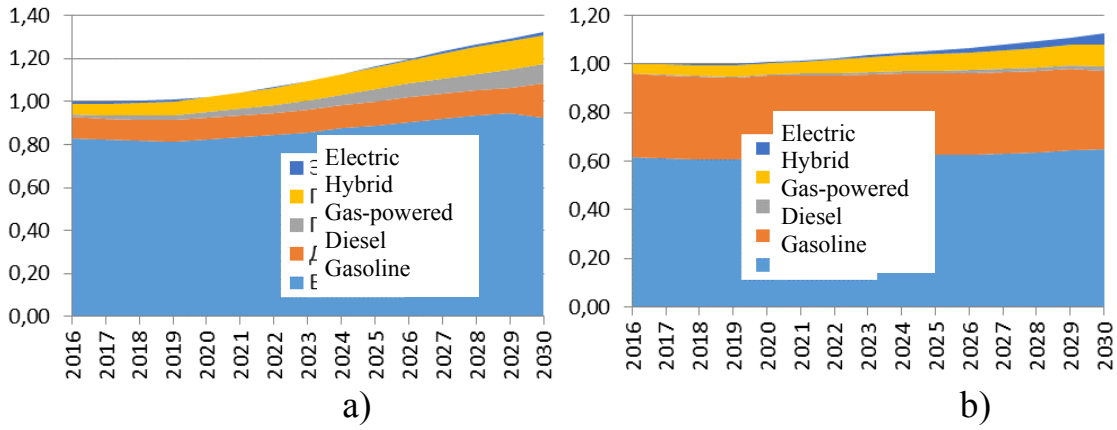
Power installation (PI) type	2015	2020	2025	2030
	Passenger cars			
Gasoline	0,930	0,807	0,763	0,699
Diesel	0,049	0,098	0,096	0,12
Gas-powered	0,021	0,027	0,049	0,07
Hybrid	0,00026	0,067	0,088	0,1
Electric	0,000003	0,0007	0,004	0,011
TOTAL	1,000	1,000	1,000	1,000
	Light commercial vehicles (LCV)			
Gasoline	0,612	0,609	0,59	0,575
Diesel	0,329	0,334	0,319	0,286
Gas-powered	0,059	0,007	0,011	0,015
Hybrid	0,0	0,047	0,064	0,08
Electric	0,0	0,003	0,016	0,044
TOTAL	1,000	1,000	1,000	1,000

	Trucks (without LCV)			
Gasoline	0,085	0,086	0,092	0,100
Diesel	0,856	0,824	0,805	0,770
Gas-powered	0,060	0,084	0,089	0,100
Hybrid	0,000	0,006	0,014	0,030
Electric	1,000	1,000	1,000	1,000
	Buses			
Gasoline	0,346	0,150	0,138	0,120
Diesel	0,575	0,69	0,489	0,350
Gas-powered	0,079	0,15	0,35	0,50
Hybrid	0,000	0,010	0,023	0,030
Electric	1,000	1,000	1,000	1,000

Thus, the forecasted shares of electric cars and hybrids in a passenger cars fleet for the accounting period are characterized by the following values: 2015 - 0.026%, 2020 - 6.77%, 2025 - 9.22%, 2030 - 11.1 %. The share of electric vehicles and hybrids in a LCV fleet in 2030 may reach 13.1%, in a truck fleet - 3% and buses - 6.1%.

Insufficient development of filling network and service infrastructure is one of the key factors hindering expansion of gas engine fuel using on road transport. According to our estimates, by 2030 in a trucks fleet the share of gas engine (on natural gas) can reach 10%, and in a buses fleet - 22.5%.

Figure 6 shows the forecast results of a relative quantity dynamics in a vehicle fleet of Russia by different types of PI.



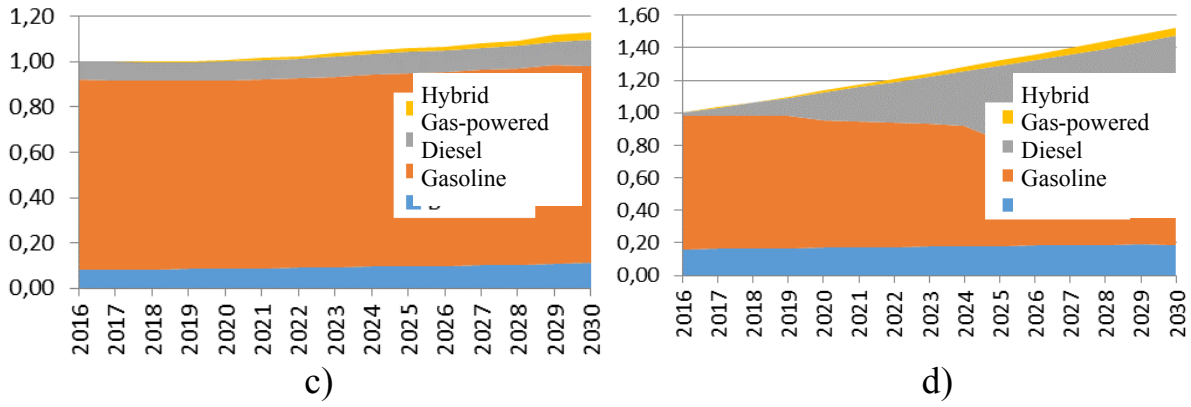


Figure 6 – Forecast of a vehicle fleet structure in Russian Federation by power installation (PI) type until 2030: a) passenger cars, b) light commercial vehicles (LCV); c) trucks (without LCV); d) buses

In 2030, gasoline vehicles will prevail in a fleet of passenger cars. Their quantity in comparison with 2015 will increase only by 3% and will amount to 42.844 mln. units. The quantity of passenger cars with diesel engines will increase from 2.187 mln. units in 2015 to 7.35 mln. units in 2030, i.e. in 3,4 times. The quantity of passenger cars with gasoline engine fuel may increase by 5 times this year from 948.6 ths. units in 2015 to 4292.4 ths. units in the year 2030. However, the maximum increase is expected in the group of passenger cars with hybrid PIs - 532 times (from 11,526 ths. units to 6.132 ths. units), and also with electric PI - by 5458 times (from 127 units to 693.2 ths. units).

While maintaining approximately the same quantity of LCVs in 2030 compared to 2015, their structure by type of power installation will change significantly. In the LCV fleet in 2030, as in 2015, gasoline vehicles will prevail, but their quantity will decrease by 11% to 1.65 mln. units. The quantity of LCV with diesel engines will decrease more - by almost 18% to 820.8 ths. units. However, the maximum reduction is expected in the LCV group on gas engine fuel - from 179 ths. units up to 43,1 ths. units. But at the same time an unprecedented increase in the number of LCV with hybrid and electric power installations is expected - practically from zero to 229.6 ths units and 149.65 ths units respectively.

With the overall increase in a trucks quantity in 2030 compared to 2015 (by 30%), the number of trucks with diesel engines will increase from 2720.7 ths. units to 3269.7 ths. units. Also, the number of trucks with gasoline engines will increase by about 20% (from 269.1 ths units to 323.4 ths units). But in 2.2 times the number of trucks on gas engine fuel will raise - from 189.7 ths. units up to 413 ths. units. The number of trucks with hybrid power installations in 2030 may reach 123.9 ths. units.

According to forecasts, in 2030 the buses quantity can reach 906,4 ths. units, which is only 5% more than in 2015. At the same time, the number of buses with gasoline engines will practically not change in 15 years (about 31 ths. units). The number of buses with diesel engines will decrease - from 500 ths. units in 2015 to

338.1 ths. units in the year 2030. But the number of buses on gas engine fuel will increase significantly - from 68.2 ths. units up to 204,0 ths. units In 2030, the number of buses with hybrid power installations could reach 54.8 ths units.

6. FORECAST OF FUEL CONSUMPTION AND GREENHOUSE GAS EMISSIONS

Using the data above and the assumptions given in [10, 11], according to the program COPERT 4 (version 11.4), predictions of greenhouse gas (GHG) emissions and fuel consumption by the Russian vehicle fleet for the period under review were fulfilled. Another assumption is the invariability of vehicle usage characteristics (average annual mileage, average speed and the proportion of runs on the driving regimes for different types of vehicles and various types of road network) by time. To determine GHG emissions from electric transport (specific emission of CO2-eq is 0.58 kg / kWh), taking into account the generation of electricity at TPPs, the Global Environment Facility methodology. For common models of electric vehicles (Mitsubishi i-MiEV, Nissan Leaf, Tesla Model S, etc.), the average specific energy consumption for vehicle movement, taking into account the loss factor for battery heating, is 23 kWh / 100 km.

It is established that due to the increase in vehicle fleet quantity, the change in its structure according to the type of the PI it is expected to increase the volumes of total consumption of motor fuel, but it is not the same for different types of fuel (Table 5).

Table 5 - Forecast of fuel consumption by the Russian Federation vehicle fleet until 2030

Fuel consumption, mln.t	2015	2020	2025	2030
Gasoline fuel	30,83	43,69	47,60	47,67
Diesel fuel	15,24	24,48	26,18	28,10
Liquefied petroleum gas	0,53	1,01	2,10	3,22
Compressed natural gas	7,69	5,74	6,30	7,44
Total	54,29	74,92	82,17	86,43

Table 6 - Forecast of greenhouse gas emissions by the Russian Federation vehicle fleet for the period up to 2030

Coefficients of reduction to CO2-eq (GEF, UNFCCC)	1	25	298	
Mass of GHG emissions, mln. t	CO_2	CH_4	N_2O*	CO2-eq
2015	166,713	0,1000	5633,01	170,9
2020	231,796	0,0430	4282,93	234,1
2025	254,620	0,0403	4606,32	257,0
2030	268,550	0,0431	4838,57	271,1

*) – tonns

Also, an increase in gross greenhouse gas (CO2-eq) emissions is expected in comparison with the baseline period (Table 6, Figure 7).

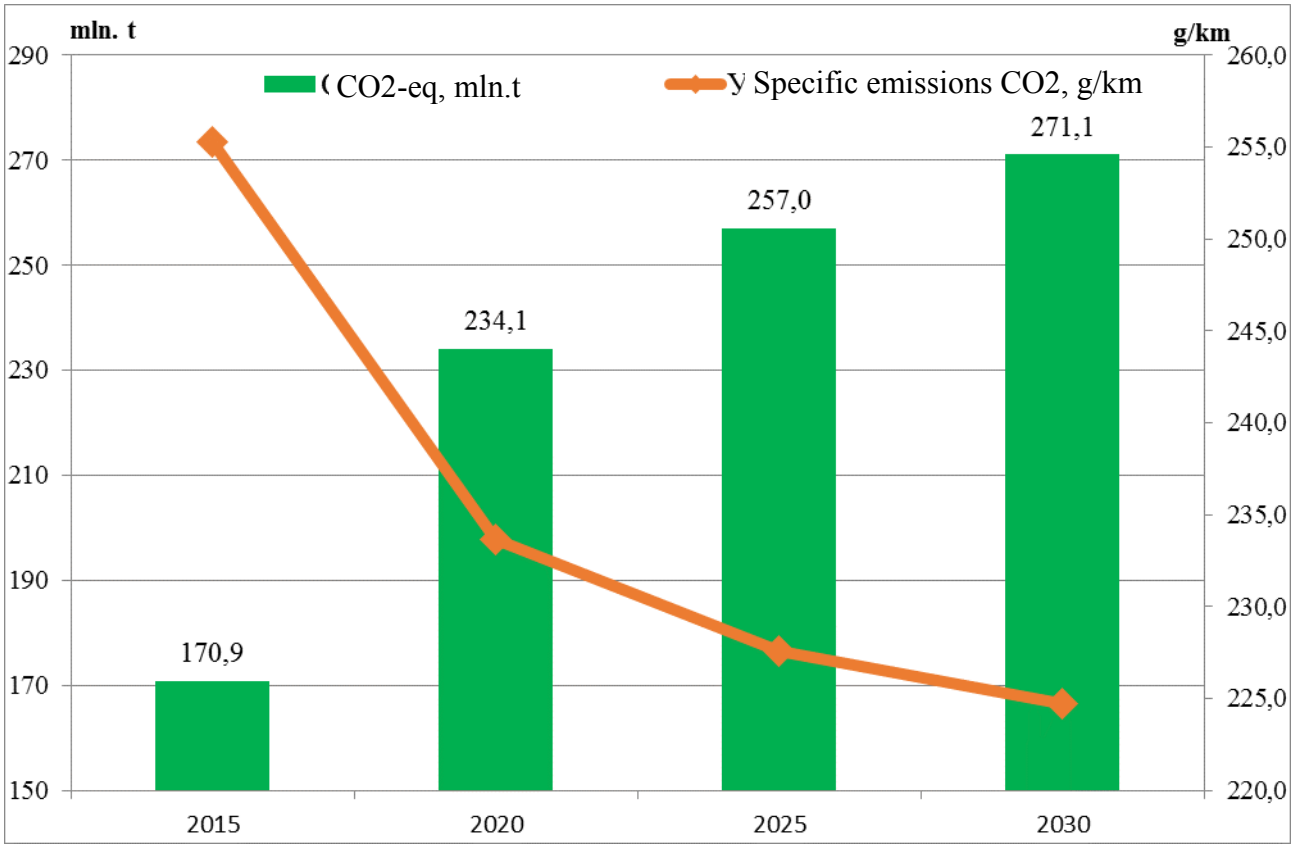


Figure 7 - Forecast of gross and specific greenhouse gas emissions by the vehicle fleet for the period up to 2030

At the same time, the changes taking place in the vehicle fleet due to gradual introduction of vehicles with a higher ecological class and the natural retirement of obsolete vehicles from exploration have a positive effect on the specific GHG emissions.

7. CONCLUSIONS

It is expected that in 2030 the quantity of a Russian vehicle fleet will increase by 30.8% compared to 2015 and can reach 69.25 mln. units according to the innovative scenario. Of these, 45.13 mln. units vehicles, working on gasoline, 11.79 mln. units - vehicles with diesel engines, 4.95 mln. units - vehicles on gas engine fuel, 6.54 mln. units - vehicles with hybrid power installations and 0.843 mln. units electric vehicles. Despite the presence in the fleet almost 7.38 mln. units hybrids and electric vehicles and 4.95 mln. units gas engine vehicles gross greenhouse gas emissions by vehicle fleet by 2030 can grow up to 271.1 mln. t. CO2-eq., i.e. 1.6 times compared to 2015, although the greenhouse gas emissions

by one weighted average vehicle will decrease from 255.3 to 224.9 g/km. In this regard, considerable efforts must be made to stabilize or reduce gross greenhouse gas emissions by road in the long term.

In addition to the transition to low-carbon vehicles gross greenhouse gas emissions should be decreased by organization of autonomous movement of vehicles in the transport stream (ADAS-systems, IT-technologies (V2V, V2I, V2P), development of digital road infrastructure (BIM-technologies) and broadband Internet 4G, 5G by reducing reruns, creating free road traffic, and replacing motor vehicles by more economical modes of transport, including non-motorized ones.

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PREDICTION OF PERMISSIBLE EXPOSURE LIMIT BASED ON TIME SERIES MEASUREMENTS OF CONCENTRATION OF POLLUTANTS IN THE ATMOSPHERE

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ABSTRACT

The aim of this report is to recommend the way of prediction values of permissible exposure limit in the atmosphere. The possibilities of using neural network technology are considered. The studies of the relationship between air pollutants and meteorological factors can provide important information about air pollution. According to proposed neural network technology in this study, daily traffic-related pollutant concentrations are not only influenced by daily meteorological parameters but also by the pollutant concentration of the previous day. The best results showed neural network expert, predicting permissible exposure limit for one day before the event for forecasting of an emergency of permissible exposure limit excess of toxicants in the environment of the industrial center. Consequently, the critical time interval is the interval from 24 to 48 hours to an emergency of the permissible exposure limit pollutants excess in the atmosphere.

Key words: pollutants, atmosphere, permissible exposure limit, neural network technology

According to researches of some specialists [1-3], the state of the urban ecosystem is satisfactorily described by the state of its main component – atmosphere. Many forms of atmospheric pollution affect human health and the environment at levels from local to global. These contaminants are emitted from

diverse sources, and some of them react together to form new compounds in the air. Industrialized nations have made important progress toward controlling some pollutants in recent decades, but air quality is much worse in many developing countries, and global circulation patterns can transport some types of pollution rapidly around the world. Atmosphere - the main factor shaping the level of pollution in the urban ecosystem, the variability additionally estimated under the set of existing meteorological parameters and the atmosphere's ability of self-purification. The numerical techniques are used in very active research areas. It is imperative that such codes can predict the evolution of pollutants from accidents or from a particular set of meteorological conditions in a short period of time (e.g. a few hours or days), in order to be in a position to issue warnings about pollution episodes.

Lagrangian codes are a different approach to track the dispersion of pollutants. A large number of “fluid particles” is tracked in the synoptic scale weather motions and the chemistry of each of these particles is calculated. They are also called “trajectory models”. This approach has the advantage of having relatively lost cost, but the accuracy of some of the assumptions used in early versions of this method is not very good, especially the modeling of the turbulent random walk experienced by the fluid as it disperse in the air. Despite this reservation, the idea of modeling the fluid as individual particles and then tracking the changes is a very useful one and the improvement of the accuracy of such models is a topic of research now.

Fundamentals of Monte Carlo techniques - a large number of events are sampled from the possible sample space and their evolution is tracked. Averages formed on the basis of such “trajectories” give the behavior, in a statistical sense, of the whole system. Other, perhaps more accurate, names for this technique include “stochastic modeling” or “stochastic simulation”.

The concerned problem of the urban ecosystem quality management is based on probabilistic risk and it most closely conforms to the neural network technology. Consequently, it is effectually to apply the neural network technology to solve the problem. Neural network technology can be used to control the quality of the urban ecosystem components: when solving the problems of the classification of natural objects for the design of expert systems, the management of industrial enterprises, decision-making under uncertainty, because of the ability to operate inaccurate numerical values.

One of the major problems of environmental management is the ability to predict environmental emergencies, the most common and destructive of which is exceeding of permissible exposure limit (PEL) of pollutants in atmosphere [1]. A certain amount of pollutants in the atmosphere of industrial centers is constantly present, however, being in the range of limit values, these contaminants do not present an immediate threat to public health. In case when PEL is exceeded it is necessary to take urgent measures to eliminate the threat.

The optimal strategy here is to take preventive measures. Therefore, prediction of the possible excess of PEL of pollutants in the atmosphere is extremely important.

Many studies [2-6] showed that if the composition of air-polluting sources is constant (as it often happens) the decisive factor of negative events occurrence - excess of PEL - is the meteorological conditions. Air pollution occurs on the layer under the combined effects of meteorological factors, earth surface topographic features and releases air pollutants from various sources. Meteorological factors such as wind velocity, wind direction, temperature, and relative humidity together with earth surface roughness are effective agents for mixture of air pollutants. The most important role of meteorology is in the dispersion, transformation and removal of air pollutants from the atmosphere. The wind speeds determine the amount of dispersion of pollutants in the atmosphere. The temperature contributes transformation of pollutants in the atmosphere. High pollution levels can be expected during fair meteorological conditions resulting local wind system and strong temperature inversions in cities. Moreover, the relationship between unfavorable meteorological conditions, and the time of which PEL in the atmosphere will be exceeded appears with some delay.

If we have the fairly complete series of measurements of the concentrations of various pollutants in the atmosphere of an industrial center in combination with meteorological data at the same time period, we can make a fairly accurate prediction of the onset of adverse events. However, it is not known for how long before the appearance of PEL excess there was an unfavorable meteorological situation, and what combination of meteorological data triggered it.

Thus, for an adequate prediction of PEL excess of pollutants in the atmosphere there can be two main tasks:

1) Determination of the delay time between the manifestation of adverse meteorological conditions and the time of PEL excess. We call it the critical time of the formation of high surface concentrations (CTFHSC).

