Seventh International Environmental Congress
(Ninth International Scientific-Technical Conference)
"ECOLOGY AND LIFE PROTECTION
OF INDUSTRIAL-TRANSPORT COMPLEXES"
25-28 September, 2019 SAMARA-TOGLIATTI, RUSSIA

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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.

Scientific Redactor of Proceedings: Andrey V. Vasilyev, Doctor of Technical Science, Professor, Head of Department of Engineering Ecology and of Ecological Monitoring of Samara Federal Research Center of RAS, Head of Department of Chemical Technology and Industrial Ecology of Samara State Technical University, Russia

The proceedings are containing the papers of the authors from France, Italy, Russia, Vietnam, 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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CONGRESS TOPICS:

- Ecology;
- Life protection;
- Environmental monitoring;
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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 PROCEEDINGS

Main congress proceedings, proceedings of 6 volumes of congress symposia, proceedings of young scientists.
More than 250 abstracts and papers and more than 400 authors from Greece, France, Italy, Russia, Uzbekistan, Vietnam, Kazakhstan.
21 selected papers have been published in congress main proceedings after double blind review by the International Scientific Committee.
70 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, Vietnam etc.). ELPIT-2019 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 Federal Research Center, and Ministry of Science and Higher 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 21 papers of the authors from France, Italy, Russia, Vietnam, 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

SEVENTH INTERNATIONAL
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ENVIRONMENTAL SAFETY ISSUES DURING CONSTRUCTION ON LOESS SOILS IN THE AREA AFFECTED BY RESERVOIRS

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ABSTRACT

The likelihood of natural and man-made disasters has increased in recent years. A significant number of disasters are related to the properties of soils, which are the basis. It is shown that in the zone of influence of the Kuibyshev and Saratov reservoirs on the Volga River there is a rapid increase in the level of groundwater, which can lead to negative consequences in the case of using loess soils as the basis. In this paper the influence of waterlogging on loess soils in urban areas is studied. It is necessary to take into account the changes in the properties of loess soils when planning the use of the city territory in the conditions of modern growth of density and number of stores of urban development.

Keywords: environmental safety, natural and man-made disasters, loess soils, impact of reservoirs, undermining, subsidence

The explosive development of urbanized areas in Russia has led to an increase in the share of the urban population to 74%. At the same time, about 15% of the country's territory has an unsatisfactory ecological condition. In terms of area, it is larger than Western and Central Europe combined [1].

Natural and man-made disasters pose a serious threat to environmental safety. In recent years, the frequency, scale and destructiveness of such events have increased significantly.

The magnitude of damage caused by natural and man-made disasters often depends on the timeliness and accuracy of their prediction, the adoption of preventive protection measures, and the likelihood and intensity of their occurrence.

Catastrophic situations cause the greatest damage, as a rule, on the territory of cities, where the production is concentrated and the population density is high.

This is very important for the Volga region, which, due to the development of industry and agriculture, is one of the areas with very high environmental stress. A significant number of natural and man-made disasters are related to the properties of soils under structures.

Under the influence of various natural and man-made factors, exogenous geological processes (EGP) may become more active, which leads to adverse consequences and may pose a threat to human life and the existence of various economic objects. Such processes include subsidence, karst-suffosion (undermining), landslide, gully-erosion, abrasion, as well as waterlogging and swamping.

Sedimentation phenomena are characteristic of the areas of loess soils distribution. Lossy soils are widespread in the territory of the Russian Federation, occupying about 17% of the country's area. Large areas are also covered with loess in Central Asia, China, Kazakhstan, Belarus, Ukraine and other countries.

It is known that loess soils in the state of natural humidity are quite stable bases. However, when soaking the soil, such a unique property as subsidence is manifested. This feature should be taken into account when building industrial and civil facilities on loess soils. This is especially true for urbanized areas, in conditions of increased density of construction.

In the case of buildings erection on loess subsidence soils the choice of locations and development of rational solutions of the system "base-fundament" are important [2]. The cost and material intensity of the object, terms of its construction, as well as operational reliability depend on it. The most rational solutions of bases and foundations are achieved on the basis of joint consideration of regularities of subsidence development, peculiarities of ground conditions, structural features of buildings, their operation conditions, possible sources of soaking [3,4].

Thus, when large reservoirs are built in the surrounding areas, the level of underground waters increases significantly. The zone of influence of the reservoir can reach several kilometers. Such impact is most pronounced in the construction of reservoirs on flat rivers, to which the Volga River belongs. Long-term engineering-geological researches in Samara have shown that there is a change of properties of loess soils in a zone of influence of Kuibyshev and Saratov reservoirs on the river Volga which in case of the flooded territories can be shown in the form of subsidence [5].

The nature and degree of change in the basic construction properties of loess soils under the influence of natural and artificial reservoirs are also studied in the works [6, 7].

Stability and properties of loess soils are determined by their real and granulometric composition, as well as by their structural and texture structure.

To determine the material composition of soils, their macroscopic description and microscopic study are carried out [8]. The mineral composition of loess soils is dominated by silica (55-80 %) in the form of quartz or chalcedony; the cementing part is represented by aggregates of clay minerals (hydro-mica and

montmorillonite, less often kaolinite (15-30 %)); water-soluble minerals - carbonates, as well as gypsum, anhydrite, less often halite (5-15%) - can be found as impurities [9, 10].

As a rule, loess soils are dusty sandy loam and loam in terms of granulometric composition and plasticity.

In a state of natural humidity loess soils have high enough durability due to the presence of grouting bonds. Therefore, they can hold vertical slopes up to 10 m or more high. When dampening losses, the grouting bonds dissolve in them and their macroporous texture is destroyed.

Soaking loess soils reduces the volume of soil. Thus there is a decrease in durability of a ground, considerable and quickly developing deformations of consolidation [10,11]. As a result, there is an uneven subsidence of the day surface, deformation and destruction of buildings and structures located on it.

In addition, loess soils are characterized by undermining, i.e. mechanical removal of particles by moving groundwater. For example, on the territory of the coastal zone of the Kuibyshev reservoir in the Spassky district of the Republic of Tatarstan in 2016, during the survey of the shore in loess strata, undermining tunnels with a diameter of about 1 m were found (Fig. 1).

Figure 1 - Undermining tunnel in loess strata (photo by D.Vasilieva)

Problems of ecological safety during construction on loess soils is actual for the territory of Samara city, as here loess soils are widespread. The city is located on the watershed, the separating plateau and the floodplain terraces of the Volga and Samara rivers, occupies an area of 54.138 thousand hectares and stretches along the Volga river in a strip up to 20 km wide and 64 km wide [5]. Various geological processes (landslides, karst, undermining, erosion, subsidence, etc.) have their manifestations on the territory of the city, the activation of which can lead to dangerous situations.

On the territory of the city the lowest relief forms are the floodplain terraces of the Volga and Samara rivers. At creation of Saratov reservoir (in 1967-1968) the most part of low floodplain was flooded. The water level of the city of Samara has increased by 5.5 m compared to the inter-city level, while the area of islands and beaches has decreased.

The city of Samara is located on the left, eastern (or Volga) bank of the Volga River, which has a relatively low level of hyposometric, its absolute marks lie within 40-50 m. The geological structure of the city territory is rather heterogeneous, the most widespread in the upper part of the section are alluvial and deluvial sediments of the quaternary system. Their lithological composition is also heterogeneous and covered with sand, sandy loam, loam and clay.

Two types of soil conditions can be distinguished by their subsidence. In areas with the first type of subsidence at soaking under domestic load does not exceed 5 cm. In the areas with the second type of ground conditions, the drawdown at soaking under domestic load is 5 - 20 cm.

In the course of elaboration of the Master Plan for the development of Samara city (2004-2006), four main areas with sedimentary soils were identified: the first and second floodplain terraces of the Samara river (Bezymyanka district), the third floodplain terrace of the Volga river and the Samara watershed slope [5, 12].

Engineering and geological research in Samara allowed to identify additional areas of sedimentary soil distribution (in Leninsky, Oktyabrsky, Kirovsky, Krasnoglinsky districts), as on the terraces of the Volga River and the Krasnoglinsky River. Samara, as well as on the root slope. It should be noted that sinking loess soils in Samara are widespread and a significant part of deformations and destruction of structures in the city is associated with this phenomenon [5, 13].