2) The classification of values of the meteorological factors in a previous stage in the CTFHSC as threat for the PEL excess.

Artificial neural networks are widely used for forecasting the pollution concentrations level in the atmosphere now [7-9]. These artificial intelligence systems can also be used to determine the CTFHSC. In this case we need to form some neural networks- experts, each of which may make prediction on the occurrence of PEL excess in their time interval [8]. An expert which shows the best prediction results on the training and test sets is the net-winner and the time interval covered by it is the desired critical interval.

We use the results of measurements of concentrations of air pollutants in the city of Nizhnekamsk for the period from January to October 2015 for forecasting. Measurements were made at intervals of one day for 15 pollutants. Exceeding of the maximum allowable concentration of at least one of them is an equivalent to the emergency. The remoteness between onset of emergency and formation of a complex of unfavorable meteorological conditions does not exceed two days [2-5].

On this basis, to determine the CTFHSC, i.e. actual time interval between the moment of formation of an unfavorable meteorological situation and the day with the excess of PEL of any one pollutant, it is possible to propose three mutually exclusive hypotheses:

1. PEL will occur two days after the occurrence of unfavorable meteorological conditions coincidence.

2. PEL will occur one day after the occurrence of unfavorable meteorological conditions coincidence.

3. PEL will occur on the same day, which formed unfavorable meteorological conditions.

These hypotheses need to compare the degree of certainty. You can use the following procedure:

1. Neural networks corresponding to each hypothesis are constructed.

For the training of each, the inputs of the neural networks are fed with meteorological data for the time period covered by the network, and on the output is the fact of exceeding (or not exceeding) the PEL at the end of the period covered by the network. Let's illustrate this idea with an example.

2. The first network tests the hypothesis that exceeding of the PEL will occur two days after the formation of unfavorable meteorological conditions, the second - that exceeding of the PEL will occur one day after the formation of unfavorable meteorological conditions, and the third - that the excess of the PEL will occur on the same day. Meteorological data for the current day of measurements are fed to the input of the first network, meteorological data for the second day to the input of the second network, data for the third day to the input of the third network. Since the excess of PEL did not occur in two, neither in one, nor during the current day, the response of all neural networks should be equal to 0.

After that, the search interval shifts by one day to the right. Therefore, meteorological data measurements for the second day are sent to the input of the first network, the second network - the third day, the third network - the fourth day. Since again exceeding the PEL did not occur at the end of any of the periods, all networks should have a zero output. Thus, we create a second set of training data for all three neural network experts.

Finally, we move the search interval for one more day to the right. Now on the inputs of the first, the second and the third neural networks meteorological data of the third, the fourth and the fifth days, respectively, are sent. The hypothesis was confirmed for the first neural network: in two days exceeding of PEL actually occurred. As well as for the second and for the third of the network-expert. Thus, as an output of all three networks, you must specify 1.

Continuing this way to shift the search interval, training sets will be formed for all three networks.

2. Each neural network-expert is trained with the same algorithm, the same number of epochs. For this technique, the type and topology of the constructed expert networks are nonessential moments, the main thing is that for all hypotheses must be used networks with the same topology. The expert, whose learning error was minimal, wins. An expert-winner can not be used for direct forecasting in the future. It only defines the CTFHSC, which should be used for forecasting.

THE NUMERICAL EXPERIMENTS

The experiment number 1. Construction of neural network experts for forecasting a single event of PEL excess depending on meteorological conditions through the multilayer perceptron (MLP) network.

As has been already mentioned, the topology of neural network-experts, checking each hypothesis, does not play a significant role in determining the critical time interval. Therefore, multilayer perceptron (MLP) was chosen to forecast the topology as the simplest neural network.

General parameters and characteristics of networks:

Structure: The number of neurons in the input layer - 5, the number of hidden layers - 1, the number of neurons in the hidden layer - 4, the number of neurons in the output layer - 1 (Fig. 1).

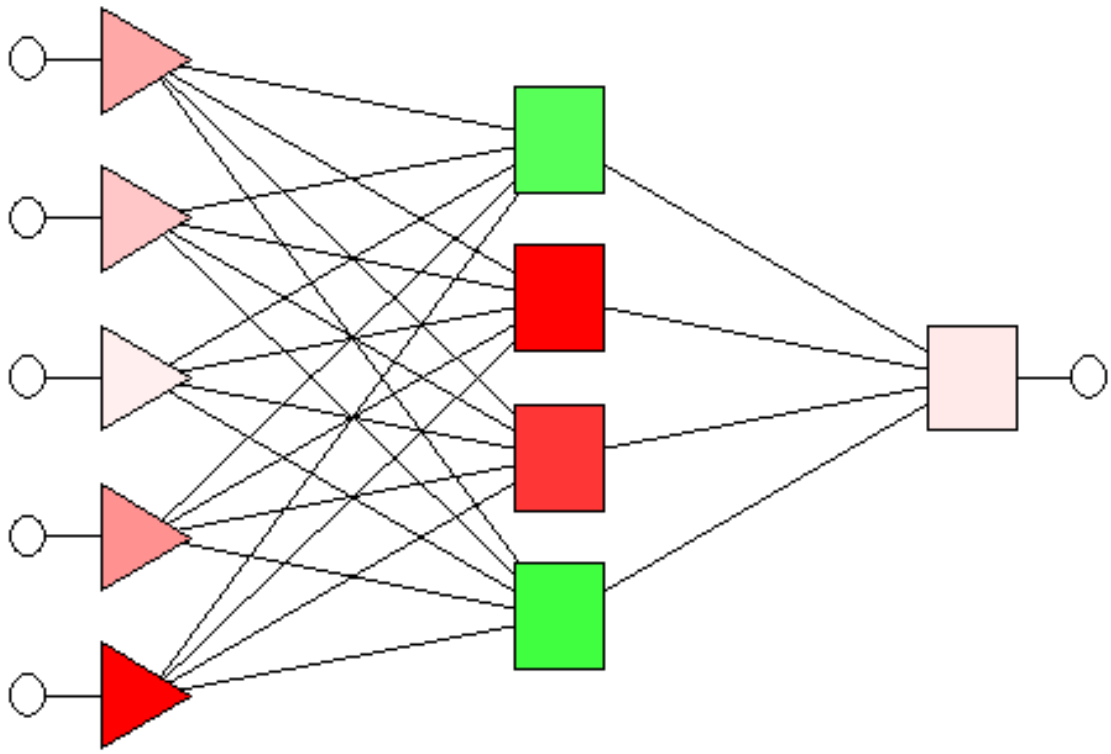

Figure 1 - The general structure of MLP networks-experts

Parameters of training: two-stage training.

- First step – back propagation method. Number of epochs - 1000.
- Second stage: the method of conjugate gradients. Number of epochs - 5000.

The network number 1. Hypothesis: PEL will occur on the same day.

- Error training: 0.31

The network number 2. Hypothesis: PEL will occur in one day.

- Error training: 0.27

The network number 3. Hypothesis: PEL will occur in two days.

- Error training: 0.34

The experiment number 2. Construction of neural network experts for the prediction of a single event - exceeding of the PEL - depending on meteorological conditions using the network for classification.

Since the Boolean variables serve as the output of neural-network experts, the prediction of PEL excess can be considered as a classification of input vectors of meteorological parameters measurement. In this case, two classes are defined - 0 and 1. Therefore, to confirm the results obtained with the MLP network, it is expedient to conduct the same experiment for the experts built on the principle of a neural network classification.

General parameters and characteristics of networks:

Structure: The number of neurons in the input layer - 5, the number of hidden layers - 1, the number of neurons in the hidden layer - 6 (Fig. 2).

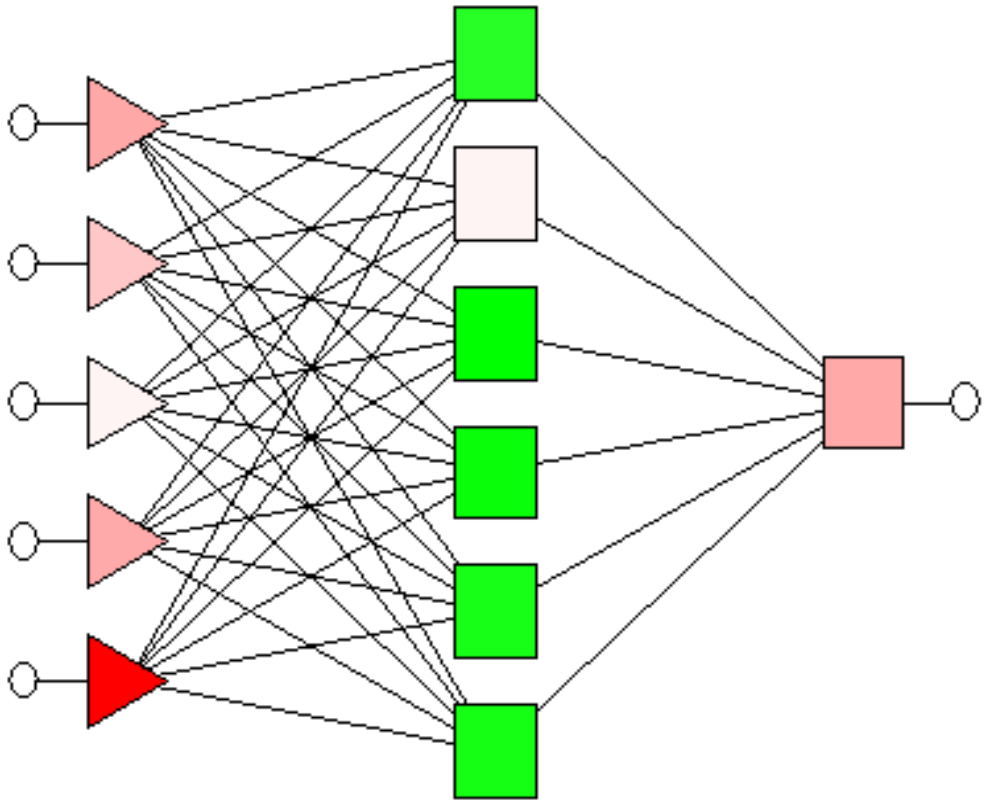

Figure 2 - The general structure of network for classification of the neural network-experts

Function for classification: cross-entropy.

Parameters of training: two-stage training.

- First step - backpropagation method. Number of epochs - 1000.
- Second stage: the method of conjugate gradients. Number of epochs - 5000.

The network number 1. Hypothesis: PEL will occur on the same day.

- Error training: 0,59
- The percentage of correctly recognized examples: 79%

The network number 2. Hypothesis: PEL will occur in one day.

• Error training: 0. 48

• The percentage of correctly recognized examples: 82%

The network number 3. Hypothesis: PEL will occur in two days.

• Error training: 0. 72

• The percentage of correctly recognized examples: 62%

The best results showed neural network expert, predicting PEL for one day before the event for forecasting of an emergency of PEL excess of toxicants in the environment of the industrial center. Consequently, the critical time interval is the interval from 24 to 48 hours to an emergency of the PEL pollutants excess in the atmosphere.

CONCLUSIONS

Summarizing the results of the researches, the following technique was developed to create and use neural networks for prediction of emergency situations such as exceeding of the PEL of pollutants in the atmosphere through a series of pollutant concentration measurements:

1. To generate a time series of observations of meteorological conditions combined with the facts of the exceeding PEL of pollutants in the atmosphere.
2. To hypothesize on the CTFHSC, the time between the appearance of unfavorable combination of meteorological factors and the manifestation of an emergency - the permissible exposure limit.
3. To build a network such as "network for the classification" with MLP paradigm and "cross-entropy" classification function with subsequent training of network on the data for each hypothesis.
4. To consider the network with the minimum error in the training as the expert-winner. To consider the appropriate hypothesis about the CTFHSC as reliable.
5. To process by the expert-winner any new set of meteorological data. In case of positive response of the expert-winner, to consider that the exceeding of PEL in the determined CTFHSC to be expected in the atmosphere.

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SIXTH INTERNATIONAL ENVIRONMENTAL CONGRESS ELPIT-2017

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SITUATIONAL ASSESSMENT OF TRANSPORTS IMPACT ON THE ACOUSTIC ENVIRONMENT OF LOCAL URBAN AREAS

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ABSTRACT

In this paper the development of model of transport impact on the acoustic environment urban areas is described. Transport noise is growing with a growing of number of vehicles. Assessment and reduction of acoustic impact of vehicles requires the application of local measures of exposure to complex environmental events. The paper discusses some approaches to solving the problem of reducing the motor noise in cities is related to the rational organization of traffic, as well as the specific means of noise reduction in the way of its propagation. The environmental effect of the application of measures to protect the population from traffic noise defines the environmental comfort of urban territories. System of quality assessment of acoustic environment close to roads involves consideration of a broad range of issues, including the development of effective local measures to reduce motor noise.

Key words: acoustic environment, traffic noise, noise levels, noise barriers, noise-reducing structures

The integration of Russia into the world community requires the fulfillment of the basic principles of the concept of sustainable development. This, above all, improving the quality of life of the population and ensuring an acceptable level of environmental safety. 2017 is the year of ecology in Russia. This is done in order to draw attention to problems in the environmental field, and to improve the status of ecological safety of the country. One of the goals is to improve environmental performance, including the status of urban space and of urban territories. The urban environment greatly exposed to an aggressive technogenic impact.

Currently, more than 60 % of the urban population of Russia lives in conditions of high and very high level of environmental pollution, especially atmospheric air. The solution to the problem of providing favorable for life and human activities the environmental situation in the densely populated urban areas is due to its appropriate rating and the maximum reduction of negative technogenic impact.

At the present level of the development of Russia's economy man-made and natural objects, processes, their interactions are characterized by complexity and high dynamism. This determines the need for collection and immediate processing of large volumes of heterogeneous information. In addition, under the circumstances, a pressing issue is the adoption and implementation of such management actions in the sphere of environmental safety, which are scientifically based and, most importantly, adequate current dynamics parameters and structures of the natural and technogenic objects of the external environment. [1, 2]

The current level of motorization and the annual increase in traffic intensity leads to an increase in noise load on the environment and the population. Especially, motor noise adversely affects people living in the areas adjacent to the road. Hour noise exposure leads to an increase in the number of nervous disorders, a number of specific diseases. Protection of cities from the motor noise is not only social but also economic. The deterioration of conditions of work and rest with an increased level of traffic noise has a negative effect on productivity and its quality. [3]. Road transport is the main source of noise in the city, in area created excessive exposure, and the magnitude of generated excess noise.

Table 1 - Maximum permissible levels (MPL) of noise

Territory	MPL of noise, dBA	
	from 23 to 7 hours (night)	from 7 to 23 hours (day)
Residential zone settlements	45	60
Industrial area	55	65
The zone of mass recreation and tourism	35	50
Sanitary-resort area	30	40

The evaluation and forecast of the impact of automobile streams on the acoustic environment, development on their basis of rational measures to reduce this impact are highly relevant. The length of the main road network of the city of eagle is 400 km, depending on the intensity and structure of traffic flows on certain sections of the road network noise characteristic of a moving vehicle is 65 dBA (the street with the share of freight transport is less than 5%) to 89 dBA (city-wide thoroughfare with a share of freight transport 5-25%). This leads to the exceeding of sanitary norms on noise levels in the areas located close to highways, 20-25 dBA, and in the apartments of residential houses facing the roads, with no special

noise protection glazing 30-35 dBA (a typical situation for areas with existing buildings). [2]

Sanitary-hygienic requirements for residential buildings, determine the need for protection of the population from the harmful effects of urban noise (figure 1). Depending on the intensity, frequency characteristics, time and duration of exposure for different places of stay of the person established certain permissible sound levels (table 1).

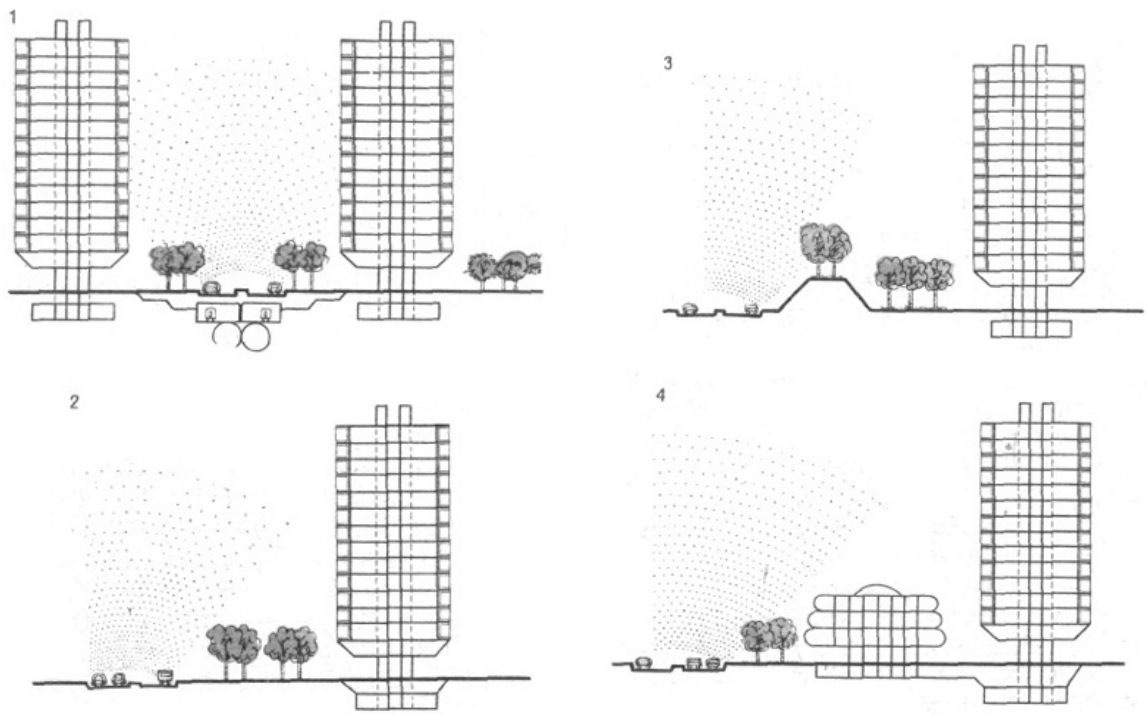

Figure 1 - Development and transport noise: 1 — closed ordinary buildings along the street; 2 — protective strip of trees between the highway and buildings; 3 — protective walls and landscaping; 4 — placement in front of buildings of buildings of public institutions

Ban the movement of trucks through the main roads of the city – a significant decrease in motor noise. On the territory of the city is transit freight transport (in close proximity with residential areas) following the Russian motor road of General use of Federal value P120 (A141) to the Federal highway M2. The issue of discharge of the city from transit and construction of a bypass road was raised in the late 1990s — early 2000-ies. Then began the construction of a bypass road near the item of Naryshkino, but in operation it is not delivered. On the next stage of the construction of interchanges in the early 2000s, the funding stopped. A few years later when funding was available, it became clear that technical standards have changed and built the site must be reconstructed. In 2014, renovation work was started but after stopped. At the beginning of 2016, the interchange is not built, but work is underway again.

Along with the organizational measures reduction of acoustic loads from vehicles during the construction of a new road along the street Mostovaia was applied and constructive methods. In may 2014 in Orel opened a new road on street Mostovaia, which provides a pass through traffic Bryansk direction, and also reduces freight traffic on the street Kolkhoznaya. The length of the new road is almost 2 km, the Width of one lane is 3.75 m. the Total road width of 15 m, the movement of cars is carried out for 4 lanes. On one side of the road located residential development protected from traffic noise by noise protecting barriers (figure 2). The total length of the noise protecting barriers 970 meters.