For example, a site located on the second floodplain terrace of the Samara River, where part of the study area is occupied by sedimentary soils, was studied. These are mainly hard-semi-hard loams and hard-plastic sandy loam. The lower boundary of the sedimentary thickness, which was discovered during the research, varies from 3.0 m to 12.5 m. The most widespread soils are soils, the value of which relative contraction at the pressure of P=0,2-0,3 MPa is εsl=0.01 - 0,022 (the value of relative contraction εsl cf =0,01; initial drawdown pressure is 95 - 220 kPa). Basically, the ground conditions of type I subsidence are widespread.

Locally, there are areas with the spread of sedimentary soils, which have a relative contraction at loads P = 0.2 - 0.3 MPa equal to εsl = 0.01 - 0.044, the initial

drawdown pressure of which varies from 70 kPa to 210 kPa. According to the relative contractility, according to GOST 25100-2011, these soils are classified as extremely subsided. Ground conditions in terms of contraction are of type II (Table 1, Fig. 2).

Table 1

Values of relative planting capacity and initial planting pressure of soils

Depth	Relative pressure drawdown, MPa			Initial drawdown pressure, Psl, kPa
	0,1	0,2	0,3	
3,0-3,2	-	0,014	-	140
5,0-5,2	0,008	0,015	0,042	120
7,0-7,2	0,006	0,013	0,029	150
9,0-9,2	-	0,012	-	170
12,0-12,2	0,007	0,009	0,021	70
14,8-15,0	-	0,014	-	140

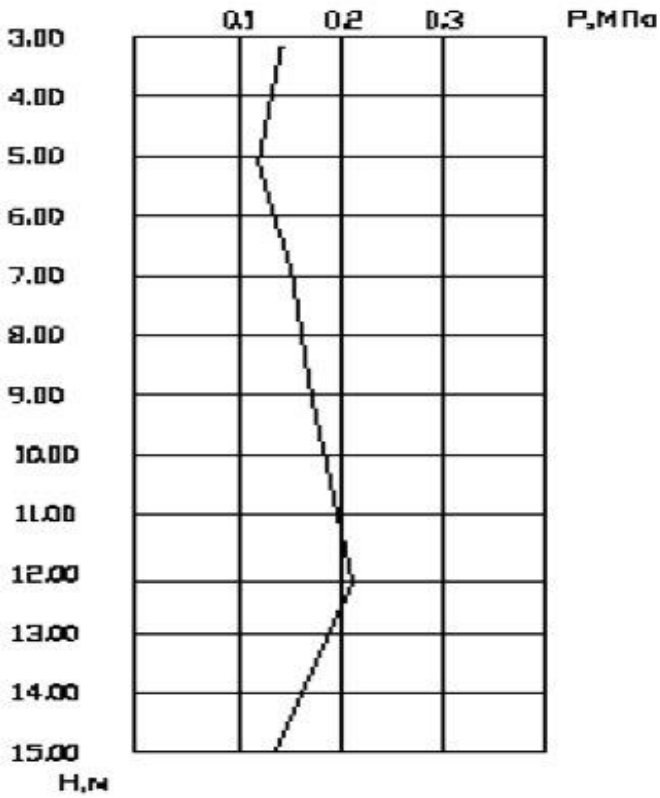

Figure 2 - Change in initial planting pressure with depth

As a result of the conducted research it has been revealed that under the influence of long-term increase of a level of ground waters there was a change of physical and mechanical properties of seeding loess soils: the index of fluidity of soils has changed from <0 - 0,25 to 0,25 - 0,50; porosity of soils has changed from 39,9 % - 50,9 % to 40 % - 31 %. Therefore, according to the classification of soils according to the yield strength index, their properties changed from solid to refractory. The natural moisture content of sandy loam and loam was 4 - 25%; subsequently it was 12 - 49%.

At construction and operation of structures at disturbance of a relief of a surface, removal of its waterproofing, at humidifying of sagging grounds by atmospheric precipitation or at technogenic soaking, there can be an uneven subsidence of a surface of the earth that will entail uneven deformations of a structure.

CONCLUSIONS

Thus, environmental safety issues are relevant for urban areas, where the majority of the country's population lives. Under the influence of the increase in the level of anthropogenic impact, compaction of buildings, increase in the number of engineering communications, etc., the activation of dangerous geological processes may occur. With the increase of groundwater level in the zone of influence of a large reservoir on the Volga River, there is an increase in the lower boundary of the sedimentary thickness distribution and a decrease in its capacity. For new construction this process can have a positive impact, but for the existing buildings and structures it is negative because of deterioration of physical and mechanical properties of soils due to increase of their humidity.

It is necessary to take into account the changes in the properties of loess soils when planning the use of the city territory in the conditions of modern growth of density and number of stores of urban development.

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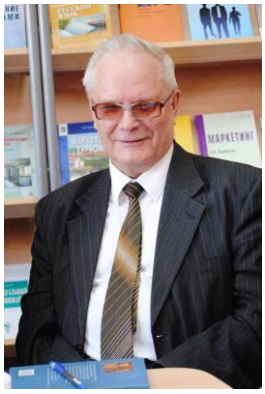
INFORMATION ABOUT THE AUTHORS



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Yuri Kholopov is the author and co-author of more than 100 scientific publications. He presented the main results of scientific research at international conferences in Moscow, St. Petersburg, Novosibirsk, Samara, Omsk, Yekaterinburg, Minsk, etc.

SEVENTH INTERNATIONAL
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EXPERIENCE OF ENVIRONMENTAL TRAINING IN THE TRANSPORT INDUSTRY

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ABSTRACT

Continuous environmental education is necessary to ensure sustainable development of socio-ecological and economic systems. In Samara State Transport University environmental education is based on the teaching of disciplines of environmental orientation, the organization of research activities of students, the implementation of youth social projects, training on the program "Ecologist in the field of railway transport", participation in competitions, international projects and publication activity. The implementation of the educational program "Ecologist in the field of railway transport" allows students and production workers to gain additional knowledge and a document on a new qualification.

Keywords: ecological education, ecological culture, youth social project, ecologist, railway transport

Environmental training of transport industry specialists is becoming an increasingly important issue every year. This is due to the growing environmental crisis and the complexity of technical devices and processes. Today it is necessary to assess the impact on the environment throughout the life cycle, change the paradigm of conquering nature to harmonize relations with it [1-4].

To ensure sustainable development of socio-ecological and economic systems, it is necessary to form not only professional competence, but also environmental culture [5-8]. Significant complexity of environmental activities due to the presence of objects of the past environmental damage [9].

For a comprehensive understanding of the nature of environmental processes it is necessary to rely on a systematic approach [10], and for environmental decision – making-to develop environmental competence, to improve the level of environmental culture. An important role in this belongs to the media [11, 12]. The main criteria for the formation of environmental knowledge are: completeness, effectiveness, consistency [13].

At present, a "system of universal and integrated environmental education" has been established at the legislative level, as well as "dissemination of environmental knowledge, including through the media, museums, libraries,

cultural institutions, environmental institutions, sports and tourism organizations". However, the subject "Ecology" is not obligatory in school programs today, that is why many students begin to think about their impact on the environment only when studying ecology at the University [12].

A certain impetus to the development of environmental education in the country was given by the announcement of 2017 as the Year of ecology in Russia and the instruction of Russian President Vladimir Putin on the results of the state Council: "to Submit proposals... on the inclusion in Federal state educational standards of requirements for the development of basic knowledge in the field of environmental protection and sustainable development...".

At Samara state University of railway engineering environmental training began with the reading by B.A. Anfilof'ev in 1980 in the construction Department of the course of construction environment. Already in 1982, the Department of labor Protection developed and approved a "Comprehensive plan for training specialists in ecology and environmental protection during the entire training period." In focus of scientific and pedagogical research were the issues of students ' consideration of various aspects of the impact of rail transport on the environment, as the course developed, textbooks, guidelines were formed, a monograph on environmental monitoring was published [14,15].

The basis of environmental training of transport industry specialists was laid by the staff of the Department of "Labor Protection", which later was called "Life Safety and chemistry", "life Safety", "life Safety and ecology". Improving the issues of teaching environmental disciplines, teachers of the Department actively involved students in research work [15].

Figure 1 - Winners of the Fifth youth environmental Congress "Northern Palmira" Julia Prochukhanova and Ilmira Sanzhapova, 2013

University students have repeatedly became winners of scientific conferences, both regional and national, international levels (Fig.1).

The subjects of students ' scientific works published in scientific journals and collections are also very diverse: methods of assessing anthropogenic impact, environmental safety of food [16], the development of urban electric transport [17], generalization of the experience of environmental education [18], the danger of accidents on railway transport [19], the creation of a comfortable urban environment [20], methods of cleaning oil-contaminated soils [21].

In May 2017, a group of students took part in the field ecological and geographical school (Volgograd) (Fig. 2). and within the international youth innovation forum "YOUNG ELPIT" the delegation of the Samara State Transport University under the leadership of associate professor Yu. A. Kholopov won medals: Maxim Basharkin (message "On complex of measures to reduce air pollution from vehicles in Samara") - gold, Anastasia Slugina, Svetlana Stikhanova ("We and environmental information: a view of young journalists") - silver, Olga Karpova ("Plastic sleepers: when you see them in Russia?") – bronze [15].

Figure 2 - Participation in the field ecological and geographical school near Volgograd, 2017

Every year more than 100 students take part in various online competitions.

Used in the SSTU practice-oriented approach to the teaching of ecology based on the increase of hours of laboratory and practical works, more than half of which were organized at the University in active and interactive forms. Reading problem lectures, watching and discussing videos on environmental topics,

organization of classes in the form of protection of student projects were well established. Most often, this approach is used in the study of such topics that are controversial, allow for pluralism of opinions: "Global environmental problems and scenarios for the development of mankind and the biosphere", "Assessment of the impact of economic objects on the environment: the view of producers, scientists and the public", "The Impact of the environmental situation on public health", etc. [15]. It is very important to interest the audience with a particular problem, to provide students with the opportunity to independently implement scientific and practical initiatives. For example, the study of "Nitrate and human health" has led to the creation of youth social project "Environmental Express", the purpose of which was the organization of an effective system of informing about the problem of nitrates and operational quality control of food of students in the hostel of Samara State Transport University [22] (Fig. 3).

Figure 3 - In the classroom to determine the content of nitrates

Students not only competently approached to registration of materials of this project, but also attracted additional funds for its implementation in the form of a grant.

Another youth social project "Selective waste collection in Samara State Transport University" [23] was developed as a result of the training courses on environmental management for employees of Russian Railways and on the basis of proposals of the interregional youth forum of the competition. This project

involves organizing the collection of waste paper and power elements (batteries) in the University and will not only 25% improve the turnover of paper, but also will have a significant educational value. In the organization of work on registration of places of gathering, coverage of the project in the media, including electronic, a special role is given to the participants of the volunteer club "Express". Proposals on material and non-material stimulation of activity of students and teachers are developed.

Since 2010, the Samara State Transport University became the only University in the country in which the Department "life Safety and ecology" was opened the training on the program of additional qualification "Ecologist in the field of railway transport"! More than 80 people have already graduated from the program [14] (Fig. 4).

Figure 4 - Ecologists in industrial practice

A distinctive feature of the training of students, both within the framework of the main discipline "Ecology", and in obtaining additional qualifications in SSTU, is the reliance on advanced technologies in the field of solving environmental problems in the workplace, including the problem of accumulated environmental damage [24], consideration of promising management decisions [25], based, on the best available technologies [26] and environmental management [27].

In the preparation of ecologists, much attention is also paid to practical environmental activities. Students participate in programs of landscaping of the

University, city parks, in the program "Restoration of forests of the Samara region."

For 3.5 years, associate professors E.V. Lukenyuk and Yu.A. Kholopov took an active part in the implementation of the international project "Tempus" "Environmental management in Russian companies - refresher courses for the adaptation and integration of eco-audit programs in the corporate decision-making process (RECOAUD)". With the participation of our scientists were released 2 volumes of the textbook in the English language [28,29], were prepared and conducted pilot refresher course (120 hours on "Environmental management", which was attended by 15 employees of the Kuibyshev railway and 17 students of the Samara state training direction "Technosphere safety"). Specialists of the Kuibyshev railway and the Samara State Transport University students who participated in the courses, got the certificates of international standard about environmental management training and gave positive feedback on the content and implementation of courses [30].

For systematic large-scale work on environmental education, university has repeatedly been awarded diplomas for prizes of the regional competition "Ecolider".

CONCLUSIONS

In the environmental training of future specialists in the transport industry in Samara State Transport University a variety of opportunities for the educational process (active and interactive forms of training, research work of students, the Olympics)are used. Students also take part in the development and implementation of youth social environmental projects, to participate in scientific forums, international and interuniversity projects. In addition, the implementation of the educational program "Ecologist in the field of railway transport" allows students and production workers to gain additional knowledge and a document on a new qualification.

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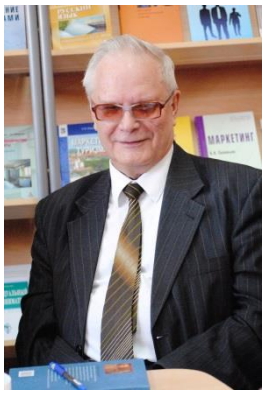

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SEVENTH INTERNATIONAL
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INFLUENCE OF ACTIVATION REAGENTS ON REMOVAL OF METHYLENE BLUE ONTO ACTIVATED CARBON DERIVED FROM *LITSEA GLUTINOSA* SEEDS

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ABSTRACT

In this study the authors prepared activated carbon derived from *Litsea glutinosa* seeds by using $NaHCO_3$, $ZnCl_2$, H_3PO_4 as a chemical reagents. The obtained activated carbon was used to remove methylene blue from aqueous solution.The results showed that the removal efficiency of activated carbon treated by $NaHCO_3$ was higher in comparison with the other activation reagents and achieved 89%. The authors determined lignocellulosic composition of *Litsea glutinosa* seeds, and successfully synthesized activated carbon derived from *Litsea glutinosa* seeds by using $NaHCO_3$, $ZnCl_2$, H_3PO_4 as chemical activators. The results showed that the removal efficiency of activated carbon treated by $NaHCO_3$ is higher than the others, reached 89% within 30 min. Thus, activated carbon prepared from *Litsea glutinosa* seeds by activator $NaHCO_3$ was a promising adsorbent for removal of methylene blue.

Keywords: activation reagents, solution, activated carbon, removal efficiency

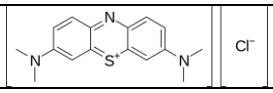
With the rapid development of textiles, cosmetics, printing and pharmaceutical industries, treating wastewater containing organic pollutants and dyes is a serious global issue. These contaminants accumulated in water bodies and threaten to human life and the environment.

Methylene blue (MB) is one of the most commonly used dyes in industries; its characteristics are shown in Table 1. Nevertheless, using MB with high concentration for a long time can be led to critical consequences for living organisms. It can cause irritation to the skin, eye burns, nausea, vomiting and diarrhea if swallowed[1]. Hence, it is necessary to remove MB from wastewaters before discharging them into the environment.

Nowadays, there are many technologies applied for removal of dyes from wastewater effluents including adsorption[3], chemical precipitation[4], advanced oxidation procedures[5,6], electrochemical treatment[7], chemical coagulation[8], and biological methods[9,10]. Each method has its merits and limitations in application. However, with the advantages such as low cost, simplicity in operation and process control, high efficiency, especially ability to be applied in the large scale, adsorption has been commonly investigated by researchers in many years.

Table 1

The characteristics of MB[2]

Dye name	Methylene blue
IUPAC name	3,7-bis(Dimethylamino)-phenothiazin-5-ium chloride
Chemical formula	$C_{16}H_{18}ClN_3S$
Molecular mass	319,85 $g \cdot mol^{-1}$
Color	Blue
Wavelength of maximum absorption	662,5 nm
Solubility	4g in 100 ml
Molecular structure	

There are various sorbent materials used in this method for purifying water, such as activated carbon (AC), graphene oxide, chitosan, zeolites, and clay minerals. Among them, AC is the remarkable adsorbent due to an abundance of raw materials, extensive surface area and surface reactivity. The preparation of ACs involves two processes, the carbonization and the activation, which can be performed in one or two steps depending on the activation method (physical or chemical). In physical activation method, an oxidized gas, such as N_2, CO_2, is used for the treatment. On the other hands, in chemical activation, activator is the chemical compounds, those more commonly used are K_2CO_3, $ZnCl_2$, H_3PO_4, H_2SO_4, NaOH, AC produced by chemical activation method has a suitable advantages to be applied in industrial production including lower temperature of pyrolysis, high yield, high surface area of AC, and the narrow micropore size distribution[11].