Figure 2 - The noise protecting barriers on the street Mostovaia

To determine the noise characteristics of vehicles flow on the road section (equivalent and maximum sound levels at 7.5 m from the axis of the nearest lane of traffic and at a height of 1 m above the roadway) conducted field measurements. The measurements were carried out in accordance with the methodology of Russian Standard 20444-85. [4]

Measurement of noise characteristics of traffic flow was conducted in the daytime during peak hours. The weather during the measurements was clear, calm, no rain. The measurement results are shown in table 2.

Table 2 - Results of measurements of noise levels on the street Mostovaia

№	The place of measurements	The intensity of vehicles flow $N_{дн.}$, avto/h	noise level, dBA		
			$L_{Аэкв.}$	$L_{Амакс}$	$L_{Амин}$
1.	2.5 m from the edge of the first lane of traffic in front of the screen	1068	75	96	54
2.	1.5 m from the screen behind the screen	1138	62,5	69,5	52,5
3.	10 m from the facade of a house behind the screen	1122	60,5	65,5	52
4.	15 m from the facade of a house behind the screen	1213	59	64	53,5

In the presence of noise walls along the multilane roads such as the road on the street Mostovaia, it is advisable to create traffic conditions drivers closer to the edge of the roadway and, therefore, anti-noise screen, by means of traffic organization. This improves the efficiency of data structures, reducing the overall noise level outside screens.

To reduce noise from vehicles on the roads with noise barriers, it is also necessary to eliminate long downtime of vehicles and reduced speed down to a stop. If a road is a route of buses, it is necessary to create dedicated lanes for buses or special pockets, which are located very close to the noise protecting barriers.

With the installation of noise protecting barrier on roads within the city and outside should meet the following conditions:

– noise protecting barrier should have the possibility of reducing the noise to the values, regulated by norms;

– noise protecting barrier shall provide road safety, not to create the risk of traffic accidents and to limit visibility to both drivers and pedestrians;

– in the event of an accident or other emergency situations (fire in the residential sector, call the ambulance at home, etc noise protecting barrier shall not impede the provision of aid and evacuation of victims, the passage of ambulances or police officers;

– noise protecting barrier should provide opportunities for public access to public transport and land pedestrian crossings;

– noise protecting barrier must be durable, i.e., materials from which made the screens should not be subject to corrosion and destruction, must be resistant to weathering, to the influence of exhaust gases and de-icing product shall conform to the standards of fire safety (fire resistance);

– noise protecting barrier should be convenient in operation and maintenance should not interfere with cleaning of roads from snow and dirt.

In addition, the design of the individual elements of noise barriers must provide their close contiguity to each other and the bottom of the screens to the subgrade to improve the acoustic efficiency.

In the calculations of the acoustic efficiency of noise protecting barrier are considered, the calculated cross section connecting the noise source and calculation point. The noise reduction of such structures is the result of education behind them, the so-called sound shadow. However, the full reduction does not occur because the sound wave is partially encircles an obstacle, which is caused by the phenomenon of diffraction.

The main characteristic that determines the acoustic quality of a noise screen-wall is its height.

The acoustic effectiveness of the screen depends on the difference of the lengths of the paths of the sound beam, defined by the following equation:

$$\delta = a + b - c, \tag{1}$$

where δ – the difference of the lengths of the paths of the sound beam, m;

a – the shortest distance between the acoustic noise source and the top edge of the screen, m;

b – the shortest distance from the top edge of the noise protecting barrier to the design points, m;

c – the shortest distance from the acoustic centre of the noise source to design point, m.

When performing the calculations, we determined the influence of traffic noise on humans at a distance of 10 m behind the noise protecting barrier, the position of the acoustic center of the noise source is assumed to be 1 m above the roadway, the height of the screen of -2.5 m.

Noise reduction effect of the protecting barrier depending on the received acoustic efficiency determined by the nomogram is 16 dBA. The calculated value of noise reduction acoustic screen corresponds to in situ measurements.

Despite a reasonably effective noise screen, identified significant deficiencies of these designs. In the locations of public transport and in places of pedestrian crossings to ensure passage of people provides breaks in the screens with the device of contramano or their overlap. On parts of the street Mostovaia in places the gap of the screen overlapping screens do not exist (figure 3).

Figure 3 - Locations of the discontinuities of the screen

The overlap of the screens shall be not less than 3-4 of the distances between the screens and the inner side of contracena runs from a noise-absorbing material.

The minimum mutual overlapping of the screens of public transport in the village is assigned at least triple the width of the passage. Aisle width shall not be less than 2 meters (figure 4).

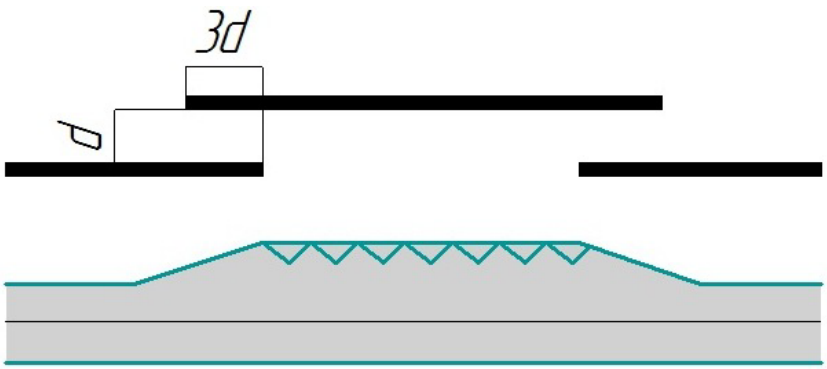

Figure 4 - Layout of the screen at the stop of public transport

Among of the measures aimed at reducing traffic noise, the most effective can also be limiting speeds on transit sections of roads along the protected from the noise of the territories. So, mandatory speed limits in the settlements indicated in table 3, reduces the acoustic impact of 1,7 to 3,7 dBA. [4]

Table 3 - Reduction in sound level when driving cars depending on the magnitude of speed reduction

The speed reduction, km/h	Reduced sound level (dBA) while driving:	
	cars	lorry
from 60 to 50	2,1	1,7
from 50 to 40	2,7	2,1
from 40 to 30	3,7	2,7

To protect residential areas from noise should be possible to use the city's green building. Green spaces, located between the noise source and residential buildings, areas for recreation, can significantly reduce the noise level. The effect increases the closer you plant to the source of the noise; the second group it is advisable to place directly around the protected object.

The sound waves bumping into leaves, pine needles, branches, trunks of trees of different orientation, scattered, reflected or absorbed. Crowns of deciduous trees absorb about 25% of the incident sound energy. Reduction of noise by plants is dependent on structure, age, density and crown, range of trees and shrubs, the spectral composition of the noise, weather conditions, etc.

Improper location of green space relative to sound sources due to the reflectivity of the foliage can have the opposite effect, i.e. increase the noise level. This can occur when planting trees with dense foliage along the axis of the street in the Boulevard. In this case, green spaces play the role of a screen, reflecting sound waves towards the housing development.

Ordinary tree planting and open space the noise does not absorb as between the ground and bottom crowns creates a sound corridor, which is repeatedly reflected and formed a sound wave. Sound reflection occurs primarily in the zone

of direct contact with the surface noise of the strip and depends on the applied stripe design and density frontal zones, perceiving a sonic boom.

The best noise reduction effect is achieved by the multi-tier planting of trees with thick foliage, interlocking with each other, and the edges of the rows of bushes, completely covering space.

Well reduce the noise of the strip of plants with a high proportion of herbs (all conifers at an average of 6-7 dBA more effectively reduce the noise level under the same parameters of the bands, than deciduous, but in urban areas their use is complicated by high sensitivity to environmental pollution).

The environmental effect of the application of measures to protect the population from traffic noise defines the environmental comfort of urban territories. System of quality assessment of acoustic environment close to roads involves consideration of a broad range of issues, including the development of effective local measures to reduce motor noise.

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WASTE MANAGEMENT SYSTEM IN RUSSIA AND APPROACHES TO ITS REALIZATION IN OIL GAS INDUSTRY

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ABSTRACT

Problem of provision of efficient waste management system operation may be considered as one of the most important now because waste number is growing every year. Waste may cause complex negative impact to the landscapes of territories, to biosphere and to the human health. Existing waste management system in Russia is analyzed. Negative impact of waste of oil-gas industry to the human's health and to environment may be especially dangerous due to the high toxicity. Systematization of kinds of classification of oily waste according to the different classification principles has been developed. Suggestions to improvement of waste management system in Russia are described. Approaches to reduction of negative impact of waste of oil-gas industry to the human's health and to environment are suggested. On the example of Samara region of Russia experience of complex organization of waste management system is considered.

Key words: waste, management, organization, oil gas industry, classification, reduction

1. INTRODUCTION

To consider the environmental impact in modern towns is possible to determine different factors causing negative impact to environment and to human's health [1, 2]. One of the main factors is waste negative impact [1-3, 8-9].

Waste number is constantly increasing. In Russian Federation annually more than 7 billion tons of different kind of waste is forming, and only 7 billion tons of waste is using again after utilization. Presently the problem of waste negative

influence reduction may be considered as one of the most important problems in all industrial countries of the world.

It is well known, that waste may cause complex negative impact to the landscapes of territories, to biosphere and to the human health. Especially dangerous are toxic waste causing negative influence to the human's health both in industry and in domestic conditions. Negative impact of waste of oil-gas industry to the human's health and to environment may be especially dangerous due to the high toxicity [2-4, 6, 7]. Toxic waste of oil-gas industry may cause different negative impact to the humans leading to the damage of cardiovascular and respiratory systems, skin damage, toxicity poisoning and other negative sequences.

This paper is devoted to the problems of analysis and improvement of realization of waste management system in Russia. Approaches to classification and reduction of negative impact of waste of oil gas industry to the human's health and to environment in urban territories and to it approbation in conditions of Samara Region of Russia are considered.

2. ANALYSIS OF PECULIARITIES OF ORGANIZATION OF WASTE MANAGEMENT SYSTEM IN RUSSIA

In general existing system of waste management in Russia may be subdivided into the different directions:

- waste collection, transportation, utilization;
- waste temporal storage;
- waste displacement in special sites;
- monitoring of waste management on the different stages;
- ecological education, organization of efficient system of teaching of specialists in the field of waste management;
- enlightenment and upbringing of population in the field of waste management;
- improvement of legal and normative documentation in the field of waste management;
- development and implementation of methods and technical solutions for reduction of waste negative impact;
- informational provision of waste management etc.

In fact waste management activity in Russia may be considered as a special cluster, the main purpose of which is provision of efficient interaction of all variety of specialists which are deciding particular questions. General purposes of cluster are:

- Integration of subjects of waste management and of secondary resources between clusters and inside of clusters;
- Development of markets of secondary resources;
- Promotion of economics of knowledge in system «upbringing – education – science - production - consumption».

Detailed purposes:

- Initiation of fundamental research of different stages of increased waste vital cycle and on topical directions of resources saving;

- Creation of conditions of accelerated certification of waste with variation of status in system "waste - secondary resource - product».

- Development of logistics of recycling;

- Determination of priorities of projects realization;

- Optimization of regional normative-legal base for reaching of strategic purpose «zero of waste».

Advantages of cluster alliances in the field of waste management are evident, and it is possible to determine it as priority direction of further development and increasing of efficiency of activity of enterprises of industry of waste treatment:

- supporting of creation and functioning of system of using of secondary resources;

- unification of resources on the basis of regional mechanisms for implementation of modern technologies of waste treatment;

- development and implementation of informational-technical systems and it using in frameworks of common informational space;

- joint training of staff of all levels;

- collaboration with foreign enterprises on exchange of advanced experience and new achievements.

In Samara region of Russia investments are directed mainly for construction of sorting stations, logistics organization, establishment of conditions for wastes temporary storage and treatment. In more high technological level are arranged waste collection and temporary storage, new container sites are created. Main task is separation of waste and re-using of resources. It allows reduce negative impact to the environment, to reduce a number of polygons of waste disposal and a volume of waste.

Regional and municipal legislative base of Samara region in the field of waste management is continuously improving. In this case much importance is attached to the development of system of waste management in the big towns of Samara region: Samara, Togliatti, Syzran, Zhigulevsk.

On the territory of city district Togliatti system of industrial and domestic waste collection, transportation and utilization is arranged in the following way. Utilization of solid domestic waste and large size garbage forming as result of vital activity of population of city district is financed by the city budget.

Scheme of industrial and domestic waste utilization in Togliatti city is integrated too the cluster of secondary resources of Samara region and includes such enterprises as "POVTOR" company, solid waste treatment plant, "PLODAR" company etc.

All the volume of solid domestic waste and large size garbage of Togliatti city is primarily delivered to "POVTOR" company, where is sorting of waste is provided. Organic waste is treated by bio-thermal composting method in solid waste treatment plant. The volumes of waste that it is not possible to utilize and to treat are disposed in special polygons.

Existing system of utilization of solid domestic waste and large size garbage of Togliatti city allows to provide efficient treatment of waste and to reduce a total volume of waste disposed at polygons up to the value of 25 % form the total value of waste.

Implementation of system of a separate collection of waste is important and complex task requiring a hard work on organization of ecological enlightenment and upbringing, motivation of inhabitants to separate paper, glass, plastic in total waste volume.

It is also an interesting experience of work of association of Samara region "Waste management" uniting as enterprises activity of which is connected with waste forming, disposal and utilization, as educational institutions.

It is necessary to underline that in Samara region of Russia much importance is attached to ecological education, enlightenment and upbringing, including also the field of waste management. Some universities of Samara region are teaching the students to ecological specializations. Mass measures, actions, exhibitions, competitions with active involving of population of region are carried out. For example, in frameworks of international ecological congresses ELPIT in Samara the international round table is arranging devoted to waste management problems with active participation of heads and specialists of enterprises, scientists, public organizations and citizens. Especially important is the task of toxic waste treatment.

3. KINDS OF NEGATIVE IMPACT OF WASTE OF OIL GAS INDUSTRY

Kinds of negative impact of oil gas industry to the human's health and to environment may be subdivided as following.

1. Global changes, variation of conditions of existence of animals and plants.
- dysfunction of exchange in the system “atmosphere-ocean”;
- mutations apparition etc.

2. Pollution of water and grounds by toxic substances:
- chronic pollution by heavy metals (mercury, cadmium, lead, arsenic, zink etc.) presenting in drilling fluids and sludges;
- penetration into the water of oil and oil fractions, high toxins, mutagenic and cancerogenic polyaromatic hydrocarbons and organic acids;
- formation of radioactive sludges by radionuclides penetrating with formation waters.

3. Threat to life activity of living substances:
-death of species;
- the emergence of pathological signs and histological disturbances in organism;
- accumulation of oil hydrocarbons in organs and tissues of plants and animals;
- great loss in the quantity of fish catch;
- decreasing of life period.

4. Destruction of structure of ecosystems:
- total disappearance of some species;

- change of dominating and sub-dominating species;
- degradation of production-destruction processes in ecosystem.
- soil damage during impact of oil containing waste;
- death of fish etc.

It is necessary to point out that the combined impact of different oil gas components may cause different effect on the man's organism. Damaging impact may be summated, attenuated or amplified, as well as may cause variation of the character of influence [4, 5, 9].

4. APPROACHES TO CLASSIFICATION OF WASTE OF OIL GAS INDUSTRY AND OF SECONDARY PRODUCTS OF OIL PROCESSING

Analysis of existing classifications of waste of enterprises of chemical, oil-chemical and oil extracting industry is allowing to conclude about the efficiency of only such approaches to classification which are coherent with technologies of utilization of waste and a rest of extraction and processing of natural raw. In such cases main classification feature (or features) is suitability of waste to processing using certain technology. Usually the boundaries of such suitability are determined by combination of physical, chemical or other properties of waste.

Waste of oil and secondary products of oil processing usually may be considered as different complex multi-component mixtures of substances having different chemical, component, phase structure, physical-mechanical and physical-chemical properties [1, 6]. It explains the difficulty of development of classification of such kind of waste.

Analysis of existing criteria and approaches to classification of waste of oil gas industry and of secondary products of oil processing is carried out by author. A number of authors have achieved the results of systematization of information about the classification of oil gas waste and of secondary products of oil processing: D.E. Bykov [1], joint group of authors of Institute of problems of oil and gas of Russian academy of science, «Gasprom VNIIGAZ» company etc. Detailed system of classification, including different issues of waste management is contains in State cadastre of waste. Cadastre is a collection of data about waste of production and consumption, including information about waste (origin, quantity, composition, properties, level of impact to environment, conditions of displacement, technologies of using and treatment) on the level of Russian Federation, subjects of Russian Federation and enterprises working in the field of waste management.

Cadastre is consists of three independent parts:

– catalogue of waste composed according to Federal classification catalogue;

– register of objects of waste displacement;

- database of waste and technologies of waste using and treatment.

Development and supporting of State register of objects of waste disposal including passportization of objects of waste disposal, classification of objects of waste disposal and giving a code to the objects of waste disposal according to the type of object of waste disposal and category of it ecological safety.

Database of waste and of technologies of waste using and treatment is allowing to carry out systematic accounting of collection, accumulation, disposal, using and displacement of waste, forming in the territory of Russian Federation, registration of existing technologies of using and (or) treatment of waste, classification and assignment code of technology of waste application or neutralization.

Main advantage of cadastre of waste as a source of information together with systematic of data is it authenticity. Compositions and properties of waste which are included to Cadastre, determined in certificated laboratories and verified by specialists of specially empowered public authorities in the field of environmental protection. Technologies in database of waste and technologies before the inclusion to Cadastre are subjected to state ecological assessment. Cadastre of waste is the main informational source in the field of waste management in Russian Federation.

Table 1 - Classification of oil-containing waste and of methods of processing

Mark of oil sludge	Technological process of formation of oil sludge	Recommending ways of using
Mark A	Sediments of oil tanks	Obtaining of hydrocarbons, lubrication of chains mechanisms, forms during manufacturing of concrete slabs in house-building factories etc.
Mark B-1	Used drilling fluid	Using in production of brick
Mark B-2		Using in production of claydite
Mark C	Oil sludges forming during repair of wells and accidents on oil pipelines	After processing for production of construction bitumen, asphalt concrete mix or after solidification for using during roads construction, sprincles ise, manufacturing of finishing agents for different repositories
Mark G-1	Oil sludges of oil processing industry	Obtainment of bitumen
Mark G-2		Obtainment of sulphur dioxide, ammoniun sulphate and high-sulphur coke
Mark D	Oil sludges forming in process of washing of pipes in pipes centers	Obtainment of paraffin

Classification database described above is the most perfect because in it all “living cycle” of waste is covered. In literature information about numerical

approaches to classification of oily waste according to the different features is described [1, 2, 4, 6, 7]. As a rule, necessity of it establishment is caused by necessity of selection borders of composition and properties of waste for which technology of utilization is developed.

For different marks of oil sludges in dependence from composition and technological accessory the following recommended ways of using may be suggested (table 1).

In result of joint efforts of scientific, project organizations and specially assigned public authorities in the field of environmental protection in year of 1997 in Russia was founded Federal classification catalogue of waste. In 2014 this classification of waste was modified, some kinds of waste were combined in more large groups, and some others are separated to more detailed described groups. It should be noted that Federal classification catalogue of waste is not giving the "key" to completed decision of the problem of utilization of waste of oil gas industry of complicated composition. Such waste are differs by special danger due to high concentrations of toxic organic and non-organic substances, non-uniform phase structure, what is significantly making difficult search of ways of protection of biosphere from it impact.

Systematization of kinds of classification of oil containing waste according to the different classification features developed by author is given in table 2.