Recently, there are many researches thathave utilized agricultural wastesas raw materials for producing AC with purpose to releasecost of product and treatment process. The agricultural biomasses contain high carbon content, which make them suitable precursor for AC production. Using chemical reagents are extensively applied in activation process of AC derived from agricultural residue. The researches activated AC by different reagents are shown in Table 2.

Moreover, there are variable parameters affected on the preparation of AC, such as activation temperature, activation time and chemical impregnation, ratio between precursor material and chemical reagents. Herein, we studied effect of chemical activators ($NaHCO_3$, $ZnCl_2$ and H_3PO_4) on removal capacity of ACs derived from *Litsea glutinosa* seeds.

Table 2

ACs derived biomasses in removing MB

Year published	Biomass	Activation reagents	Reference
2007	Coconut shell	Potassium hydroxide (KOH) and sulphuric acid (H_2SO_4)	[12]
2012	Rice husk	Zinc chloride ($ZnCl_2$)	[13]
2014	Jackfruit peel waste	Phosphoric acid (H_3PO_4)	[14]
2015	Typhaorientalis leaves	Phosphoric acid (H_3PO_4)	[15]
2016	Guava seeds	Sodium hydroxide (NaOH)	[16]
2017	Date seed	Phosphoric acid (H_3PO_4)	[17]
2017	Mosambi peels	Sulphuric acid (H_2SO_4)	[18]
2018	Sunflower seed	Zinc chloride ($ZnCl_2$) or phosphoric acid (H_3PO_4)	[19]
2018	Banana stem waste	Phosphoric acid (H_3PO_4)	[20]

Table 3

Lignocellulosic composition of *Litsea glutinosa* seeds

Composition	Wt, %
Extractive	26,37
Cellulose	17,35
Hemicellulose	25,52
Lignin	27,65
Ash	3,11

Seeds of *Litsea glutinosa* (diameter 5 – 8 mm) were collected as the raw material in the forest in Central Vietnam. After that, it was washed to remove dust

and dirt, and dried at 60°C for3 days. The amounts of ash, hemicellulose, lignin and cellulose in *Litsea glutinosa* seeds were determined according to methods described in references[21, 22]. The characteristics of *Litsea glutinosa* seeds are shown in Table 3.

In the synthesis process, seeds were impregnated with solution of $NaHCO_3$ (18%), $ZnCl_2$ (18%), H_3PO_4 (37,7%) and underwent carbonization process at temperature 270° C for 1 hour. The AC from *Litsea glutinosa* seeds in the form of bead is presented in Fig.1.

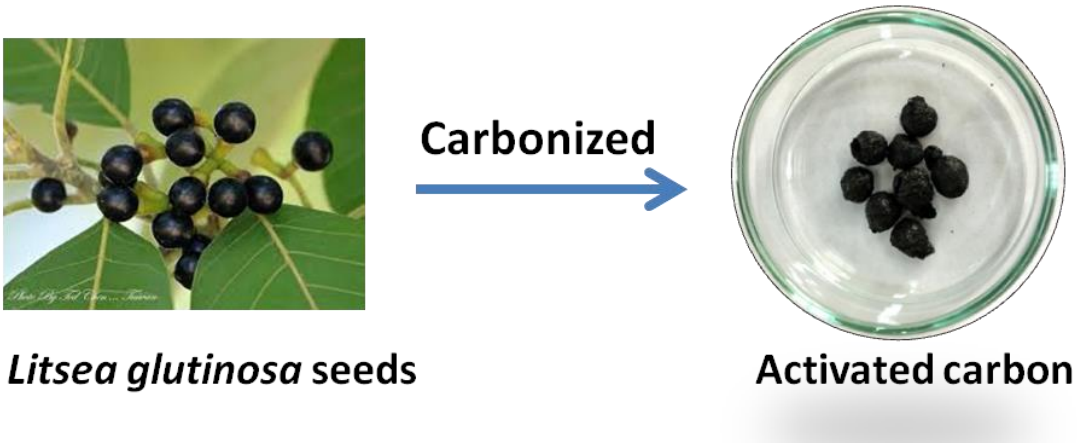


Figure 1- AC derived from *Litsea glutinosa* seeds

The dye removalability of *Litsea glutinosa* seed beads activated by different reagents was investigated for treating MB with initial concentration 10 mg/l in a period 30 minutes and the result is shown in Fig.2.

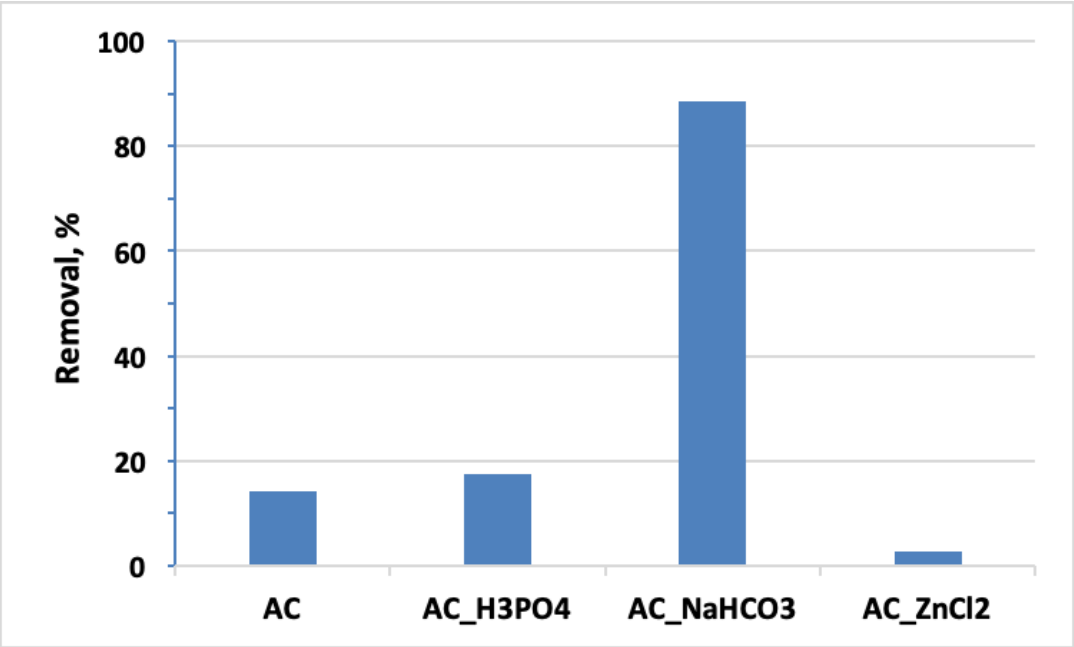


Figure 2 - Effect of activating reagents on removal of MB

The results show that the MB removal efficiency of AC from *Litsea glutinosa* and AC with activators H_3PO_4, $NaHCO_3$ and $ZnCl_2$ is 14,11%, 17,39%, 88,56% and 3,66%, respectively. Obvious, removal efficiency of AC activated by activators is higher than AC no activated, excepted AC-$ZnCl_2$. This could be due to the difference of optimum temperature of activation process for each reagent. For AC-$ZnCl_2$, activation process prefers to high carbonization temperature above 400°C to reach maximum absorption capacity[23]. However, according our experiments, at temperatures higher than 300°C, the bead form of AC could be destroyed. On the contrary, at the temperatures lower than 270°C, the carbonization process occurred incompletely, leading to decrease removal efficiency. Hence, we chose temperature of 270°C for optimum carbonization of *Litsea glutinosa* seeds and retaining the form of beads.The results also prove that at temperature 270°C, AC treated by $NaHCO_3$ well activated and achieved higher efficiency to compare to the others.

In conclusion, in this study, we determined lignocellulosic composition of *Litsea glutinosa* seeds, and successfully synthesized AC derived from *Litsea glutinosa* seeds by using $NaHCO_3$, $ZnCl_2$, H_3PO_4 as the chemical activators. The results showed that the removal efficiency of AC treated by $NaHCO_3$ is higher than the others, reached 88,56% within 30 min. Thus, AC prepared from *Litsea glutinosa* seeds by activator $NaHCO_3$ was a promising adsorbent for removal of MB.