Table 2 - Systematization of kinds of classification on oil containing waste according to the different classification features

1. According to conditions of formation
- discharges during cleaning of oil reservoirs; - accidental spills during oil extraction and transportation; - barn oils; - ground oil slugdes; - bottom oil sludges; - oil sludges of resrvoir type; - waste from repair; - oil ground; - asphalt maloperation deposits; - waste of reagentless processing of oil containing waste water; - waste are generated in result of reagent treatment of oil containing waste waters; - mixed waste of difficult separated oil containing materials (synthetic surfactants, the flotation concentrates etc.); - used lubricants, products of oil tanks cleaning; - bottom waste which are forming on the bottom of different water reservoirs after spill oil; - waste after well drilling; - waste formed in the process of oil extraction in the processs of cleansing oil; - waste forming during oil storage and transporting in tanks etc.
2. According to aggregate state

- liquid oil containing waste; - solid and high-viscosity oil containing waste; - ground waste as a product of junction of soil and spilled oil; - surplus activated sludge etc.
3. According to physical-chemical prorerties
- physical properties; - chemical composition; - presence of mechanical additives etc.
4. According to the degree of ecological danger
- class of danger of waste; - degree of toxicity of waste; - field of potential ecological impact (soil, water reservoirs, ground waters, specially protected natural territories etc.).
5. According to the type of technological process of oil sludge formation
- oil sludges are generated during repair of well and accidents with oil pipelines; - oil sludges of oil treatment industry; - oil sludges are generated in the process of washing of pipes in pipe storage etc.
6. According to the methods of processing
Thermal methods - Incineration in open storehouses; - burning in ovens of different types and constructions; - thermal drying; - pyrolyse etc. **Physical methods** - gravitational sedimentation; - separation in centrifugal field; - filtering etc. **Physical-chemical methods** - solidification by dispersion with hydrophobic reagents; - neutralization; - oxidation; - electro-physical methods; - flotation; - coagulation; - sorption; - extraction etc. **Biological methods** - treatment by active sludge; - anaerobic fermentation; - biothermal composting; - phytocide etc.
7. According to the possibility of using
- waste to be subject of secondary using;

- waste to be subject of disposal; - waste to be subject of destruction (burning etc.).
8. According to the field of application
- obtainment of hydrocarbons; - lubrication of mechanisms of chains; - obtainment of forms during manufacturing of concrete slabs in house-building factories etc.; - using as prophylactic agents for prevention of freezing together of coal and for prevention from wind erosion during it transportation; - burning as oven fuel; - using in production of bricks; - using in production of keramzit; - obtainment of bitumen; - obtainment of sulphur dioxide, ammonium sulphate and high-sulphur coke; - obtainment of paraffin etc.

4. APPROACHES TO REDUCTION OF NEGATIVE IMPACT OF WASTE AND APPROBATION IN CONDITIONS OF SAMARA REGION OF RUSSIA

Generally it is possible to subdivide main approaches and steps to reduction of negative impact of waste in Russia:

- collection, transportation, utilization of waste polluted by oily products;
- displacement of waste polluted by oily products in special sites;
- monitoring of degree of pollution of waste by oily products;
- using of technical solutions and technologies for waste and biosphere components treatment from oily products;
- ecological education, organization of efficient system of teaching of specialists in the field of waste management;
- enlightenment and upbringing of population in the field of waste management;
- improvement of legal and normative documentation in the field of waste management;
- informational provision degree of pollution of soil etc.
- Initiation of fundamental research of different stages of soil treatment from oily products;
- Development of logistics of soil treatment from oily products;
- Optimization of regional normative-legal base for reaching of strategic purpose «zero of waste».

It is necessary to point out that also monitoring of waste and biosphere components pollution is very important for efficient soil treatment. In Russia there is a system of waste monitoring including observation, control and collection of information at different levels:

- monitoring of impact to environment;

- monitoring of waste displacement etc.

Monitoring of environmental impact assessment provides for control of the following parameters: object of control, methods of research, frequency of measurements, methods and equipment of control, periodicity of measurements data processing and analysis, methods of estimation of environmental impact assessment, methods of estimation of environmental damage. In result it is necessary to implement the measures allowing to reduce the exceeding values of oily waste negative impact and to arrange control measurements.

In Samara region of Russia there is a good experience of waste negative impact reduction. Regional and municipal legislative base of Samara region in the field of waste management is continuously improving. It is necessary to point out evident advantages of special cluster organization in the field of waste management in Samara region.

In Samara region of Russia there is a special program "Improvement of system of industrial and domestic waste management and forming of cluster of using of secondary resources on the territory of Samara region". Main purposes of the program are:

- creation of joint system of industrial and domestic waste management on the principles of consolidation and unification of state structures with all the representative of professional society;
- finding of investments into economics of Samara region, creation of additional working places, provision of ecologically safe keeping, treatment and liquidation of waste.

Presently different technologies of utilization of oily waste are using. Mainly they are basing on the processes of separation of water and organic phases like sedimentation, filtering, burning. For oil contaminated soils the most propagated the method of biological destruction of hydrocarbon component.

It is possible to use of oil-slimes in road construction. With this waste may be used without treatment for the purposes of fortification of earthen cloth, send underlayment and macadam base of road.

In Samara state technical university new method of utilization of oil containing waste is suggested including processes of atmosphere and vacuum distillation with further oxidation. Such solution allows return to production cycle of oil distillation row materials in wastes of oil gas industry. It allows significantly reduce negative impact of oil gas sludge to environment.

Thus, analysis of world experience and patent research are showing that there is necessity of development of complex small-waste technology of treatment of oil containing waste with maximal using of it resource potential by receiving of valuable secondary oil products, like hydrocarbons of diesel fraction and road bitumen.

5. CONCLUSIONS

The problem of waste management is especially important in Russia due to the large volume of waste that is not utilized. Analysis of peculiarities of

organization of waste management system in Russia is carried out. Existing system of waste management system in Russia is described. Cluster approach is considered.

Considering further researches of classification of waste of oil gas industry and secondary products of oil treatment it should be noted the necessity of creation of normative-technical base of kinds of oil containing waste and approaches of it estimation, including special gededic surveys and inspections, determination of negative factors, estimation and forecast, prevention and elimination of negative processes during impact to man anf to biosphere. It is necessary to develop in more details a number of necessary parameters and criteria during estimation of negative impact of oil containing waste. For monitoring of land pollution by oily waste it is necessary to use more widely modern methods and technical means of monitoring (including satellite geodesy systems, methods of remote probes, surface express-methods, methods of biological indication, biological testing etc.).

It is possible to conclude that efficient reduction of waste negative impact to the population and to environment may be achieved only by realization of complex approach to waste management including waste collection, transportation, disposal, treatment, utilization, education, information of population etc.

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NEGATIVE IMPACT OF LUBRICATING COOLING LIQUIDS AND THE WAYS OF ITS REDUCTION

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ABSTRACT

Lubricating cooling liquids are widely used as in industry as for domestic purposes. The problem of it negative influence to the human's health and to environment have become especially important for the last years due to the significant volumes of it and the high toxicity. Results of analysis of negative influence of lubricating cooling liquids to the human's health and to environment are described. Methods of classification of negative impact of lubricating cooling liquids are suggested including it biological, chemical and physical features. Approaches to lubricating cooling liquids negative impact reduction are suggested. The main directions of lubricating cooling liquids reduction are including:
- Using of ecologically safe materials instead of lubricating cooling liquids;
- Treatment without of using of lubricating cooling liquids;
- Treatment with minimal using of lubricating cooling liquids.

The classification of the ways of reduction of lubricating cooling liquids negative influence to the human's health is suggested.
It is pointed out that only design and implementation of complex of methods may give efficient results and significant reduction of negative influence of lubricating cooling liquids and to reduce the damage to the environment and to the man's health.

Key words: lubricating cooling liquids, classification, reduction toxicity, human's health, influence, estimation, reduction

1. INTRODUCTION

Now lubricating cooling liquids are widely used not only in industry, but also for domestic purposes. The problem of it negative influence to the human's health both in industry and in domestic conditions have become urgent for the last years as due to the significant volumes of it as or the high toxicity.

Mainly lubricating cooling liquids are the mineral oils or the oils with wear-protective additives or it water emulsions consisting of water, mineral oils, emulsifiers, inhibitors of corrosion, bactericides or other dangerous components.

Due to it chemical nature lubricating cooling liquids may cause different negative impact to the humans leading to the damage of cardiovascular and respiratory systems, skin damage, toxicity poisoning and other negative sequences.

Existing marks of lubricating cooling liquids are toxic and having the different degrees of toxicity (from hyper toxicity to middle toxicity). It contains components polluting the environment: oil products, ether extracting particles, fatty acids etc.

It is important task to make an analysis of lubricating cooling liquids negative influence to the human's health and to suggest the ways of it reduction.

This paper is devoted to development of approaches to classification and to reduction of negative impact of lubricating cooling liquids.

2. ANALYSIS OF NEGATIVE INFLUENCE OF LUBRICATING COOLING LIQUIDS TO THE HUMAN'S HEALTH AND TO ENVIRONMENT

Lubricating cooling liquids (LCL) may cause negative influence to the man as in result of direct contact with skin of man or due to the contact through the special protective clothing and also in result of penetration of gases, aerosols, condensate of LCL to the human organism through the respiratory system.

Analysis of special features of negative influence of lubricating cooling liquids to the human's health shows that it tends to the growth of professional illnesses of workers of different branches of industry. E.g. in Public Joint Stock Company "AVTOVAZ" it tends to increase the growth of such professional illnesses as bronchitis and eczemas.

Influence of used lubricating cooling liquids is especially dangerous both for man and for environment.

It is well known influence of lubricating cooling liquids to the man's health in industrial conditions. One of the main sequences of lubricating cooling liquids impact is professional illnesses. Analysis of scientific papers in this field is proving the that aerosols of lubricating cooling liquids may cause pneumonia, cause skin illnesses, damage heart muscles, liver and kidney [1, 5, 7, 9]. Moreover, it is determined that products of thermal destruction of harmless components of lubricating cooling liquids as well as possible chemical formations in zone of treatment are also may cause negative impact to the man's health.

Due to the chemical nature lubricating cooling liquids are causing negative impact to the workers in industrial conditions in result of direct contact with skin and as result of lubricating cooling liquids evaporation. Degree of negative impact is depending to the chemical composition of lubricating cooling liquids; conditions of treatment of metals; conditions of surrounding microclimate.

Influence of lubricating cooling liquids may cause significant negative impact to environment mainly due to the toxic impact. For example, atmosphere pollution by lubricating cooling liquids impact may occur not only in the process of it exploitation, but also due to evaporation and combustion of lubricating oils. Used lubricating cooling liquids may be considered as dangerous toxic wastes, utilization of which is very difficult [3].

Possible negative influence of lubricating cooling liquids to the health of man and to environment are shown in fugure 1.

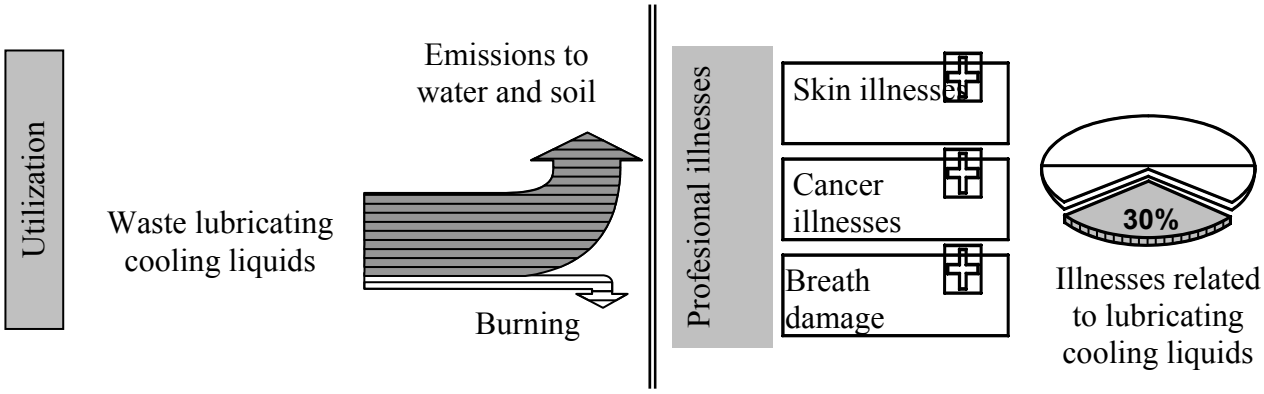

Figure 1 - Possible negative influence of lubricating cooling liquids to the health of man and to environment

It should be noted that even feebly toxic medium may cause significant negative influence on water reservoir biota. Waste waters of industrial enterprises are containing LCL causing toxic impact to water resources. For example, waste water of Public Joint Stock Company "AVTOVAZ" is causing low toxic impact to Kuibyshevsky water reservoir. Therefore it is very necessary to develop efficient methods and means of further minimization of negative impact of toxicity of LCL and of monitoring of it negative impact.

3. CLASSIFICATION OF NEGATIVE INFLUENCE OF LUBRICATING COOLING LIQUIDS TO THE HUMAN'S HEALTH AND TO ENVIRONMENT

Environmental control of toxicity is a complex procedure including estimation of sources of toxicity, determination of the most potentially dangerous zones of toxicity of urban territories, selection of methods for estimation of toxicity, analysis of results of estimation of toxicity, conclusions about the degree

of toxicity, and, finally, development and implementation of methods concerning reduction of negative impact of toxicants.

New method for estimation of toxicity has been suggested by the authors of this paper. Characteristic feature of the developed method in comparison with existing methods is complex consideration of the main toxicological values of toxicants (e.g. lubricating cooling liquids) on the basis of its point-rating ranging.

The following toxicological characteristics have been taken into consideration:

- irritating effect on eyes;
- skin-resorptive effect;
- sensitizing effect;
- toxic particles assignable under exploitation of lubricating cooling liquids (number of singled out toxicants and it class of danger);
- toxicity during inside-stomach injection.

In table 1 the scheme of distribution of points during estimation of degree of toxic effect of lubricating cooling liquids on the man and environment is presented.

Table 1 - The scheme of distribution of points during estimation of degree of toxic effect of lubricating cooling liquids on the man and environment

Name of indicator of estimation	Parameter of estimation	Points
Irritating effect on eyes	No effect	0 points
	Weak effect	1 point
	Irritating effect	2 points
Skin-resorptive effect	No effect	0 points
	Weak effect	1 point
	Irritating effect	2 points
Sensitizing effect	No effect	0 points
	Weak effect	1 point
	Irritating effect	2 points
Toxic substances assignable under exploitation of lubricating cooling liquids (for estimation the substance corresponding to the most high class of danger is selected)	I class of danger	4 points
	II class of danger	3 points
	III class of danger	2 points
	IV class of danger	1 point
Toxicity during inside-stomach injection (medium mortal dose (LD50) under injection into the stomach)	LD50 ≤ 5000 mg/kg	2 points
	LD50 > 5000 mg/kg	1 point
	Toxic impact is not determined	0 points

4. CLASSIFICATION OF THE WAYS OF REDUCTION OF NEGATIVE INFLUENCE OF LUBRICATING COOLING LIQUIDS TO THE HUMAN'S HEALTH AND TO ENVIRONMENT

The general ways of lubricating cooling liquids negative impact reduction are shown in fig. 2. It is suggested to subdivide the ways of lubricating cooling liquids reduction into three main directions:
- Using of ecologically safe materials instead of LCL;
- Treatment without of using of LCL;
- Treatment with minimal using of LCL.

Traditional approach to reduction of negative influence of by lubricating cooling liquids to environment is it utilization. But utilization of used LCL it is not safe and rather expensive.

As an alternative to the expensive and ecologically dangerous process of LCL utilization is investigation and implementation of methods of reduction of using of LCL or the full avoiding of LCL using during technological operations. According to the data of Swiss company «Micron SA Agno», the average cost of lubricating cooling liquids used for one lathe daily is equal to the sum of 50-250 of US dollars. It means that annually company «Micron SA Agno» spends the money for application of one lathe approximately 12 750 - 63 730 of US dollars. For machines building enterprises the average cost of lubricating cooling liquids used for one lathe is equal to 8000 US dollars annually.

Avoiding of using of lubricating cooling liquids allows increase also the quality of manufactures parts, for example in work [2] is shown that chemically-active elements of LCL are causing the reduction of endurance and corrosion protection of surfaces of details. It should be noted that the absence of lubricating cooling liquids in zone of treatment allows to use more widely an active control in process of treatment and to eliminate the effect of heat shock on the surface of the instrument.

Avoiding of using of lubricating cooling liquids in the process of treatment force to decide the following main problems:
- Withdrawal of heat from the zone of cutting;
- Reduction of coefficient of friction in the process of treatment;
- Moving off shaving from the zone of treatment.

Analysis of authors is showing that presently technologies of ecologically sound treatment without of lubricating cooling liquids only for 10% of all existing lathe equipment in Russian Federation and in West countries.

The more carefully the questions of treatment without of using of lubricating cooling liquids are investigated in West European countries, and also in USA and in Japan. In these countries different kinds of blade and abrasive processing without of lubricating cooling liquids are investigated: drilling, turning, grinding, glazing.

Review of Russian and foreign literature allows point out the basis of investigations of dry treatment by using of methods of surface plastic warping and

allows determine the ways of decision of problems arising during the treatment without of lubricating cooling liquids. Such process of treatment is mostly convenient for the primary stage of investigations of processes occurring during the dry treatment because it has no such intensive heat emission and chip forming as cutting or grinding. Thus, the main task is reduction of coefficient of friction between the instrument and procurement.

Implementation of new technology allows decide the following problems:

1. Reduction of expenses, because of the most of lubricating cooling liquids on the basis of oils are having comparatively small flash temperature.
2. Improvement of labor conditions, because of lubricating cooling liquids components may cause different illnesses.
3. To increase ecological safety of industrial production because of losses during the leakages and of carry-over, emission, flushing water and utilization of waste LCL are polluting soil, water and air.
4. To reduce the expenses for purchase, storage, transportation and utilization of lubricating cooling liquids.
5. To increase the quality of treatment due to expansion of possibilities of using of the means of active control.

It should be noted that monitoring of the state of environment is also efficient way of estimation and of forecasting of changes of the state and of pollution of biosphere or of it separate components under the impact of lubricating cooling liquids. Presently many scientists are carrying out researches for using of different biological indicators as test-objects. In a meantime, estimation of degree of toxicity of lubricating cooling liquids is having certain specific and needs in detailed examination.

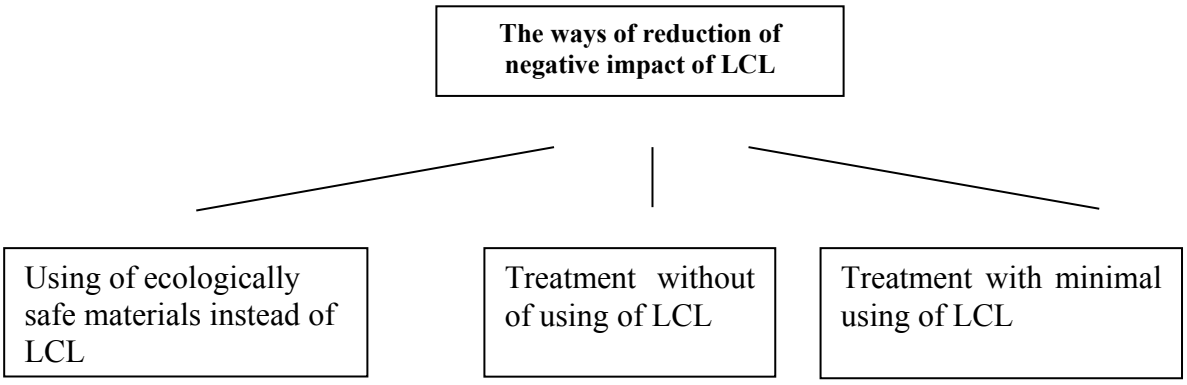

Figure 2 - The main ways of reduction of negative impact of lubricating cooling liquids (LCL)

Analysis of literature sources shows that during the estimation of toxicity of several objects of biological testing (including also lubricating cooling liquids) the mostly generally studied. It is reasonable to use as a test-objects of green algae Chlorella (*Chlorella vulgaris* Beijer), PND F 14.1:2:4.10-04, 16.1:2:3:3.7-04, and of crawfishes Daphnia magna Straus, PND F T 14.1:2:4.12-06, 16.1:2:3:3.9-06.