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SEVENTH INTERNATIONAL
ENVIRONMENTAL CONGRESS ELPIT-2019

25-28 September 2019, Samara-Togliatti, Russia

SMART CITIES: FROM HIGH-TECH AREAS TO LIVEABLE PLACES

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ABSTRACT

During several years, fuelled by science-fiction and the early stages of Internet of Things, Smart Cities have been envisioned as highly technological information systems. Technology has modified our relationship to the city, providing its users augmented experience as well as more efficiency for administrators. Digital services are changing the mapping of urban stakeholders, creating a relational city where public-private partnerships flourish and include new actors. This transition implies new opportunities but involves also risks, including privacy and societal inclusiveness. With the rising feedback from first experiments, the awareness of such questions leads to the expansion of a problem-solving and holistic approach –a vision of the Smart City where the demonstration of high technologies has been replaced by the purpose of liveability.

Keywords: smart cities, technology, urban services, models

1. BACKGROUND AND OBJECTIVE

Since the industrial revolution, the future of cities has always been associated with new technologies. The upcoming evolution of urban areas is related to both our current scientific knowledge and our fantasies to live in science-fiction worlds. Therefore, there is no surprise that the current concept of the future cities, usually envisioned under the name of Smart Cities, is filled with highly technological visions and desires. Transferred to the reality of our daily life and to the city streets, technology has transformed our behaviours, and will offer far more capacities in the upcoming years. We start to understand that science-fiction worlds have become possible, with their utopias – and dystopias.

We need now to relate the imaginary of Smart Cities with the reality of our territories [1]. 70% of the world's population will live in urban areas by 2050 [2], meaning our cities will concentrate the large majority of human population in limited geographical areas. This will be a challenge to face the externalities generated by density, but also climate change and rarity of resources, budget reductions, territories inequalities and citizens inequity. While first visions of

Smart Cities referred to a layer of tech that would allow seamless function, the objective of the following work is to show and explain the sensible evolution noticeable worldwide in Smart Cities definition.

2. TECHNOLOGY: AN ENABLER OF THE RELATIONAL CITY

"Smartphone has become a universal remote control that allows us to interact with our environment and change parameters of this environment."
–Joël de Rosnay

2.1 Augmented experience

The expression of Smart Cities is inherently linked to the world of high-tech – and business. The name "Smarter Cities" is a commercial brand trademarked by IBM in 2011 [3]. The IT company identified the emerging IT infrastructure of the cities as a large potential market. This wording has been used to sell infrastructure and services to administrations, until the expression got usual in public talks [4]. The popularity of this wording has been enhanced by the diversity of resembling expressions used since the 2000s to design the emergence of technology in urban space – and the city of the future has become Smart City.

Wikipedia– one of the most universal generic sources these days - states that "a Smart City is an urban area that uses different types of electronic Internet of Things sensors to collect data and then use these data to manage assets and resources efficiently", [5]. Several scientific works also confirm this approach, defining Smart Cities as "the adjunction of a technological layer on urban infrastructure" [6] and underlining how they "emphasize integration of new technologies in city management" [7].

This technological layer transformed our daily use of the city – with the individual smartphone being one the most disruptive vectors of this transformation. The constant flow of available and real-time information brought to our knowledge by constant connection has revolutionized our relationship to the urban environment – but also generates a change in our expectations.

These new expectations are not specific to the urban services, they are fully in line with the global transition of customers' needs, that has been seen in marketing in the last years– introducing the theory of experience. "Customer Experience" and "User Experience" have led to the akin idea of "Citizen Experience" or more inclusively "City User Experience"–underlining the similarity of new expectations that have appeared in our use of services:

- Personalization and customization;
- On-demand and real-time response;
- Easiness and seamlessness;
- Value for money;
- Emotional happiness.

And the enthusiasm generated by Smart Cities is no stranger to the idea that high technologies are both the source and the answer to these emerging needs.

2.2 Improved efficiency

Indeed, technology also provides a wide range of possibilities for the design and management of urban services.

First, it allows real-time knowledge and monitoring of the city. The spreading of sensors makes it easier to know what happens, when, where, and at which frequency. For now, the operational model is based on fixed, institutionally managed sensors - in Singapore for instance, more than 95000 smart lampposts monitor temperature, rain, humidity, noise, pollutants, footfall, mobility devices [8]. But beyond that, all our smartphones are also sensors, and the data they provide can go further than people's behaviour and generate a real-time understanding of the environment. Waze is for instance one of the companies using this already, allowing for faster and more accurate information on traffic jams or blocked roads. But developed further, the concept can also provide continuous analysis of the city infrastructure, increasing efficiency of predictive maintenance – experiments are for instance currently leads to analyse the condition of bridges vibrations through cars accelerometers [9].

Second, this more precise understanding of the city allows design services with a more coherent, customized layout, fit to the behaviour of its users. Algorithms can analyse the collected information at a high level of complexity, while monitoring social networks provides better information of people's needs. Both contribute to a more accurate urban planning: "Before, the bus routes were planned according to the city - but now with the data mapping we can plan the lines according to the real use of transportation" [10].

And third, this accurate design is a source of efficiency in urban management. It avoids extra costs in additional infrastructure – the "erasure mechanism" [11]: the better use of an existing road can avoid for instance the construction of additional lanes. It canal so help to reduce existing costs - to continue the example of bus networks, a network planned as "fit-to-needs" contributes to reduce costly empty circulations. In the future, it can even remove them, with upcoming transportation systems that will dynamically change and adapt the routes, according to the real time demand expressed by the users through the smartphone applications.

2.3 Relational City

But in the last few years has appeared a new trend within the digital ecosystem: along side services that are developed and supervised by the urban operators, there is an exponential growth of third-party applications. The models are whether:

- integration of the city information in big platforms as Google Maps or Apple Maps ;
- development of applications by independent programmers or start-up companies.

And finally, the most used applications are not necessarily the ones developed by the institutional operators: when "the *Grand Lyon Metropole has conducted an investigation into passenger information services, it emerged that Google Maps was used more by the population than Optimod, the project developed by the community."* [12].

This multiple-actors-based urban system is expected to grow strongly in the next years, not only with the development of digital and IoT, but also the independent operations of hardware solutions. One example, in the field of transportation, would be car sharing fleets, installed and supervised by private companies on public area.

Those solutions will work more seamlessly if planned accordingly to the city system and public equipment, but also with development plans and urban strategy. Therefore, dialogue is expected to grow between the city managers and the private actors to maximise efficiency and manage safety - cities already negotiate with Waze to avoid the routing nearby schools or hazardous routes.

Table 1

	Traditional City	Relational City
Examples of actors	- Administrators - Infrastructure Operators	- Digital Companies - Pure Players - App Developers
Competencies	Urban infrastructure	Information technologies
Vision	Optimisation of flows and processes	Relational vision of the city : digital services directly addressed to final users
Business Model	B2G : public tenders and intervention towards public actors	B2C : disruption in the relationship of public actors to citizens
Proposed Services	Services paid and controlled by public actors	Free or cheap services for the users, but new business models such as data collection

Source : Cédric Verpeaux, Christine Raynard, Camille Boulenguer, «Coûts d'investissements et financement de la Smart City», France Stratégie, 2017

This disruption in services, lead by digital solutions more than infrastructure evolution, is part of the transition from the traditional model of B2G andG2C (Business to Government → Government to Citizen) to a relational model, where this does coexist with a system of B2C (direct Business to Customer/User) – creating a new paradigm of city management, the Relational City (table 1).

This emerging mapping of urban stakeholders creates a value displacement: whereas all the added value of urban services was before brought to the user by institutional operators, it slides towards a shared approach with value proposals from the private actors.

3. A VALUE DISPLACEMENT IN URBAN SERVICES: OPPORTUNITIES AND RISKS

"The choice of technical solutions is political: they help to include or exclude users." –Brice Laurent

3.1 Cofunding

The global finance needs of Smart Cities is estimated to an average of 1000 billion euros per year starting 2020 [12]. Among this sum, 80 to 90% will concern infrastructure, while 10 to 20% of the costs will concern digital treatment [14].

Table 2

Financing Mode	Model
Usual Revenue Models	
Concession	Delegated use of the infrastructure
Availability	Performance based contract
Hybrid	User-supported costs + Availability + Subsidies
Emerging Funding Models	
Savings	Company receives a part of the savings as a revenue
Real Estate Valuation Deferred Taxing	Taxing real estate added value 10 years after the creation of a public infrastructure
Green Bonds	Reduce costs of funding through Green Bonds Issuing

Source: Gérard Naulleau, Funding Smart Cities, Netexplo Observatory, 2019

But "according to the current condition of the cities debts and budget, only 20 to 30% can be financed by the public sector" [13]. There is therefore a strong

forecast and opportunity of cofunding between the private and public sector: the public/private partnerships are even considered the main way to build the Smart Cities. There are different models of public/private partnerships – three usual revenue models, and three more emerging models.