Above mentioned methods are certificated in Russia. It allows obtain rather high precision of results during it using for researches.

Generally, only using of complex of methods may give efficient results of significant reduction of negative influence of lubricating cooling liquids.

5. CONCLUSIONS

Lubricating cooling liquids are used in industry in large volumes. Due to the high toxicity ad other negative characteristic lubricating cooling liquids may cause significant negative impact both to the man's health and to environment. Analysis of special features of negative influence of lubricating cooling liquids to the human's health shows that it tends to the growth of professional illnesses of workers of different branches of industry.

The general ways of lubricating cooling liquids negative impact reduction are described. New method for estimation of toxicity has been suggested. Characteristic feature of the developed method in comparison with existing methods is complex consideration of the main toxicological values of toxicants (e.g. lubricating cooling liquids) on the basis of its point-rating ranging.

The general ways of lubricating cooling liquids negative impact reduction are described. It is suggested to subdivide the ways of lubricating cooling liquids reduction into three main directions: using of ecologically safe materials instead of LCL; treatment without of using of LCL; treatment with minimal using of LCL. It is pointed out that as an alternative to the expensive and ecologically dangerous process of LCL utilization it is reasonable to investigate and implement the methods of reduction of using of LCL or the full avoiding of LCL using during technological operations.

Monitoring of the state of environment is also efficient way of estimation and of forecasting of changes of the state and of pollution of biosphere or of it separate components under the impact of lubricating cooling liquids. Different methods of LCL impact monitoring are discussed.

Generally, only using of complex of methods may give efficient results of significant reduction of negative influence of lubricating cooling liquids.

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EXPERIENCE AND RESULTS OF MONITORING OF PHYSICAL POLLUTIONS IN CONDITIONS OF URBAN TERRITORIES

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ABSTRACT

Physical factors (noise, vibration, infrasound, electromagnetic fields, ionized radiation etc.) may cause significant negative influence both to environment and to the health of population. The negative impact of different physical factors may cause different effect of impact to the man's organism and to environment. Than is why it is necessary to take the required measures for physical pollutions reduction. For this purposes it is necessary to carry out physical pollutions monitoring. Approaches to ecological monitoring in Russia are described. Analysis and examples of approaches to estimation of physical pollutions influence to the human's health in Samara Region of Russian Federation are considered.

Key words: physical factors, urban territory, estimation, impact

1. INTRODUCTION

In conditions of urban territories the impact of negative factors to environment and to population is constantly increasing. Among of these factors are physical pollutions: electromagnetic fields, ionization, radon, noise, vibration, infrasound etc.

Noise level is increasing together with the cities growth. More than 60% of population of large cities is living in exceeding noise conditions [1-9]. Damaging influence of intensive noise to the human's health is not restricted only by impact to ears. It is known, that noise is affecting to the human's central and vegetative nervous systems, influencing to the human's psychological condition etc. The most serious problems are caused by low frequency acoustic affection.

Vibration may cause impact to the different urban areas (environmental, industrial, domestic) [1, 3, 6, 9]. It is difficult to find in modern town the place where vibration is completely absent. Vibration in urban areas may cause serious negative problems up to the buildings and construction breakdown and inhabitants decease. Vibration and structural noise may cause decrease the operational characteristic, durability, reliability of different kind of power plant and industrial equipment. Among of the negative sequences are destruction of parts and units of machines and equipment, pipelines, junctions of aggregates etc. Industrial vibration leads to workers disease, fatigue breakdown of pipeline and apparatus junction, disturbance of sealing airproof, decreasing of machine operating characteristics, etc.

Infrasound waves are acoustic waves whose frequencies are below the audible frequency band of the human ear, which typically ranges from 16 Hz to 20 kHz. Infrasound is produced by a variety of natural and man-made sources such as sea waves wind turbulence, exploding volcanoes, earthquakes, nuclear and chemical explosions, transport, energetic plants (especially low rotated engines), industrial enterprises etc. Infrasound may cause significant negative impact to the health of population and of workers. It may cause heart illnesses, encephalon damage etc. Moreover, man can sense near infrasound both with hearing and with a tactile sensation, but its sound pressure level have to be sufficiently high. In fact hearing becomes gradually less sensitive as frequency decreases and at 20 Hz the audibility threshold is around 85 dB. When the level of the infrasound is higher it is possible to feel vibration in various parts of the body.

Electromagnetic fields may cause significant negative influence to the human's health [6, 7, 10]. The negative effect of impact of electromagnetic radiation to the humans depends upon the power and the frequency of the radiation. For low-frequency radiation (radio waves to visible light) the best-understood effects are those due to radiation power alone, acting through the effect of simple heating when the radiation is absorbed by the cell. For these thermal effects, the frequency of the radiation is important only as it affects radiation penetration into the organism (for example microwaves penetrate better than infrared). Initially, it was believed that low frequency fields that were too weak to cause significant heating could not possibly have any biological effect.

Ionizing radiation is either kind of electromagnetic radiation in which an individual particle/photon carries enough energy to ionize an atom or molecule by completely removing an electron from its orbit. If the individual particles do not carry this amount of energy, it is essentially impossible for even a large flood of particles to cause ionization. Examples of ionizing particles are energetic alpha particles, beta particles, and neutrons.

The ability of electromagnetic waves (photons) to ionize an atom or molecule depends on its frequency. Electromagnetic radiation can cause ionization if the energy per photon, or frequency, is high enough, and thus the wavelength is short enough.

The most dangerous illness caused by the impact of ionizing radiation is cancer: a class of diseases in which a group of cells display uncontrolled growth

(division beyond the normal limits), invasion (intrusion on and destruction of adjacent tissues), and sometimes metastasis (spread to other locations in the body via lymph or blood). These three malignant properties of cancers differentiate them from benigh tumors, which are self-limited, and do not invade or metastasize. Most cancers form a tumor but some, like leukemia, do not. The branch of medicine concerned with the study, diagnosis, treatment, and prevention of cancer is oncology. Mutations are changes in the deoxyribonucleic acid sequence of a cell's genome.

Radon is a colorless, odorless gas that can be found in the soil and rocks beneath homes, in well water, and in building materials. Radon is in the soil because the soil contains naturally occurring uranium that eventually decays to radon gas. Radon can get into our homes from the soil through any cracks or holes in the foundation and from the water supply. The radon concentration allowed in water supplies is highly regulated; therefore, it is the radon in air coming in to your home from the ground that can pose a danger [6].

Radon is estimated to cause many thousands of deaths each year. That's because when you breathe air containing radon, you can get lung cancer. In fact, the Surgeon General has warned that radon is the second leading cause of lung cancer in the United States today. Only smoking causes more lung cancer deaths.

These and many other examples are proving that physical factors may cause significant negative influence to the health of population and to environment.

To be able to take the required measures for physical pollutions reduction it is necessary to carry out physical pollutions monitoring [6, 7].

This paper is devoted to description of experience of monitoring of physical factors in conditions of urban territories on the example of Samara region of Russia.

2. ESSENCE AND MAIN PRINCIPLES OF ECOLOGICAL MONITORING IN RUSSIA

Objects of ecological monitoring usually are natural, anthropogenic or natural- anthropogenic systems. Ecological monitoring is not only passive statement of facts, but also modeling and forecasting of the processes.

Main purposes of ecological monitoring are:

- Current accounting of variations of environment and preventing of deterioration of quality of environment;
- Forecasting of variations of environment and connected with it ecological sequences.

Ecological monitoring must include different levels:

- Global (biosphere) monitoring on the basis of international collaboration;
- National monitoring arranging in frameworks of one state;
- Regional monitoring arranging in frameworks of different regions of one state;
- Local monitoring in towns, districts or exactly in enterprises.

Among of the main principles of ecological monitoring of physical pollutions it is possible to emphasize the following:

- Identification of sources of physical pollutions of urban territories and of degree of it potential ecological danger;
- The most dangerous zones of urban territories from the point of impact of physical pollutions;
- Measurements of physical pollutions in conditions of urban territories;
- Processing of experimental data, issue of conclusions;
- Mathematic and calculative modeling of propagation and estimation of physical pollutions in conditions of urban territories;
- Development of physical pollutions mapping in conditions of urban territories;
- Development of measures of reduction of physical pollutions in the most dangerous zones of urban territories.

3. RESULTS OF MONITORING OF PHYSICAL POLLUTIONS ON THE TERRITORY OF SAMARA REGION OF RUSSIA

As examples of monitoring of physical pollutions of urban territories in Russia let us describe some results of monitoring of the living area of Samara region of Russia.

Samara region is one of the industrial centers of Russia on the territory of which are a number of big industrial enterprises of different branches (mechanical engineering, chemistry, energetic etc.). Also intensive transport flows are in the region, especially cars, buses, lorry transport, but also railway transport, trams, underground etc.

The most potentially dangerous zones of territory of Samara region on the impact of physical pollutions were identified.

Measurements of different physical factors were carried out in the most important towns of Samara region. Conclusions about fitting to sanitary norms were done. Zones of territory of Samara region with exceeding levels of physical factors were determined.

Let us describe some results of monitoring of physical factors of the territory of Samara region.

On the territory of city district Samara more than 500 measurements of power of ambient equivalent of dose of gamma-radiation were done more than in 50 points of measurements. For estimation of ionizing radiation dosimeter of gamma-radiation DKG-07 D "DROZD" was used. Analysis of results of measurements is showing that there is no exceeding of sanitary norms requirements. Maximally registered level of power of ambient equivalent of dose of gamma-radiation was observed in the following points of measurements:
- Sovetsky district, Vysokovoltnaya Str., house N10;
- Octiabrskiy district, Novo-Sadovaya Str., house N33;
- Zheleznodorozhny district, Partizanskaya str., house N40.

The value of registered level was 0,13-14 micro sievert per hour. This value is not exceeding permitted values.

Measurements of electromagnetic fields were carried out for industrial frequency range (electrical part E, kV/m and magnetic part H, A/m of

electromagnetic field strength) and for radio frequency range (electrical part E, kV/m; magnetic part H, A/m of electromagnetic field strength and density of flow of energy, mkW/sm^2). In total more than 250 measurements of electromagnetic fields were carried out.

Results of measurements of electromagnetic fields strength industrial frequency range in the territory of Komsomolsky district of Togliatti city are showing that the most values of electromagnetic fields strength were near to electric power lines Exceeding of sanitary norms was determined for Esenin street situated near to the Zhigulevsky hydro power station. For Central and Avtozavodsky districts the main problem is impact of electromagnetic fields of radio frequency range near to the TV mast / towers. Exceeding of sanitary norms were fixed for Mira street (Central district) and Sverdlov street (Avtozavodsky district).

On the territory of city district Zhigulevsk more than 100 measurements of electromagnetic fields strength of industrial frequency were done more than in 30 points of measurements. Analysis of results of measurements of electric field strength of industrial frequency is showing that exceeding of sanitary norms requirements are fixed in the following points of measurements:

- point of measurements N21, near to the dam of Zhigulevsk hydro power station, turn on the track to Kopylova peninsular, E = 1,265 kV/m);
- point of measurements N22, near to the dam of Zhigulevsk hydro power station (E = 1,150 kV/m);
- point of measurements N24, near to the dam of Zhigulevsk hydro power station, crossing with electricity transmission line in 500 meters from post of transport police (E = 1,270 kV/m).

Also on the territory of city district Zhigulevsk more than 100 measurements of electromagnetic fields strength of radio frequency range and of flux density energy of electric and magnetic fields were done more than in 30 points of measurements. Analysis of results of measurements is showing that there is no any exceeding of sanitary norms requirements. For flux density energy maximal value of measurements was fixed in the point of measurements of Polevaya str., house N9 on the frequency 50 MHz and was equal to 234 NW/sm^2, what is significantly lower that maximally permissible normative values.

For noise monitoring as object of study living territory of the Avtozavodsky, Central and Komsomolsky districts of Togliatti city was selected near to the city streets with intensive transport movement. In total over 150 points have been investigated. Measurements of noise levels in places of living territory of Togliatti city adjoining to noise dangerous zones have been conducted in strict correspondence with above mentioned requirements.

Near to the Central and Komsomolsky districts of Togliatti city it is situated a number of industrial enterprises united to so called "North Industrial Unit". Noise estimation and monitoring of North Industrial Unit enterprises for further determination of sanitary zone have been also carried out. Measurements have conducted in daytime in weekdays mainly in rush hours and during the lunch-time; and in night time (since 23.00 till 7.00).

The most significant excess of standard equivalent noise levels have been observed for the following points. Komsomolsky district, night time: point K-07, Matrosova Str., 60, the value of exceeding of normative requirements of equivalent noise level is 8 dBA, maximal noise level - 6 dBA; point K-12, Yaroslavskaya Str., 11: the value of exceeding of normative requirements of equivalent noise level is 5 dBA, maximal level - 8 dBA; day time: point K-10, Chaykina Str., 67, the value of exceeding of normative requirements of maximal noise level is 9 dBA; point K-13, Yaroslavskaya Str., 61, the value of exceeding of normative requirements of maximal noise level is 9 dBA. Central district, night time: point C-18, Lenina Str., 98, the value of exceeding of normative requirements of equivalent noise level is 10 dBA, maximal noise level - 5 dBA; point C-23, Mira Str., 60, the value of exceeding of normative requirements of equivalent noise level is 12 dBA, maximal noise level - 12 dBA; day time: point C-24, Mira Str., 114, the value of exceeding of normative requirements of equivalent noise level is 4 dBA, maximal noise level - 3 dBA. Avtozavodsky district, night time: point A-32, Dzerzhinskogo Str., the value of exceeding of normative requirements of equivalent noise level is 8 dBA, maximal noise level - 3 dBA; day time: point A-04, Topolinaya Str., 21, the value of exceeding of normative requirements of maximal noise level - 19 dBA.

It should be noted that not only living areas, but also industrial sites of territory of Samara region were estimated. For example, noise and vibration at industrial cites of chemical production of Russia were estimated. Example of noise estimation at industrial cite of construction of carbon dioxide production of "Khimteco" joint stock company is shown at the figure 1.

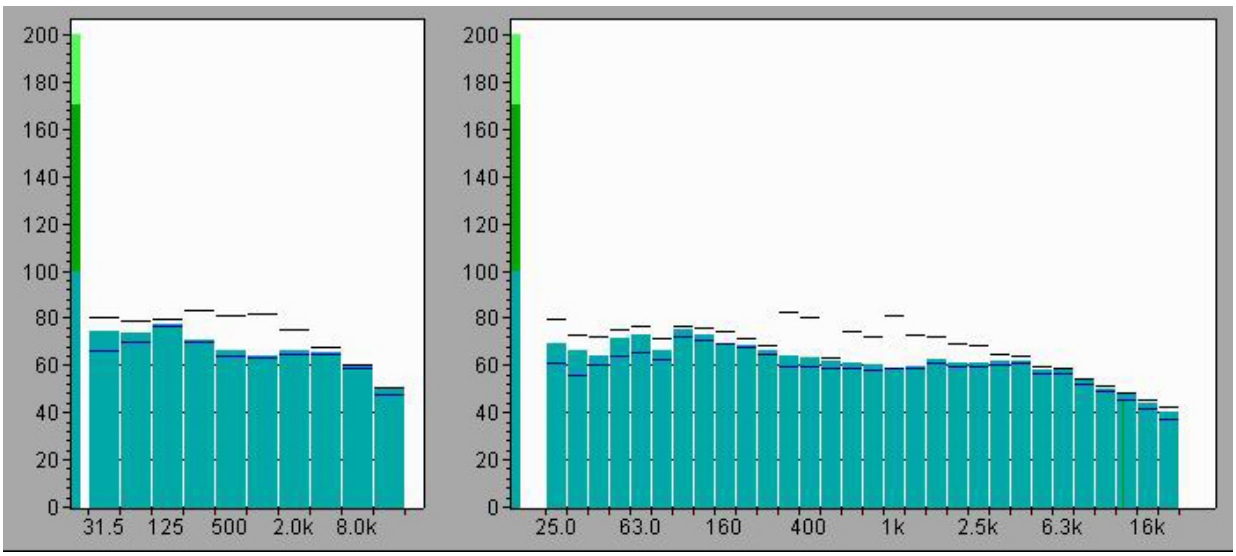

Figure 1 - Diagram of spectral characteristics of sound levels estimation at industrial cite of construction of carbon dioxide production of "Khimteco" joint stock company for point 1 of measurements (octave and 1/3 octave bands)

Example of vibration measurement on the territory of energy-efficient production of cyclogeksanon of "KuibyshevAzot" public joint stock company is shown in figure 2.

Results of measurements are fitting to Russian sanitary norms rules.

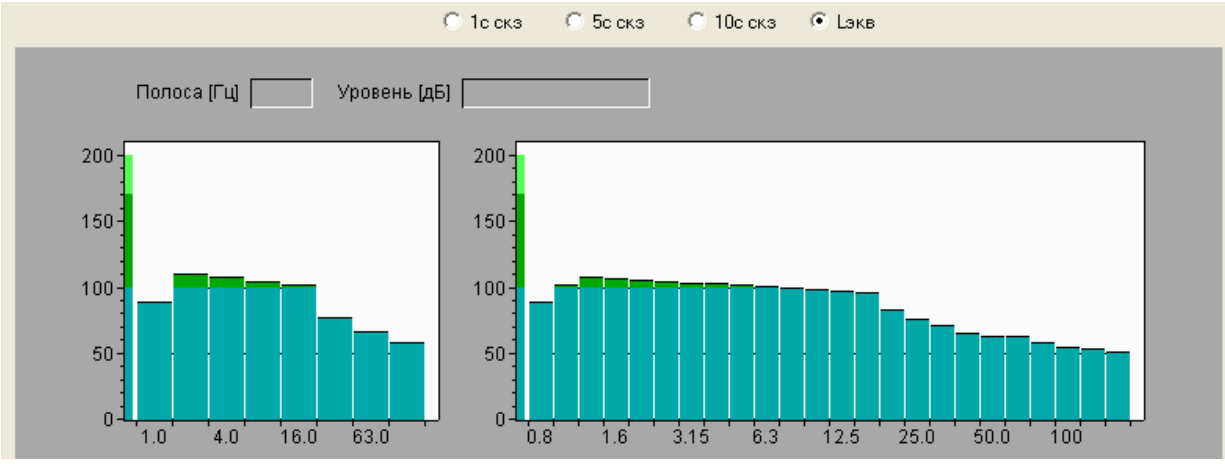

Figure 2 - Diagram of vibration measurement results for point of measurements 9 (direction z) at industrial cite of construction of energy-efficient production of "KuibyshevAzot" public joint stock company

4. MAPPING OF PHYSICAL POLLUTIONS ON THE TERRITORY OF SAMARA REGION OF RUSSIA

Mapping of physical pollutions in city area is efficient way of evaluation and forecasting, [3-8, 14, 15, 19]. Using physical pollutions mapping it is very convenient to determine the zones with increased physical pollutions impact, to calculate expected impact near to transport road and inside of the buildings near to the road, to choose and evaluate the measures of physical pollutions reduction etc. The modern methods are combining integrated approach to physical pollutions mapping and reduction [6].

There are the different methods of physical pollutions mapping. One of the methods is using of topographic data, schemes etc. of living territory. Measured and calculated results in very of points of measurements are drawing to the map, noise dangerous zones are marked. There is possibility of physical pollutions situation forecasting in the living territories which are similar to the investigated territory. Method of indication of physical pollutions levels may be also different. The most clear method is varying of color intensity: from light for low physical pollutions levels to dark – for high physical pollutions levels.

It was developed the own software for physical pollutions mapping by the authors of this paper [6, 10]. By using of developed program provision maps of different physical pollutions of urban territory of Samara region were developed. In total over 30 maps were done.

As example map of electromagnetic fields of industrial frequency of Shluzovoy district is shown in fig. 3.

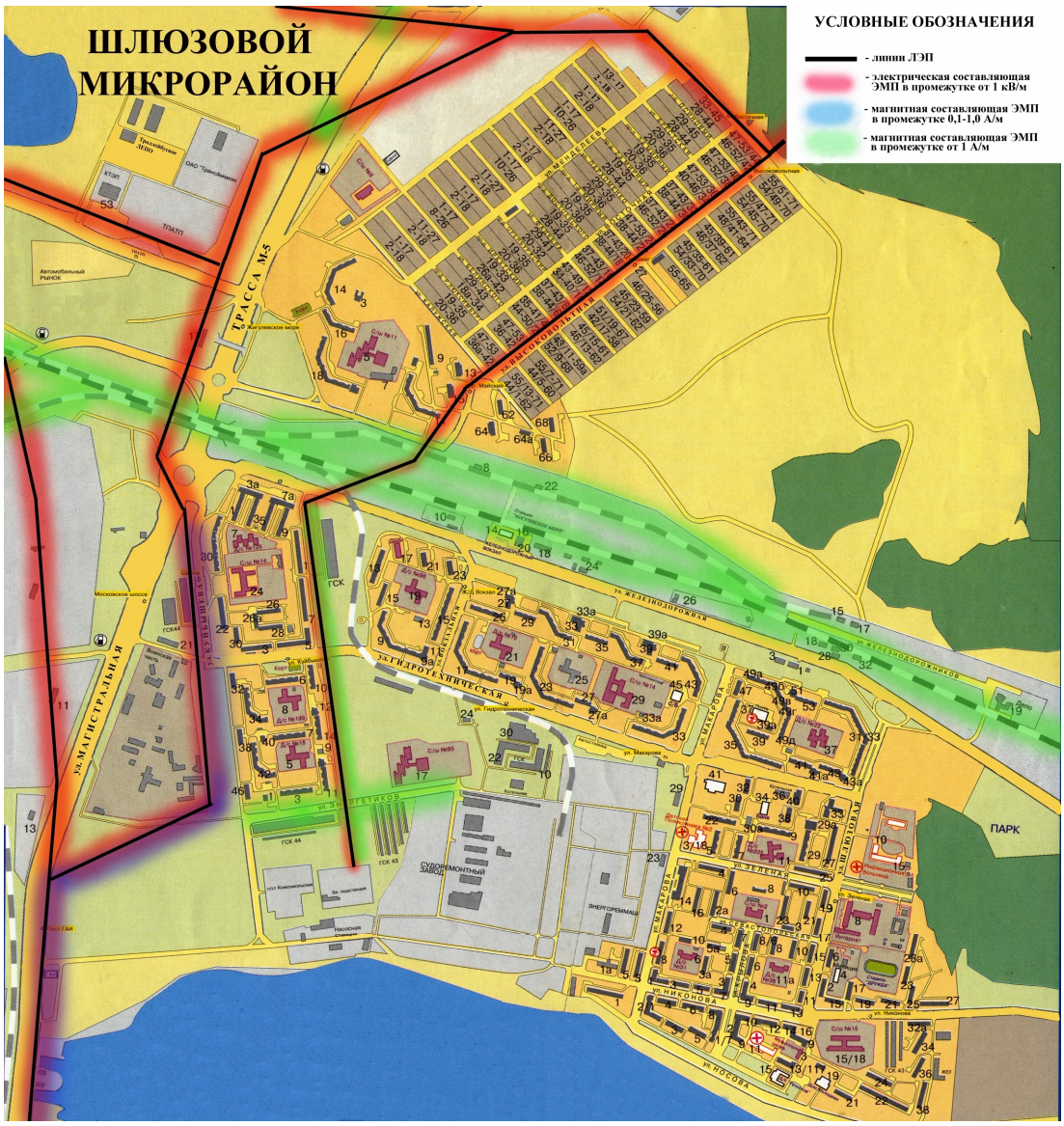

Figure 3 - Map of electromagnetic fields of industrial frequency of the territory of Shluzovoy district of Samara region of Russia

5. CONCLUSIONS

Methods and approaches of estimation of physical factors negative impact to the health of population and to environment are described. It was shown that the impact of physical pollutions (electromagnetic fields, noise, vibration, ionization etc.) may cause significant discomfort and health damage of inhabitants of urban territories and of workers of industrial enterprises as well as of ecological state of territory.

Methods and values of some physical pollutions estimation are described in the hygiene requirements, stated by valid Sanitary Norms and Russian State Standards.

Some results of monitoring of physical pollutions of urban territories in Russia are described on the example of the living area of Samara region of Russia. Analysis of measurement results are showing that there are dangerous zones of

dwelling territory for different physical factors negative impact. It should be noted that not only living areas, but also industrial sites of territory of Samara region were estimated. Examples of noise and vibration estimation at industrial cites of chemical production of Russia are given.

In total, the results of work are allowing to forecast and to reduce negative impact of physical factors to the human's health and to environment more efficiently.

ACKNOWLEDGMENT

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SIMULATION OF REMOVING ACCIDENTS AND INCIDENTS BY MEANS OF OPERATIONAL PERSONNEL WRONG ACTIONS REDUCTION

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ABSTRACT

The main regularities of accidents and injuries occurrence are considered. It is found that their main reason is the personnel wrong actions. A model is developed for determining and optimizing the integrated index of the occurrence probability of such actions. An information optimization model has been created that deals with an integral assessment of a person's psychological traits and organizational factor, which makes it possible to reduce the wrong actions occurrence probability. Due to the computational procedures complexity, the developed optimization model requires the implementation machine not only to perform optimization calculations, but also to store and generalize statistical data.

Key words: cars, power installations, fuel, emissions, greenhouse gases, forecast

Generally, the technogenic factory accidents and incidents causes are [1]:

- wrong or dangerous action;
- equipment failure and technological process missequencing;
- harmful or dangerous effects for human and environment;
- unsatisfactory production organization, most of all lack of proper control over the performance.

The number of dangerous, wrong or unauthorized actions reaches up to 70% of all accidents and injuries, while the technological equipment is less than 25% of the situations.

Additional factors of accidents and injuries are insufficient reliability and ergonomics of technological equipment, inadequate staff selection and training, poor quality of technology and work activity management, leading to the need for

people occupancy in the potentially hazardous areas, as well as factors associated with discomfort working conditions. Most of them did not always lead to accidents, but significantly complicated the working conditions due to technology strict regimentation, the need for comply with numerous security measures, thereby contributing to labor intensity increase and hazards.

Some factors directly contribute to accidents and injuries are: weak hand-on experience of staff working in abnormal or complex situations, lack of judgment, poor quality of work area design, and operator insufficient discipline.

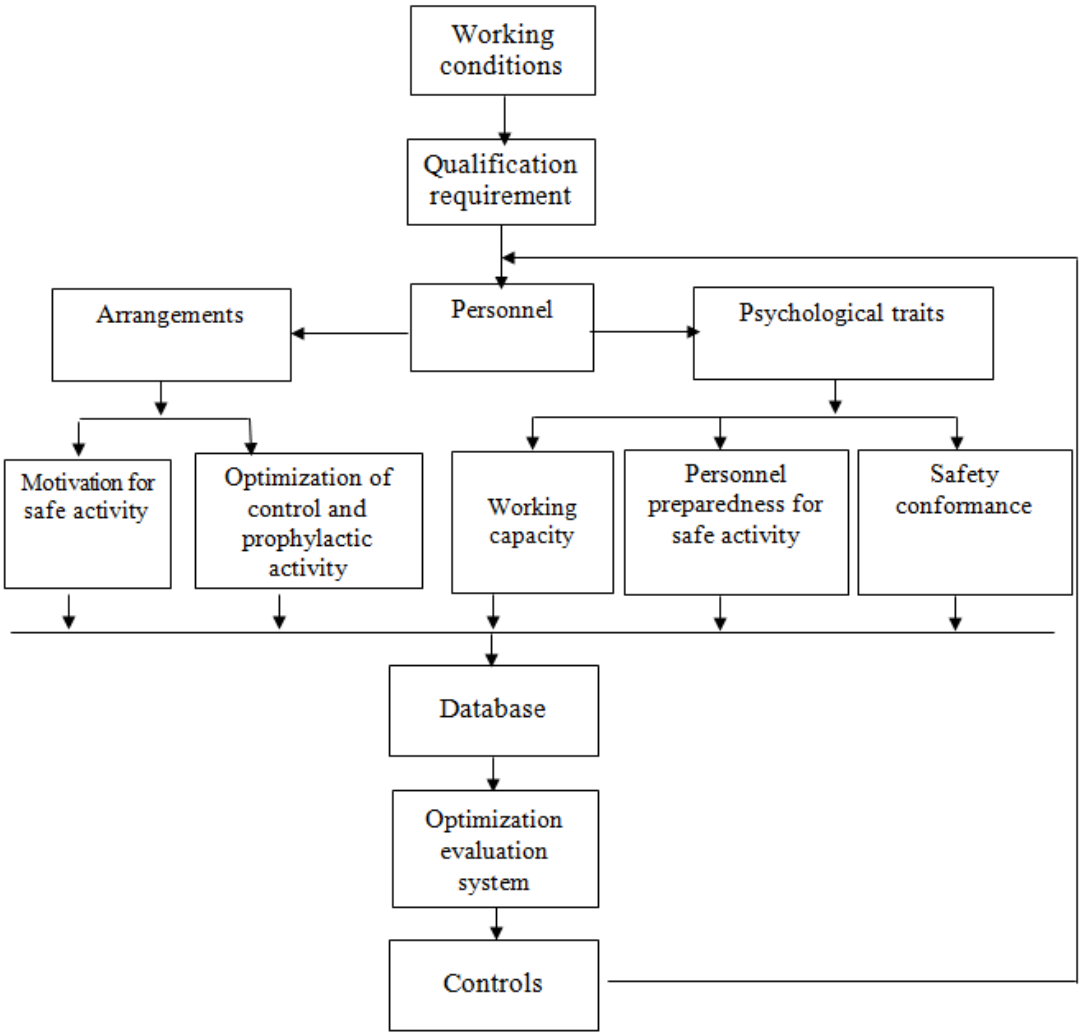

Figure 1 - The model for determining and optimizing the integrative factor of the personnel wrong actions occurrence probability

The main regularities of the accidents and incidents causes can be formulated as follows [2]:

- accident risks and injuries during production and technological processes (with an acceptable level of confidence) can be interpreted as a set of random event streams, the number of which at limited time intervals is distributed according to Poisson's law;

- each specific incident or occupational disease are, as a rule, a consequence of not an individual cause, but the result of initiation and progression of a background causal chain;

- the initiators of incidents causal chains are human faults due to their insufficient professional development for work with equipment that is characterized by constructive imperfection and potentially dangerous technology of its use, or failure of technological equipment caused by its own low reliability, as well as resulting from employees wrong actions or off-design or unexpected effects on people and equipment from the outside.

These ideas about the laws, conditions and causes of the accidents occurrence mainly coincide with other known results both in the composition and relative importance of the accidents factors, injuries and occupational diseases taken into account, and on the fundamental conditions for the appearance of events and phenomena as a whole. Perhaps, the prevalent role of the so-termed human factor in the formation of initial conditions and primary background is already generally recognized. Its proportion varies, according to various sources, from 60-70% [3,4,5].

Thus, the main task is reducing the number of human faults. This is especially important when personnel have deal with transportation of various types of energy resources, because the consequence of incidents in this case is fraught with considerable moral and material damage.

When developing measures for elimination of personnel wrong actions, it is necessary to determine what way they influence, develop a comprehensive factor and create a model for selecting the most effective measures.

The model for determining and optimizing the integrative factor of the personnel wrong actions occurrence probability is shown in Fig. 1.

The general scheme for analyzing the information obtained as a result of the analysis of the model concerning the integral evaluation of psycho physiological and organizational factors can be represented in the solution curve form (2) [6].

- at the point to the solution curve, there is an estimate of the current state $x\ (k)$ and the covariance error matrix of this estimate $K + x\ (k)$ (estimation uncertainty);
- at the point $k + 1$, a measurement of z is made, which is connected by a functional vector equation with the phase state of the system;
- according to the measurements, an estimate of the new (refined) state $x\ (k + 1)$, a new covariance matrix of the state errors $K^{+}{}_{x}(k+1)$; If the system passes from one state to another with some uncertainty, then this scheme must take into account the growth of uncertainty, then this scheme must take into account the growth of uncertainty in the transition from one state to another.);

Taking into account that the system can be subject to the action of random perturbations, in order to conclude on the values of the characteristics estimates, the number of measurements may not be sufficient. Therefore, it is necessary to provide useful information in the presence of interference.

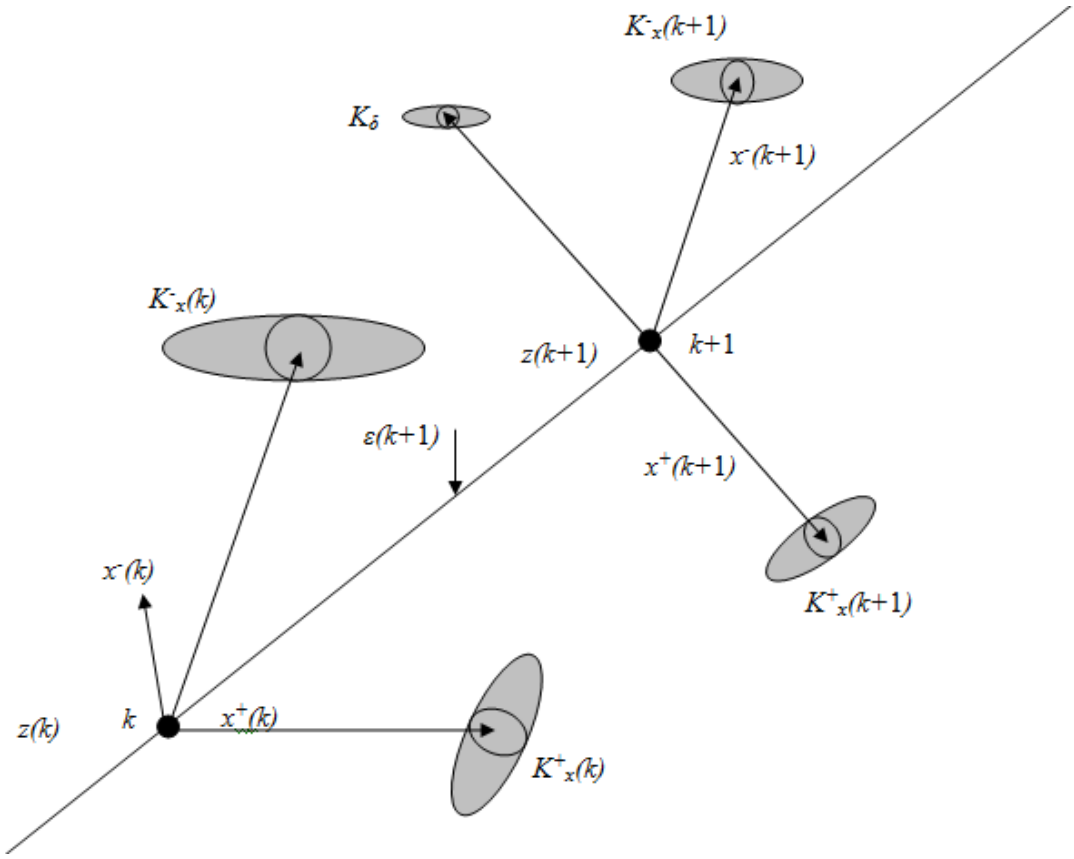

Figure 2 - Solution curve for integral evaluation process of a analysis result of psycho physiological and organizational factors

In this case, the set of characteristics (variables) is divided into two groups, are essentially different in that one group quickly ("fast" variables) lends itself to a purposeful influence (control) to change their values, and the impact on another group ("slow" variables) is ineffective or rather weak (Figure 3) [6].

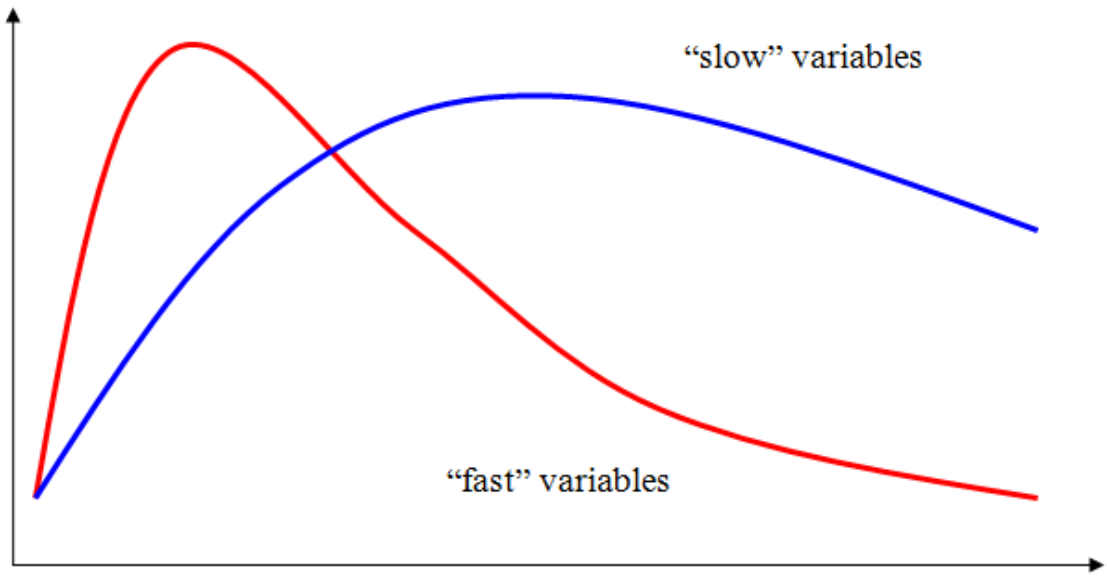

Figure 3 - State variables time-varying behavior

In its turn, the group of "fast" variables is divided into two subgroups: a subgroup of rapidly recoverable variables (RRV1) and a subgroup of slowly recoverable variables (SRV) (Fig. 4)

Subgroups of variables are divided into active and passive. Active qualities can be changed (improved) as a result of control actions. Passive qualities are slowly achieved as a result of control actions.

There is the possibility of an indirect effect on passive variables through exposure to active ones using classical methods (expert appraisal, factor analysis or correlation analysis, etc.). At the initial stage of system analysis, it is necessary to make both external and internal expert appraisals.