These political choices will not only influence the city strategy and shaping, they will also frame the system of powers and the mapping of ownerships. The detailed contracting of public/private partnerships can have direct impacts on operational scopes, but also on background functions such as the question of data.

3.2 Data

The development of tech in Smart Cities implies the inherent idea of a data-managed city [4], seen as a platform of data generation and collection, driven by algorithms and scale analysis. "The collection of data is still nowadays a very used mean by the cities who qualify themselves as Smart Cities" [7] – and is indeed at the centre of the aforementioned efficiency.

The first stake of data is the data model. Before everything else, the purpose of city management is to serve its users. When it starts to collect huge quantities of data through sensors, smartphones and devices, it raises several questions:

- Who controls the data?
- Where is it stored?
- What is data architecture?
- What is the level of privacy?

The answers shape four different models, that have been currently identified in the way data is managed within a Smart City [15]:

Table 3

Data Control	The city controls all the data
Data Concession	The city gives data operation to a third party
Data Business	Data is sold as a business model
Data Privacy	Open source de-identified data

There is no visible trend yet about the main model chosen by cities, but there is a strong trend in the scientific works pushing towards the fourth model – anonymous open data is shown as the most virtuous model.

The second stake of the data is therefore privacy, while "Smart Cities create data that can be analyzed, sold, and which can eventually lead to forms of control and monitoring of individuals" [4]. The idea of a real-time citizen control has been thoroughly documented by literature and science-fiction, from the famous George Orwell's 1984 to contemporary video games like Watch Dogs, based on seamless facial recognition and instant data profiling. These science-fiction environments raise many questions today, as the quantity of data collected, still most of the time

without the real consciousness of the user, give unprecedented possibilities to profiling, and massive influence on behaviours. The use of this data in Smart Cities can therefore take two directions: controlling its users through real-time monitoring ("Big brother model") or improving lifestyle through customization ("Godfather model") [15]. There is no clear trend yet on what will be the prevailing model [15], and this is one of the main concerns regarding Smart Cities, underlining ghow" protecting data and privacy are rights, not luxury" [1].

The third stake of data is its availability. Paradoxically, the best way to protect individual data is to make it open and public. First, this will avoid any monopoly of an institution or of a company on the control of the data, which would lock any possibility to change the solution or supplier in the future. Second, no one wants its personalized data to be seen in public – which means open data implies to "de-identify at source" [16], and allows third party control of this anonymisation. And third, it is a strong catalyser for performant and up-to-date digital services, a powerful tool to encourage initiative.

Indeed, while big data can contribute to the progress of the city, the challenge is to transform it into various and meaningful projects – or the digital Smart City will show several limits and increase challenges that it already has to face.

3.3 Limits

The first limit concerns inclusiveness and the expansion of gentrification phenomenon. While one third of worldwide population lives in slums or precarious housing [17], the high-tech Smart City is now mostly designed to attract "smart people" - "creating a rare experience for the creative class" [4] or a city that "can only accommodate a rich population." [18]. This could regenerate the digital divide of a population at ease with connected services and high technology while "users who would not be smart by refusing to be efficient and use this Smart City will then be sidelined thus creating a kind of Smart City ghetto." [4]. Transferred into urban fabric, this might increase dichotomy between some hyperconnected districts and a secondary network of more "fragile territories" [19], developing a territorial divide between "smarter districts" and the others. Moreover, smart-branded urban projects have the capacity to reduce the debate on social acceptability, whether they benefit all the city or only a small part."Intelligence staging" or technological showcase, "the central digital and intelligent theme", allows "…to mask controversies about benefits." [4].

The second threat is linked to the environmental impact of new technologies. A full technological approach of the Smart City has an unsolved question: sustainability. Indeed, Information Technologies represent today 15% of the energy consumption in France, and 5% of GHG emissions – more than aerial transportation [15]. The environmental cost of Internet of Things is yet not very well apprehended, but seen from today, the deployment of connected life means an important development of clouds and big data storage, and there is no clue yet that

the increase of energy performance of the machines will be enough to compensate the increase in number. Moreover, high-end solutions can be promptly outdated: "technology has to be used wisely, otherwise you'll end up in the situation where it will just become obsolete." [19]. The hardware part of Smart Cities generate long-term investments, while it can be outdated hardly after the end of deployment – generating “a risk of designing the largest programmed obsolescence program that ever existed” [21].

Finally, the third risk is to stack digital solutions that would be decontextualized from the environment. “Smart City is a solution sold by housing developers, based more on the supply than on demand" [4], leading potentiallyto “Smart City products” disconnected from their context. “Digital companies sell solutions to the cities and they ignore the historical, political, social, territorial and cultural context of each municipality. This results in discrepancy between the product sold and the needs felt”, a sum of technological products and solutions making a Smart City that is disconnected from the people living in it.

This leads towards a new vision of Smart Cities, in which technology becomes less visible, and where other notions such as life quality and liveability are under the spotlights.

4. THE SMART CITIES TRENDING MODELS: TOWARDS A HOLISTIC APPROACH

“The outcome - shared prosperity or increasing inequality - will be determined not by technologies but by the choices we make as individuals, organizations, and societies.” – Erik Brynjolfsson

4.1 Smart Governance

Beyond the idea of Smart City appears the idea of a deep transformation of the city management and governance, usually described under the name of “Smart Governance” [4].

The first orientation is contextualization. Diagnosis is the base of each urban action, but as aforementioned, digital solutions can often skip the step. A technological offer is more about to be useful for a city if based on in situ problem solving. After a short period of standardization, the trend of Smart Cities is now turning towards customized solutions.

The City of Boston is a good example, for it has created a guide called “Boston Smart City Playbook”. As an introduction, this guide states: “So far, many Smart City pilot projects that we’ve undertaken here in Boston have ended with a glossy presentation, and a collective shrug. Nobody’s really known what to do next, or how the technology and data might lead to new or improved services. We want to change that.” And they propose six rules (“Smart City Plays”) to design solutions: [22]

1. Stop sending sales people;

2. Solve real problems for real people;
3. Don’t worship efficiency;
4. Better decisions, not (just) better data;
5. Platforms make us go ¯_(ツ)_/¯;
6. Towards a "public" privacy policy.

This shows how public authorities take a step back on high-tech packages. The holistic approach understands the word Smart in the meaning of “ingenious”, based on contextualisation and territorialisation. Researchers state that “Smart Cities are not a technological revolution, it is a sociological revolution” [15], and operational city managers go in a similar direction: “Smart Cities must organize collective intelligence” says Jean-Louis Missika [23], “which implies a change in the way the rulers decide in order to empower inhabitants.” [24]. It’s a Smart City that understands that “being data-driven is not primarily a challenge of technology: it is a challenge of direction and organizational leadership” [25].

The second direction is therefore a clear Smart City governance, with dedicated teams, a strategy and action plans.“The definition of a clear governance model will result in a better coordination of the different “internal” players involved (municipality departments), as well as external players. Finally, it will help to structure a model that will enable to define and manage priorities, to follow the achievement of the different objectives as well as the allocation of resources, and to integrate everyone’s perspectives and actions [26]. ”The increasing implication of the private actors in city management needs for a special attention to the development of the competencies of the public actors, especially for the teams who will participate to the negotiations, and in smaller cities where there can be a risk of a competency’s asymmetry between the representatives of private companies and the public workers [13]. This will help teams having a clear understanding of the stakes involved by the Smart City paradigm on their territory, and not be overwhelmed by sales and marketing of experimental solutions.

Indeed, Smart City is not only about experimenting any more – and this is the third orientation: it is not any more about one district, or one real estate operation, or one proof of concept. In the city of Paris, the strategy is now “not only example projects but immediately spread models that work” [27] - allowing smart projects to benefit the largest possible population. And to go in that direction, one of emerging trends is the co-creation and co-modernization – a bottom-up city in which users actively participate in the design of tomorrow’s services, through workshops and dedicated meeting places, and are encouraged to develop ideas: “the best approach for implementing successful Smart City initiatives is to develop a strong framework for initiatives.” [28].

4.2 High-tech is not a goal

This is the model advocated by the Hubcité project in Lomé. Its founder, Senamé Agbodjinou, highlights that the Smarter City will be the one built by inhabitants. He therefore created places of productive collaboration based on the

traditional society model: the idea is to have third places where people can gather, propose and experiment their ideas. This prefigures a new organisation of the city, based on common thinking and made real through frugal solutions - the project defines itself as “low-tech”, considering that innovative solutions can be smart without calling technology at all.