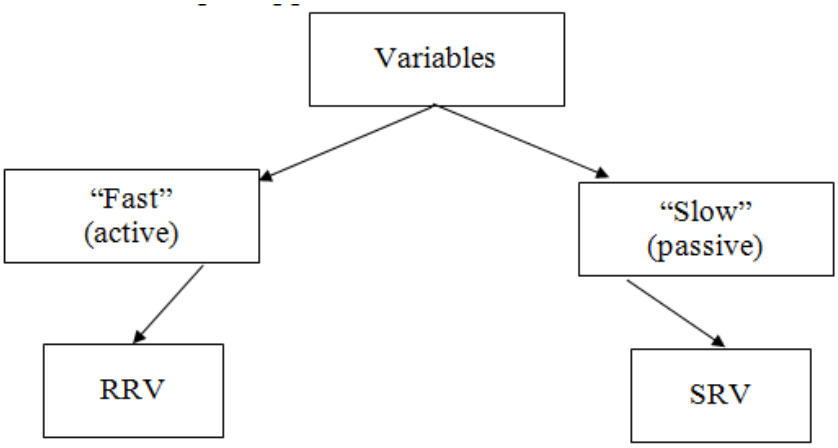

Figure 4 - State variables structure

The estimation and state vector-matrix equation can be written as follow:

$$\begin{gathered} x(k+1)=A(k,k+1)x(k)+B(k,k+1)y(k)+L_1(k,k+1)u(k)- \\ S_1(k,k+1)v(k)+\varepsilon(k+1), \\ y(k+1)=C(k,k+1)x(k)+D(k,k+1)y(k)+L_2(k,k+1)u(k)- \\ S_2(k,k+1)v(k)+\omega(k+1), \\ z(k+1)=H(k+1)x(k+1)+J(k+1)y(k+1)+\delta, \end{gathered} \tag{1}$$

where $[k,k+1]$– time interval ($k = 1,2,3,...,N$);
x– column vector of order (n*1) of the "fast" system state variables;
y– column vector of order (m*1) of the "slow" system state variables;
u– column vector of order (p*1) of the controls;
v– column vector of order (g*l)of the control results;
A–matrix of order (n*n) of the state rate;
B–matrix of order (n*m) of the state rate;
C–matrix of order (m*n) of the state rate;
D–matrix of order (m*m) of the state rate;
L_1, L_2– matrixes of order (n*p), (m*p) of the controls influence rate;

S_1, S_2– matrixes of order (n*g), (m*g) of the system change rate;
ε, ω, δ– column vectors of order (n*l). (m*l). (j*l) of additive random effects.

We introduce the following notation for the components of the vector variables (in points).

System state:

x – ("fast" state variables):
- x_1 – control optimization system;
- x_2 – labor routine and rest optimization;
- x_3 – professional selection system;

y – ("slow" state variables):
y_1 – system of personnel safe activity training;
y_2 – system of professional qualities education;
y_3 – system of personnel motivation for safe activity;

z – measurement:
- z_1 – level of training for safe activity;
- z_2 –level of professional qualities;
- z_3 –personnel performance status;
- z_4 –control level;
- z_5 –personnel motivation state for safe activity;

u – controls:
- u_1 –personnel training for safe activity;
- u_2 –professional qualities level increase;
- u_3 –performance status level increase;
- u_4 –control optimization;
- u_5 – level of motivation for safe activity;

v –personnel psychological and executive traits changes:
- v_1 –traits monitoring;
- v_2 – subjective attributes.

The model (1) advantage is the "fast" and "slow" variables separation, because there is an opportunity to explore their mutual influence.

We assume that the random process characterized by the model (1) is Markovian

$$f(x_i / x_{i-1}, x_{i-2}, \ldots, x_1) = f(x_i), \tag{2}$$

where $f(x_i)$ –probability density function.

Assume that there is a priori information in the known numerical characteristics form.

$$M(\varepsilon)=0,\ M(\omega)=0,\ M(\delta)=0; \tag{3}$$
$$M(\varepsilon\varepsilon')=K_\varepsilon(k),\ M(\omega\omega')=K_\omega(k),\ M(\delta\delta')=K_\delta(k),$$

where $K_\varepsilon(k)$, $K_\omega(k)$, $K_\delta(k)$– positive definite covariance matrix of order(n*n), (m*m), (j*j).

At the k-th step there is an system state vectors estimate $x^-(k), y^-(k)$ with positive definite covariance error matrix

$$K_x(k)=M\{[x(k)-x^-(k)][x(k)-x^-(k)]'\};$$
$$K_y(k)=M\{[y(k)-y^-(k)][y(k)-y^-(k)]'\}; \quad (4$$
$$K_{xy}(k)=M\{[x(k)-x^-(k)][y(k)-y^-(k)]'\}$$

of order $(n*n)$, $(m*m)$, $(n*m)$.

Taking into account (2), (3), (4) and the statistical expectation properties, we can write

$$x^-(k+1)=A(k,k+1)x^+(k)+B(k,k+1)y^+(k)+L_1(k,k+1)u(k)-S_1(k,k+1)v(k);$$
$$y^-(k+1)=C(k,k+1)x^+(k)+D(k,k+1)y^+(k)+L_2(k,k+1)u(k)-S_2(k,k+1)v(k). \quad (5)$$

The problem consists in finding new system state vectors estimates $x^+(k+1)$, $y^+(k+1)$ taking into account the measurements $z(k+1)$ and in determination of covariance errors matrices of new estimates, their mutual covariance matrix with a priori measurement errors information and covariance error matrices of old estimates at the time point k.

The model allows not only evaluating the system but also optimizing it. For example, if optimization criterion A is the criterion for a minimum sum of covariance error matrices traces for evaluating the new system state in the form of old estimates linear combinations and a centered measurement vector

$$x^+(k+1)= x^-(k+1)+F(k+1)[z(k+1)-M(z)];$$
$$y^+(k+1)= y^-(k+1)+G(k+1)[z(k+1)-M(z)], \quad (6)$$

where F, G – unknown gain matrixes of order $(n*n)$, $(m*m)$.

The choice of (6) in the linear operators form is justified by the fact that for the normal measurement errors distributive law it is optimal one.

Taking (1) into account, we obtain

$$M(z)=H(k+1)x^-(k+1)+J(k+1)y^-(k+1). \quad (7)$$

Subtracting the true system state vectors values from both sides of the vector equations (7), we have

$$\varepsilon^+(k+1)=\varepsilon^-(k+1)+F(k+1)[\delta(k+1)-H(k+1)\varepsilon^-(k+1)-$$
$$-J(k+1)\omega^-(k+1)]; \quad (8)$$
$$\omega^+(k+1)= \omega^-(k+1)+J(k+1)[\delta(k+1)-H(k+1)\varepsilon^-(k+1)-$$

$$-J(k+1)\omega^{-}(k+1)],$$

where

$$\varepsilon^{+}(k+1)=x^{+}(k+1)-x(k+1),\ \varepsilon^{-}(k+1)=x^{-}(k+1)-x(k+1;,$$
$$\omega^{+}(k+1)=y^{+}(k+1)-y(k+1),\ \omega^{-}(k+1)=y^{-}(k+1)-y(k+1). \tag{9}$$

Multiplying (8) by the result of its transposition after some transformations, taking into account (3), (4) we obtain

$$K^{+}_{x}(k+1)=M[\varepsilon^{+}(k+1)\ \varepsilon^{+\prime}(k+1)]= K^{-}_{x}(k+1)+$$
$$+F(k+1)K_{\delta}(k+1)F'(k+1)-K^{-}_{x}(k+1)H'(k+1)F'(k+1)-$$
$$-K^{-}_{\varepsilon\omega}(k+1)J'(k+1)F'(k+1)-F(k+1)H(k+1)K^{-}_{x}(k+1)-$$
$$-F(k+1)J(k+1)K^{-}_{\varepsilon\omega}(k+1)+F(k+1)H(k+1)K^{-}_{x}(k+1)J'(k+1)F'(k+1)+$$
$$+F(k+1)J(k+1)K^{-}_{\varepsilon\omega}(k+1)J'(k+1)F'(k+1),$$

$$K^{+}_{y}(k+1)=M[\omega^{+}(k+1)\ \omega^{+\prime}(k+1)]= K^{-}_{y}(k+1)+ \tag{10}$$
$$+G(k+1)K_{\delta}(k+1)G'(k+1)-K^{-}_{y}(k+1)H'(k+1)G'(k+1)-$$
$$-K^{-}_{\varepsilon\omega}(k+1)J'(k+1)G'(k+1)-G(k+1)H(k+1)K^{-}_{y}(k+1)-$$
$$-G(k+1)J(k+1)K^{-}_{\varepsilon\omega}(k+1)+G(k+1)H(k+1)K^{-}_{y}(k+1)H'(k+1)G'(k+1)+$$
$$+G(k+1)J(k+1)K^{-}_{\varepsilon\omega}(k+1)J'(k+1)G'(k+1).$$

Necessary and sufficient conditions for the optimization criterion A minimum

$$TrK=TrK^{+}_{x}(k+1)+TrK^{+}_{y}(k+1)$$

have the form

$$dTrK/dF(k+1)=F(k+1)[K_{\delta}+H(k+1)K^{-}_{x}(k+1)H'(k+1)+$$
$$+J(k+1)K^{-}_{\varepsilon\omega}(k+1)H'(k+1)+H(k+1)K^{-}_{\varepsilon\omega}(k+1)J'(k+1)+$$
$$+J(k+1)K^{-}_{x}(k+1)J'(k+1)]-K^{-}_{x}(k+1)H'(k+1)-$$
$$-K^{-}_{\varepsilon\omega}(k+1)J'(k+1)=0;$$

$$dTrK/dG(k+1)=G(k+1)[K_{\delta}+J(k+1)K^{-}_{y}(k+1)J'(k+1)+$$
$$+H(k+1)K^{-}_{\varepsilon\omega}(k+1)J'(k+1)+J(k+1)K^{-}_{\varepsilon\omega}(k+1)H'(k+1)+ \tag{11}$$
$$+H(k+1)K^{-}_{y}(k+1)H'(k+1)]-K^{-}_{y}(k+1)J'(k+1)-$$
$$-K^{-}_{\varepsilon\omega}(k+1)H'(k+1)=0;$$

$$d^{2}TrK/dF^{2}(k+1)=K_{\delta}+H(k+1)K^{-}_{x}(k+1)H'(k+1)+$$
$$+J(k+1)K^{-}_{\varepsilon\omega}(k+1)H'(k+1)+H(k+1)K^{-}_{\varepsilon\omega}(k+1)J'(k+1)+$$
$$+J(k+1)K^{-}_{x}(k+1)J'(k+1)>0;$$
$$d^{2}TrK/dF^{2}(k+1)*d^{2}TrK/dG^{2}(k+1)-\{ d^{2}TrK/dG(k+1)*dF(k+1)\}^{2}=$$

$$=[K_\delta+H(k+1)K^-_x(k+1)H'(k+1)+J(k+1)K^-_{\varepsilon\omega}(k+1)H'(k+1)+$$
$$+H(k+1)K^-_{\varepsilon\omega}(k+1)J'(k+1)+J(k+1)K^-_x(k+1)J'(k+1)]*[K_\delta+$$
$$+J(k+1)K^-_y(k+1)J'(k+1)+H(k+1)K^-_{\varepsilon\omega}(k+1)J'(k+1)+$$
$$+J(k+1)K^-_{\varepsilon\omega}(k+1)H'(k+1)+H(k+1)K^-_y(k+1)H'(k+1)]>0.$$

The optimization criterion is minimized by choosing the gain matrixes in the form:

$$F_{\text{opt}}(k+1)=[K^-_x(k+1)H'(k+1)+K^-_{\varepsilon\omega}(k+1)J'(k+1)]\ [K_\delta+$$
$$+H(k+1)K^-_x(k+1)H'(k+1)+J(k+1)K^-_{\varepsilon\omega}(k+1)H'(k+1)+$$
$$+H(k+1)K^-_{\varepsilon\omega}(k+1)J'(k+1)+J(k+1)K^-_x(k+1)J'(k+1)]^{-1};$$

(12)

$$G_{\text{opt}}(k+1)=)=[K^-_y(k+1)J'(k+1)+K^-_{\varepsilon\omega}(k+1)H'(k+1)]\ )]\ [K_\delta+$$
$$+J(k+1)K^-_y(k+1)J'(k+1)+H(k+1)K^-_{\varepsilon\omega}(k+1)J'(k+1)+$$
$$+J(k+1)K^-_{\varepsilon\omega}(k+1)H'(k+1)+H(k+1)K^-_y(k+1)H'(k+1)]^{-1}.$$

Substituting (12) into (10), we can obtain the expressions for $K^+_x(k+1)_{\min}$ and $K^+_y(k+1)_{\min}$.

As a result, we have a dynamic mathematical recursive A-optimal optimization model:

$$x^-(k+1)=A(k,k+1)x^+(k)+B(k,k+1)y^+(k)+L_1(k,k+1)u(k)-S_1(k,k+1)v(k);$$

$$y^-(k+1)=C(k,k+1)x^+(k)+D(k,k+1)y^+(k)+L_2(k,k+1)u(k)-S_2(k,k+1)v(k);$$

$$K^+_x(k+1)=M[\varepsilon^+(k+1)\ \varepsilon^{+\prime}(k+1)]= K^-_x(k+1)+$$
$$+F(k+1)K_\delta(k+1)F'(k+1)-K^-_x(k+1)H'(k+1)F'(k+1)-$$
$$-K^-_{\varepsilon\omega}(k+1)J'(k+1)F'(k+1)-F(k+1)H(k+1)K^-_x(k+1)-$$
$$-F(k+1)J(k+1)K^-_{\varepsilon\omega}(k+1)+F(k+1)H(k+1)K^-_x(k+1)J'(k+1)F'(k+1)+$$
$$+F(k+1)J(k+1)K^-_{\varepsilon\omega}(k+1)J'(k+1)F'(k+1);$$
$$K^+_y(k+1)=M[\omega^+(k+1)\ \omega^{+\prime}(k+1)]= K^-_y(k+1)+$$
$$+G(k+1)K_\delta(k+1)G'(k+1)-K^-_y(k+1)H'(k+1)G'(k+1)-$$
$$-K^-_{\varepsilon\omega}(k+1)J'(k+1)G'(k+1)-G(k+1)H(k+1)K^-_y(k+1)-$$
$$-G(k+1)J(k+1)K^-_{\varepsilon\omega}(k+1)+G(k+1)H(k+1)K^-_y(k+1)H'(k+1)G'(k+1)+$$
$$+G(k+1)J(k+1)K^-_{\varepsilon\omega}(k+1)J'(k+1)G'(k+1);$$

$$F_{\text{opt}}(k+1)=[K^-_x(k+1)H'(k+1)+K^-_{\varepsilon\omega}(k+1)J'(k+1)]\ [K_\delta+$$
$$+H(k+1)K^-_x(k+1)H'(k+1)+J(k+1)K^-_{\varepsilon\omega}(k+1)H'(k+1)+$$
$$+H(k+1)K^-_{\varepsilon\omega}(k+1)J'(k+1)+J(k+1)K^-_x(k+1)J'(k+1)]^{-1};$$

$$G_{opt}(k+1)=)=[K^{-}_{y}(k+1)J'(k+1)+K^{-}_{\varepsilon\omega}(k+1)H'(k+1)])] [K_{\delta}+$$
$$+J(k+1)K^{-}_{y}(k+1)J'(k+1)+H(k+1)K^{-}_{\varepsilon\omega}(k+1)J'(k+1)+$$
$$+J(k+1)K^{-}_{\varepsilon\omega}(k+1)H'(k+1)+H(k+1)K^{-}_{y}(k+1)H'(k+1)]^{-1}.$$

Due to the computational procedures complexity, the model requires the implementation machine not only to perform optimization calculations, but also to store and generalize statistical data.

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DANDELION OF DANGERS - GRAPHIC IMAGE OF COMPLEX OF DANGERS

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ABSTRACT

The article presents the results of a detailed analysis of the use of graphical constructions for depicting dangers. The author provides results of analysis the use of color, shape, size of images to describe the various characteristics of dangers. Various variants of the graphic representation of dangers are offered in complexity and content. Graphical representation of the complex dangers to the object of security called "Dandelion of dangers" is proposed. The intensity of the color of the hazard corresponds to the probability of this hazard. Thus, the "Dandelion of dangers" includes the five most important characteristics of danger. The scope of the graphic representation of hazards is not limited to technology. Such a view can be successfully used to assess economic, social, and biological dangers for technical facilities, natural complexes, individuals, social groups, states.

Key words: danger, risk, graphic image, security object

1. INTRODUCTION

Different symbols of danger and safety people have used since ancient times. For example, in ancient Rome, the personification of security was Securitas. The most famous symbol of danger and death is the pirate flag "Jolly Roger" – a skull with crossbones on a black background. The development of production and transport has contributed to an increase in the number of different generally accepted symbols of danger and security. Particular mention should be made of transport, where the basis of traffic rules are various signs and markings. Symbols

of safety of labor, hazardous biological substances, radiation, marking of dangerous goods, etc., have become universally accepted. In practice, the hazard indicators of various colors are widely used, allowing you to visually monitor the parameters of technical processes. Special marking is applied to dangerous parts of mechanisms and structures to improve the safety of people.

Diagrams and graphs are widely used in the theory and practice of forecasting, monitoring hazards, as well as in the development of measures to prevent exposure to hazards. It is in this area that the use of various symbols and constructions is not sufficiently developed. The wide use of danger symbols makes it easier to systematically study them, allows you to visually assess the degree of danger and take priority measures, which means optimizing resources to prevent hazards and reduce their impact on the site.

2. CHARACTERISTICS OF DANGERS

The purpose of the graphic representation of hazards is a reasonable and logically understandable display of these or other hazard characteristics. Classification and characterization of hazards is based on hazard identification. Danger is the possibility of the emergence of circumstances in which matter, field, energy, information or a combination thereof can thus affect a complex system (security object), which will lead to the deterioration or inability of its functioning and development [1]. In this article, the notion of danger is widely used, although the majority of graphical constructions can be attributed to the characterization of risk as to the quantitative expression of the hazard.

Any danger is characterized by a number of parameters, in particular:

- Probability of manifestation.
- Time of manifestation.
- The duration of the negative impact.
- Intensity of action.
- Variability of the intensity of the negative impact.
- The magnitude of the consequences.

In addition, the hazards are classified by:

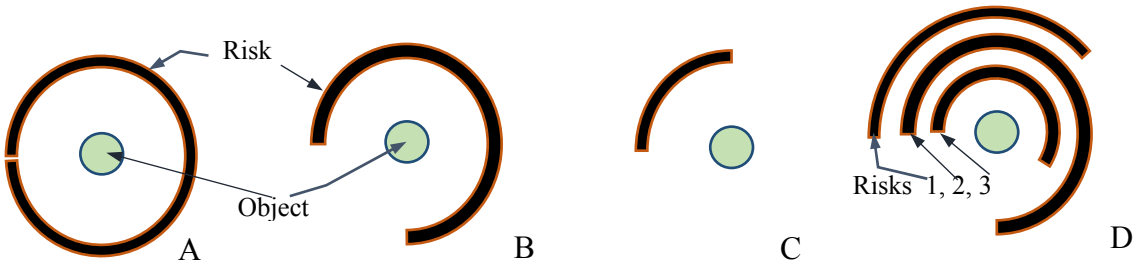
- Genesis.
- Structure.
- The sphere of manifestation.
- Localization.
- Nature of the action per person or objects [2].

To solve tasks to ensure the security of the facility (in this context, a person, process, phenomenon or any complex system can be a security object), one or several characteristics of danger or several hazards can be graphically represented.

3. GRAPHICAL REPRESENTATION OF THE PROBABILITY OF MANIFESTATION OF DANGER

In the first place, characterizing this or that danger, determine the probability of its occurrence. This allows you to identify hazards that can be neglected. The dangers that have a low probability can be paid less attention, and the dangers that are more likely to manifest should be paid more attention. Graphically, the probability of danger manifestation can be represented in the form of a ring, with the condition that the complete ring corresponds to 1 or 100% of the probability of this risk for the object, respectively, partial semi-rings will characterize a greater or lesser probability of hazard manifestation (Figure 1).