But "the most successful Smart Cities have acknowledged that it's neither top-down nor bottom-up approach, it's a combination of both” [20]; and this can be the bottom line of them id-tech model, considering smart solutions based on simple and existing technologies. The example of Sao Paulo illustrates this model: “Less apps, improved services-less futurism, more realism” [1]. For instance, the city created a unique phone number to call the municipality, at the opposite of bureaucracy digitalization, that puts people in stressing situations when the only possible relationship goes through online services. The result is 20000 calls a day, and 70000 requests filled per month [1], showing the need of people to have direct connection with city administration, and not only applications.

4.3 Liveability

All those reflexions lead to a new era of Smart City thinking based on a holistic approach – a transversal approach where technology not only aims at improving efficiency or performance, but before all at improving happiness and well-being.

According to sociologist Bernard Cathelat [15], the holistic approach is based on four pillars:

- People Lifestyle;
- Economy Wealth;
- Sustainable Environment;
- Logistic Efficiency.

The idea is to put the real challenges of the city before the technological approach, and to use technology as a tool, if necessary and if it brings added value, to face those challenges; to make the city efficient, but also – liveable: “Smart City is not a software, but a method that aims at turning the cities into living spaces” [29].

According to Antoine Picon [17], liveability englobes five dimensions, that cannot be dissociated:

- Sustainable Buildings;
- A healthier and friendlier urban fabric;
- New forms of efficiency;
- A better relation to the natural environment;
- Greater inclusion and citizenship.

Barcelona is considered an example of holistic approach, defining its vision of the Smart City as “the one, that, through public-private collaboration, improves the efficiency of the city, betters the quality of life of its citizens, and grows the local economy” [30].

Technology is no longer used in this definition of Smart City, a way of thinking that is confirmed by Josep-Ramon Ferrer, Director of Barcelona's Smart City: "Technology should not be seen as a goal in itself. Technology is simply a facilitator. The purpose of data analysis is not to generate big amount of data. The ultimate goal – in fact, the only one that matters – isto help better decision and policy-making at the city level. Technology is at the core of the current Smart City revolution, but most importantly, it represents a tool to govern and organize our cities in a smarter way - particularly because it enables to engage and empower citizens, and make them participate in the policy-making process. All this results in more open, transparent and participatory urban systems." [26].

5. CONCLUSIONS

If there is no doubt that the technology and data will be present in our future cities, pushed by both administrations and users for all the possibilities that they make possible, and by companies for their business models, it will not make a difference unless it is based on a problem-solving and contextualized approach, with the well-being of people in mind. "Technology is not a goal, it is a tool, a way to improve things and go forwards. What is visible and innovative today will not be in five years, so pure tech is not relevant. What will remain is the story that goes with it." [15].

The story is what we will feel as the users of the city, the well-being and happiness it can provide to us. "Is the goal a smile?" asks sociologist Sandrine Cathelat [31]. "When we think about Smart Cities, do we intend giving a smile to all the citizens of this territory? – SmartCity is a playground, an adventure. This is what will make us smile, not a machine city".

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MONITORING OF ECOLOGICAL PROCESSES TO DESIGN URBAN TERRITORIES

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ABSTRACT

Ecological safety and high quality of life in the city is the principal requirements of the architectural concept. In the process of designing buildings and infrastructures of the city are being developed and implemented activities reduce anthropogenic impact on the Wednesday. The dynamics of this effect establishes environmental monitoring process through the creation of cartographic bases on which put locked items. This gives a visual interpretation of dynamic changes of environmental factors in time and space. Compiling digital maps of urban ecological danger obtained through spatial interpolation (approximation) values of risk established by the calculation not only in specified places within the territory, but also in time. Analysis of these maps allows determine the reasons and environmental hazards on the basic criteria: contamination depending on its planning structure and seasonal stratification of the atmosphere, depending on the infrastructure and transport impacts, depending on the spatial disposition of the industrial enterprises, and thermal power plants.

Keywords: monitoring, process, urban territory, design

The formation of city infrastructure coupled with environmental requirements requires determine environmental pollution source data to address towns design tasks. The architect solves these tasks during the design of a new city or renovation of old buildings. Such tasks are including [1]:

- forecasting the intensity of pedestrian traffic and vehicles;
- definition of patterns of mobility of the population and the formation of pedestrian and traffic flows;
- design of the highway-road network, individual elements of the streets, transport interchanges and overpasses that provide throughput of vehicles;
- design of bike paths, cycling organization and intercept parking;
- design of parking vehicles on the territory of the city.

In the process of solving tasks of the architect is confronted with novelty versatility and complexity of the problems that must find innovative solutions in projects of reconstruction of old cities and when designing new town. In

conjunction with the objects built by human activities (existing roads, buildings, constructions), local conditions of topography, hydrography, woodlands reconstruction of the highway-road network and/or project (new town the plan) should be a convenient transport system [1, 3, 6, 7]. The requirements for environmental safety and preservation of the natural landscape with the need for decisions of a technical nature are contradictory [1]. Here you must make trade-offs. These requirements and the demands of aesthetic conditions have repeatedly been in the literature on transport of the city [3, 6, 7]. Awareness and staging such tasks were formed back in the 80-ies of the 20-th century [6, 7], but they are not currently in full. For example, designing a new city and enter the city vehicles requires device junctions in different levels. But it is expensive contraption is not always the case. Thus, the development of design techniques for reconstruction of urban areas and the new town design, taking into account ecological processes is a challenge.

Natural processes occurring over time are random. These include shifts in temperature, atmospheric pressure, velocity and direction of wind, soil moisture and/or air flow of solar radiation, the presence and intensity of precipitation. The combination of these factors determines the weather conditions of the region. The availability and relative changes in population and falling on them, buildings, structures, absolute and relative length of streets, their orientation in space, transport interchanges, the square closed asphalt, area parks and green areas represent the probability space of the urban territory. Here is the mutual penetration of anthropogenic and natural processes and factors that shape corresponding to synergistic space. This space of natural and anthropogenic processes, coupled with each other, form a Habitat for urban residents Wednesday: human, animals and pets (cats, dogs, birds).

1. Devastating (destructive) conscious and/or unconscious actions. Lead to a deterioration in the quality of living organisms and habitats Wednesday, including man.
2. Stabilizing informed action to stop (pause) negative anthropogenic destruction of natural process Wednesday.
3. Constructive conscious action to prevent negative anthropogenic destruction natural Wednesday or restore a positive form.

During the monitoring period environmental factors for the design of urban construction and infrastructure you need to track momentum patterns of mutual penetration of natural and anthropogenic processes. These laws may change from destructive to stabilizing processes continue to processes, preventing the destruction of Wednesday. There is a need to identify the type of anthropogenic influence. For example, the following ambient air monitoring strategy:

- Obtaining objective information about the level of air pollution, assessment of the air Wednesday;
- Identification of emission sources (location, materials, etc.);
- Quantification of emissions, emission control;

- Study of atmospheric pollutant transport processes (depending on the height of the pipes, the distance to the source, the meteorological conditions);
- The study of chemical and photochemical processes of transformation of pollutants in the atmosphere;
- Forecast State of the atmosphere;
- Evaluation of the effectiveness of measures to protect the air Wednesday;
- Emergency information about sharp changes of pollution;
- Study of the effects of atmospheric pollutants on objects surrounding Wednesday.

This is a convenient monitoring strategy through the creation of cartographic bases on which put the captured elements of environmental factors. This gives a visual interpretation of the elements of monitoring, the dynamics of changes which can be tracked in both space and time. Transition to digital mapping techniques [2] or for geographic information systems (GIS), expanded the possibility of application of large-scale digital maps (DTM) and mathematical models of the terrain (MMM). They are used to summarize the data on environmental pollution Wednesday, various data analysis and visualization of results (fig. 1).

Figure 1 - Emissions of atmospheric pollutants per capita, kg/person

Features of geoecological mapping in relation to specific natural Wednesday are as follows:

1. Creation of thematic maps: geo-materials for Aerospace filming and scanning the territory as they are processed by means of GIS;
2. Detrmination of the main source of information when you are creating environmental and various thematic (natural-security, performance, etc.);
3. Valuation and appraisal site environmental areas: landscape and its geochemical characteristics; cadastral land use; anthropogenic and technological sources of exposure; soil, reflecting quality (degradation) soils; the condition of the

vegetation; hydrogeological condition of ground waters; hydrological regime of water objects; estimation of geomorphological processes; medical condition health; demographic processes.