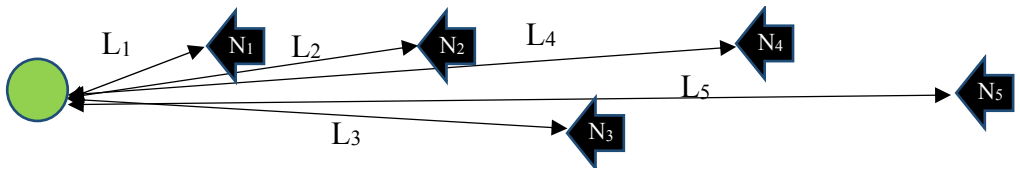
The graphical image presented at Figure 1 D allows you visually assess the likelihood of various hazards for the object in question. To assess the likelihood of occurrence of these or other hazards, other types of graphic images may be used, with different scales in a circular columnar, linear or other form.



A - probability of risk is 0.99, B - risk probability 0.75, C - probability of risk - 0.25, D - probability images of several risks (1, 2, 3) for the considered object
Source: own development

Figure 1 - Graphical representation of the probability of occurrence of danger (risk) in the form of semi-rings

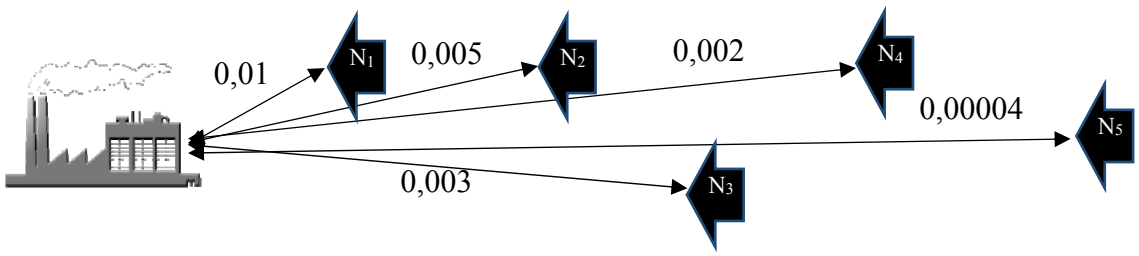
The probability of danger occurrence (risk) can be represented as a conventional distance to the graphic image of the security object in Fig. 2. According to the principle: "The probability of danger is less, the further the graphic image of the danger from the object". Thus, to denote the probability of danger occurrence, we use the distance Ln from the hazard image Nn to the image of the security object. In graphic images, the distance Ln can be represented on a certain scale, corresponding to the probability value. For simplified schemes, the relative correlation of the distance Ln with the probability of danger occurrence will be sufficient.



N_1-N_5 – dangers, L_1-L_5 probability of their manifestation. *Source: own development.*

Figure 2 - Graphical representation of the probability of occurrence of a hazard (risk) in the form of a relative distance to the security object

To improve the informative value of the hazard probability scheme, one can use the signatures of probability on the corresponding lines (Fig. 3).



N_1-N_5 – The probability of manifestations of hazards is indicated in the form of signatures. *Source: own development.*

Figure 3 - Graphical representation of the probability of occurrence of a hazard (risk) in the form of a proportional distance to the security object (enterprise)

The representation of the probability of danger in the form of a distance to the object is visual and can be used to demonstrate a large number of different hazards. In electronic data mapping systems, it is possible to make a dynamic model of the probability of manifestation of various hazards for the object under consideration. This graphical construction is the simplest and is characterized by only one indicator of danger.

For the visualization of the probability of manifestation of danger, it is of interest to use the color gamut.

Color is widely used to refer to danger and safety. In Ukrainian legislation, the use of color is regulated by the National Standard of Ukraine ISO 3864-1: 2002, IDT; DSTU ISO 3864-1: 2005 Graphic symbols. Colors and safety signs.

According to the above-mentioned documents, the following are the signal colors for safety: red - immediate danger, yellow - possible danger, green - safety and blue - prescription in order to avoid danger. Red color, in particular, is used for

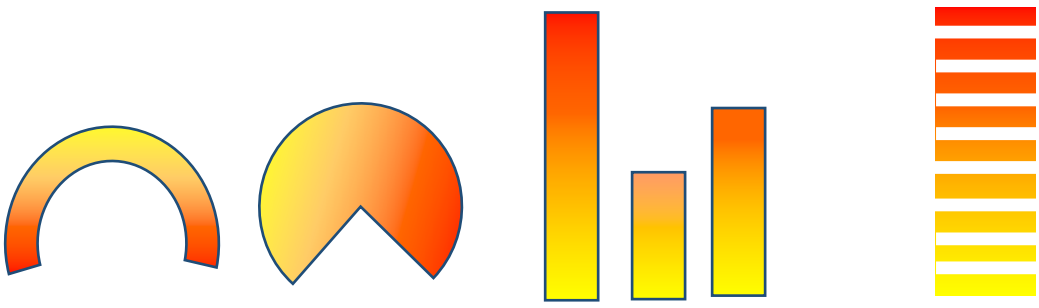
signal lamps and a scoreboard with information notifying of a violation of the technological process or violation of safety conditions: "Alarm", "Fault", etc. Yellow color provides for the need for increased attention [3]. To enhance the visual perception of color images of safety signs and signal markings, signal colors are used in combination with contrasting colors - white or black.

a. Tachometer b. Electronic speedometer c. Speedometer d. Manometer

Sources of photos and drawings:
Fig. a: http://uaz-upi.com/ru/price?page=4&selectors%5Bcomdity%5D=1110
Fig. b: https://play.google.com/store/apps/details?id=com.joynow.ecodrivefree
Fig. c: https://tapfame.com/app/com.appaspect.speedometer/speedometer/
Fig. d: http://vkabare. =433

Figure 4 - The use of color to indicate safe work and risk in the instruments

The color gamut is rarely used to quantify the danger. As a rule, various shades of yellow and red colors are used for this purpose in various indicators and sensors. In Fig. 4 shows examples of the use of green, red and yellow colors in various switch mechanical and electronic sensors: a tachometer, a speedometer, a manometer.



a. Ring b. Circular c. Column solid d. Column discrete

Source: own development.

Figure 5 - Variants of use of a color scale for characterizing the magnitude of risk

In sensors and indicators with mechanical arrows, it is most convenient to use a colored background. The most common arrow sensors with a color background found in the control systems of the elements of rotation (tachometer, speedometer, etc.), for monitoring systems that are under pressure (pressure gauge), as well as in temperature control systems.

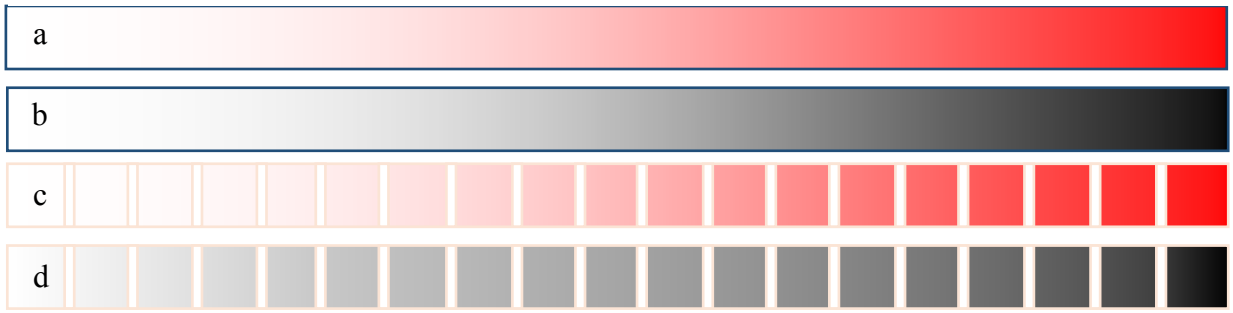
The development of electronics allows not only to create an image in the form of arrow sensors on a certain background (see Figure 4. b. "Electronic speedometer"), but also to use color, as well as its intensity in the form of circular, sector, rectangular indicators, some variants of such display are shown in electronic means of information display.

Using the color gamut allows you to expand the possibilities of graphical display of various hazard characteristics. Color can be used to display the probability of danger, as well as to display the duration of the negative impact, the magnitude of the consequences of the manifestation of the hazard, the intensity of the negative impact.

Instead of using the color gamut, you can use the color intensity to graphically display one or another hazard characteristic (Figure 6).

A more intense color will correspond to a greater value of this or that hazard characteristic. For such constructions, it is best to use red color (color of attention and excitation) or black color (the color of all negative).

The use of colors and their shades in the graphic representation of hazards is limited by the physiology of man. In particular, people do not have the ability to evaluate the absolute values of external stimuli. Despite a number of limitations imposed by the perception of color by a person, the use of color and intensity of coloring together with other elements allows us to graphically display a greater number of hazard characteristics, which increases the informative nature of the schemes and drawings.



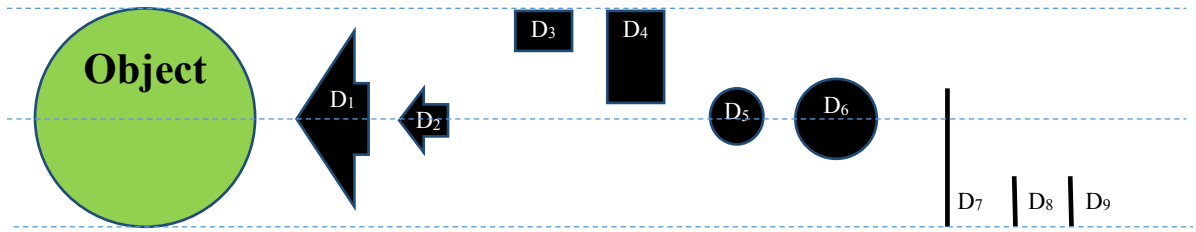
a. Solid with the use of red. b. Solid with black color. c. Discrete with the use of red color. d. Discrete with the use of black color. *Source: own development*.

Figure 6 - Use of color intensity to characterize the hazard

In addition to the probability of manifestation of the hazard and the time of manifestation of danger, it is important to include in the figure or chart the hazard figures. The magnitude of the danger implies a possible result of the negative impact that results from the manifestation of the hazard. To denote the magnitude of the negative consequences of danger, the term "damage" or its synonym, "loss" is most often used. Damage can be expressed in various ways and different indicators:

✓ Economic damage, expressed in financial terms.
✓ Physical damage - the number of damaged or destroyed elements of the security object.
✓ Residual workability of the object or system, expressed in points or%.
✓ Damage to the security agent expressed in points or other units.

Graphically, the damage is most expedient to express by the size of a schematic image of the hazard in the form of a circle, square, line or other figure that correlate with the size of the security object. Thus, the danger that can completely destroy the security object can be represented by a figure of the same size as the security object, and the dangers that can damage only a part of the elements of the security object are displayed proportionally to smaller figures



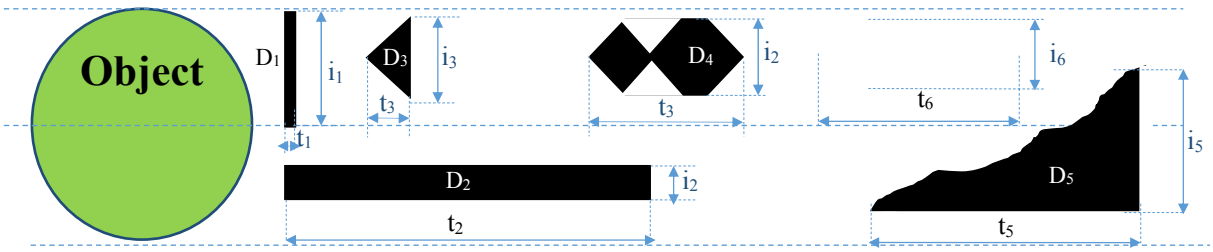
D_1-D_2 – the damage value is represented by arrows of different sizes, D_3-D_4. – rectangles, D_5-D_6 – circles, D_7-D_9 – lines. *Source: own development.*

(Figure 7).

Figure 7 - Graphical representation of damage (magnitude of danger) in the form of the relative size of the hazard image to the security object

Increase the information content of the graphic image of the hazard can be included by including the element of the duration of the likely negative impact. In Figure 8, the simplest versions of the hazard image are the rectangles D_1 and D_2 (Figure 8). Taking the height of the figure for the level of damage, the danger of D_1 will cause 50% damage to the security object. The time of action of this danger is small, as indicated by the small thickness of the schematic image of this hazard.

The figure denoting the danger of D_2 (Figure 8) in comparison with the figure denoting.



The amount of damage ($i_n \times t_n$) for the figures D_1–D_4 and D_6 corresponds to the area of the figure

Figure 8 - Graphical representation of the intensity of the impact (in) and the duration of the negative impact (t_n)

A more complex variant of interpreting the graphic image of the dangers D_1 and D_2 will be the introduction of the following characteristics: the height of the figures i_1 and i_2 corresponds to the average intensity of the negative impact on the object, the width of the figures t_1 and t_2 is the duration of the negative impact on the object, therefore, the area of the figure will be equal to the overall negative effect - damage (equation 1).

$$\text{Damage}_n = i_n \times t_n \quad (1)$$

where: $\mathbf{i_n}$ is the intensity of the negative impact on the object for the nth hazard, $\mathbf{t_n}$ is the duration of the negative impact on the object for the **n**-th hazard.

In this interpretation, the danger of D_1 will correspond to a short-term intensive negative impact, with little damage (for example, a blow), whereas the D_2 danger will correspond to a long-term medium intensity effect that will cause significant damage (for example, a storm). Increase the information content of the graphical representation of hazards by using more accurate time characteristics of the intensity of the negative impact instead of the average negative impact indicator.

The figures denoting the hazards of D_3 and D_4 characterize the intensity of the negative impact in accordance with the exposure time. The intensity of the hazard, indicated by the figure D_3, increases from the minimum value at the beginning and reaches a maximum (i_3) at the end of its action. The danger indicated by the figure D_4 has a more complex intensity structure, it will increase from the minimum value to the maximum (i_4), then the intensity decreases to a small value, and then again increases to the maximum. The maximum impact lasts a while, then decreases in an arithmetic progression to zero. It should be noted that the intensity of increase and decrease of exposure for hazards D_3 and D_4 corresponds to the trend, and not to the exact values. If you have all the necessary data, you can build a figure of danger with the exact values of the negative impact or damage at a certain point in time. The danger shown in figure D_5 shows the increase in damage as a function of the time of exposure (incremental damage). Accordingly, i_5 (maximum height of figure D_5) corresponds to the maximum damage from the given impact, which can be expressed in absolute values or % to total damage.

The height of the figure D_5 would correspond to the total damage similar in height to the figure of the security object.

Fig. 9. Graphical representation of 11 hazards for the object.

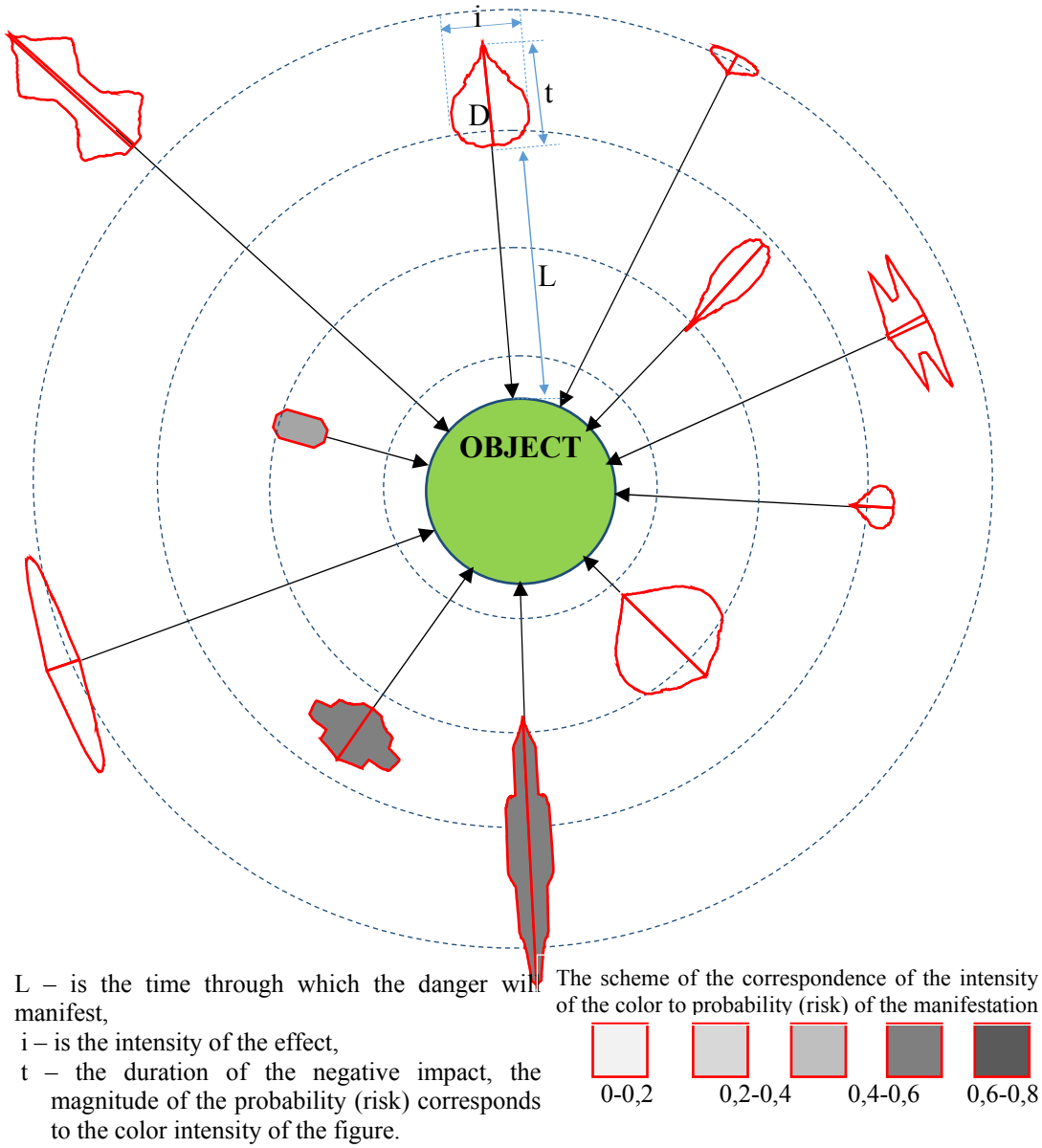


Figure 9 - Dandelion of hazards

The danger, depicted by the figure D_6, characterizes the intensity of the negative impact in exact accordance with the time. The height of the figure (i_6) corresponds to the maximum intensity of the impact, which can be expressed in balls, %, or other units. The negative impact time is indicated by t_6. The area of figure D_6 will correspond to the total damage from the negative impact.

To model the n-th number of hazards for an object, you can apply a construction called the "dandelion of hazards" by the author (Fig. 9).

This type of construction allows you to include a large number of hazards and their characteristics. Let's take a closer look at figure 9. The distance (L) from the object to the figure symbolizing the danger (D) corresponds to the waiting time for the danger. The length of the hazard figure (t) corresponds to the negative impact time, and the section width of the figure (i) corresponds to the intensity of the hazard exposure in accordance with the time. The area of the hazard figure will correspond to the magnitude of the damage. The intensity of the color of the hazard corresponds to the probability of this hazard. Thus, the "dandelion of dangers" includes the five most important characteristics of danger.

CONCLUSIONS

The use of a graphic depiction of hazards makes it possible to visualize a number of their characteristics, which can be used in safety theory and practice - when choosing a strategy and tactics for preventing and protecting hazards. Graphical constructions allow you to make quick decisions without the need for complex calculations and detailed graphs. The use of electronic means allows the creation of dynamic hazard constructs that allow monitoring the emergence of new hazards, as well as changes in the main characteristics of existing hazards.

The scope of the graphic representation of hazards is not limited to technology. Such a view can be successfully used to assess economic, social, and biological dangers for technical facilities, natural complexes, individuals, social groups, states.

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