4. Environmental maps for the rationale and design of the investment process (fig. 2). List of mandatory or recommended cards consisting of documents on environmental justification of investments at various stages of the investment process. The main stages of the environmental justification for investment, requiring ordnance survey are engineering-ecological survey and environmental impact assessment (EIA) Wednesday.

Figure 2 - Space shot (environmental) card port of Nakhodka for analysis and justification of the investment process and the formation of strategy-planning forecast

5. Geo-ecological map in urban design, which combine two blocks: asset and integral.

- Inventory maps options for urban design. It features City Wednesday: air, acoustic mode, vegetation, soil and microclimate in urban areas (insolation and wind regimes), geological, geo-morphological, hydro-geological and hydrological conditions. Displayed phenomena are tied to the urban factors which are taken into account in project decisions.
- Integrated maps contain constructive recommendations for solving environmental problems in urban areas and reflect the essence of the ecological and urban design. Such maps are prepared for large urban areas or city as a whole in the formation and urban development strategy forecast. There is the master plan of the city. In comparison with inventory maps are presented in maps of integral finer scale and reflect the diversity of urban sprawl combined the territories of various functional purposes.

Creation of digital terrain models continue to exercise investigated by scanning the terrain laser scanner. Results of the scan are the 3D coordinates of the

elements of the situation and terrain throughout the object. The main advantage of this method is to get quality shots or measurement data with unlimited storage time. The information is used to design the new facility including time delay. There are two types of survey works: ground and aerial laser scanning. Ground scan the terrain allows you to receive high-level detail plans, as well as create 3D models. When inside you are scanning laser scanner is placed on an aircraft.

Recently, a game concept began to change [1, 2, 8]. When designing urban infrastructure focusing more on people than transport. Change strategy reconstruction of the old urban areas and design of new urban streets. The primary role it plays focus on the environment and improving the quality of life of the people. Designed and implemented for this design, protecting transport process improves the energy efficiency of vehicles is being implemented intellectual computerized management of urban transport, formed a convenient freight interchange nodes, and organized cycling. These activities mitigate environmental parameters of the urban territory, and cycling can be an alternative to road transport [1, 4].

Compiling digital maps of urban ecological danger obtained through spatial interpolation (approximation) values of risk established by the calculation not only in specified places within the territory, but also in time. Analysis of these maps allows determine the reasons and environmental hazards on the basic criteria: contamination depending on its planning structure and seasonal stratification of the atmosphere, depending on the infrastructure and transport impacts, depending on the spatial disposition of the industrial enterprises, and thermal power plants.

Environmental monitoring methodology with the application of geo-information technologies becomes necessary in urban environmental policy, the basic principles of which are [2, 8]:

- The State environmental monitoring system;
- Submissive departmental observations uniform criteria;
- System reporting on urban environmental performance Wednesday;
- Complete and uniform coverage of the territory of the city's environmental monitoring network;
- Environmental regulation of criteria for monitoring;
- Application of GIS-technologies for advanced and in-depth analysis of environmental criteria;
- Economic and technical rationale for making design decisions.

Using these principles allow suggest the application activities aimed at reducing environmental risk, for example, for the city of Voronezh [2]. Analysis of these events gives the possibility to use them for other cities in Russia.

- New city transport network formation or reconstruction of old cities, taking into account throughput, quality of road surface, speed of movement of vehicles and the use of new advanced types of vehicles in urban conditions;
- Modernization of technological processes in the direction of reducing (termination) of harmful emissions into the atmosphere of the enterprises of power engineering;

- Construction of non-urban territory and takeaway abroad city industrial enterprises with increased environmental hazards;
- Designing ecological skeleton in new cities and reconstruction of systems of InterCity and suburban landscaping.

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SEVENTH INTERNATIONAL
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CREATION OF A CONCEPTUAL MODEL FOR THE DISTRIBUTION OF A TECHNOGENIC HYDROCARBON LENS USING SURFER AND PETREL SOFTWARE PRODUCTS

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ABSTRACT

The problem of creating a conceptual model of spreading technogenic oil lens using professional geological software products such as Surfer and Petrel is discussed. To date, there has not been an adequate analytical model to predict lens movement behavior. In this work much attention is attached to phenomena of the technogenic lens and features of modeling specific field under the refinery. The authors analyze the similarities and differences between the algorithms of modeling traditional oil and gas field and specified. The results demonstrate a possible approach for working with technogenic mobile lenses. It is advisable to create a conceptual model based on the analysis of the constructed maps of oil product levels. It can also lead towards further models that can predict the technogenic oil lenses behavior.

Keywords: oil thickness, oil lens, geological modeling, surfer, petrel, technogenic oil lens, refinery, geoecology, technogenic hydrocarbon lens, oil leak

1. INTRODUCTION

The environmental situation has always been an essential aspect of the functioning of the oil and gas industry. The causes of pollution are accidents at trunk and field pipelines, imperfection of oil production technology, accidental and technological emissions, etc. Practically under any object related to the production, refining, transportation, storage, sale of oil and oil products, a zone of contamination of soils and groundwater by various hydrocarbons of the oil series will be formed. Under many oil storages, warehouses and enterprises, large technogenic oil "lenses" have accumulated. Moreover, the lens of petroleum products is constantly migrating. [1]

This paper discusses the problem of environmental pollution in the territory of oil refineries and needs to create 3 D model of lost petroleum productsto calculate possible reserves and forecast their movement. This topic has not lost its

relevance for over 50 years, because there are still no universal methods for eliminating the consequences of the loss of petroleum products under the oil refineries, as well as algorithms for creating a 3D model of such technogenic hydrocarbon lens aimed to scale the oil products leak.

As a result of technologicoil leaks over the years of operation of oil refineries, technogenichydrocarbon lens are formed.This situation threats to the ecological balance, both on the territory of the refineries and in nearby areas.

2. THE SIMILARITIES AND DIFFERENCES BETWEEN THE ALGORITHMS OF MODELING TRADITIONAL OIL AND GAS FIELD AND TECHNOGENIC LENSES

Technogenic lenses are understood as an accumulation of petroleum products of anthropogenic origin, which leads to the emergence of a constant source of environmental pollution: soil, air, ground water. A similar problem touched such oil-producing regions of Russia as Western Siberia, the Middle and Lower Volga regions, and others [4].

Particularly dangerous are the lenses of petroleum products if they form on the surface of groundwater. This is due to a number of the following features:

• Possibility of oil products entering urban water intakes;
• Migration of oil products on the surface of groundwater;
• Crowding out of oil products from underground to the day surface during the spring flood;
• The likelihood of oil products seeping along with groundwater into nearby bodies of water;
• The complexity of monitoring and predicting the movement of the lens.

Creating a digital model of technogenic hydrocarbon lenses allows us to solve the following tasks:

• Visualization: creating a current understanding of the state of anthropogenic deposits;
• Estimated hydrocarbon reserves;
• Monitoring hydrocarbon migration;
• Creation of a conceptual model for developing a hydrocarbon recovery action plan.

However, a clear methodology for creating a geological model of such objects has not been developed yet. This is due precisely to the specifics of the technogenic hydrocarbon lens. Let's note several features of modeling such lenses:

• Depth: technogenic lenses are formed, as a rule, at shallow depths of up to 100 m;
• The influx of petroleum products occurs from the day surface;
• It is necessary to “model” lenses whose edges are a thin layer of oil products on the water surface several mm thick, while the thickness in their central part reaches tens of meters. In this regard, requirements for grid resolution are increasing. As a result, the number of cells of such grid can reach several billion, which leads to

limitations in further calculations on such models, since colossal computing power is required.

• Specificity of lithology modeling. The migration channels are horizons with a light particle size distribution, i.e.,in the case of a technogenic hydrocarbon, the soil acts as a collector. It turns out that in the model the lithology cube is represented only by the collector, and further calculations and constructions will depend on the capacitance-filtration properties.

• The constant mobility of the technogenic hydrocarbon lens leads to necessary, making a deciding on choosing certain months data that will be displayed in a static geological model and will be the most representative. For this, it is necessary to conduct preliminary construction of maps of the distribution of anthropogenic deposits for monitoring and analysis.

• The area of formation and occurrence of the lens also determines the features of pressure data. So, in the case of modeling lenticular deposits, the pressure range is presented from 1.05 to 2.03 MPa that differs from traditional formation pressures. (Fig. 1).

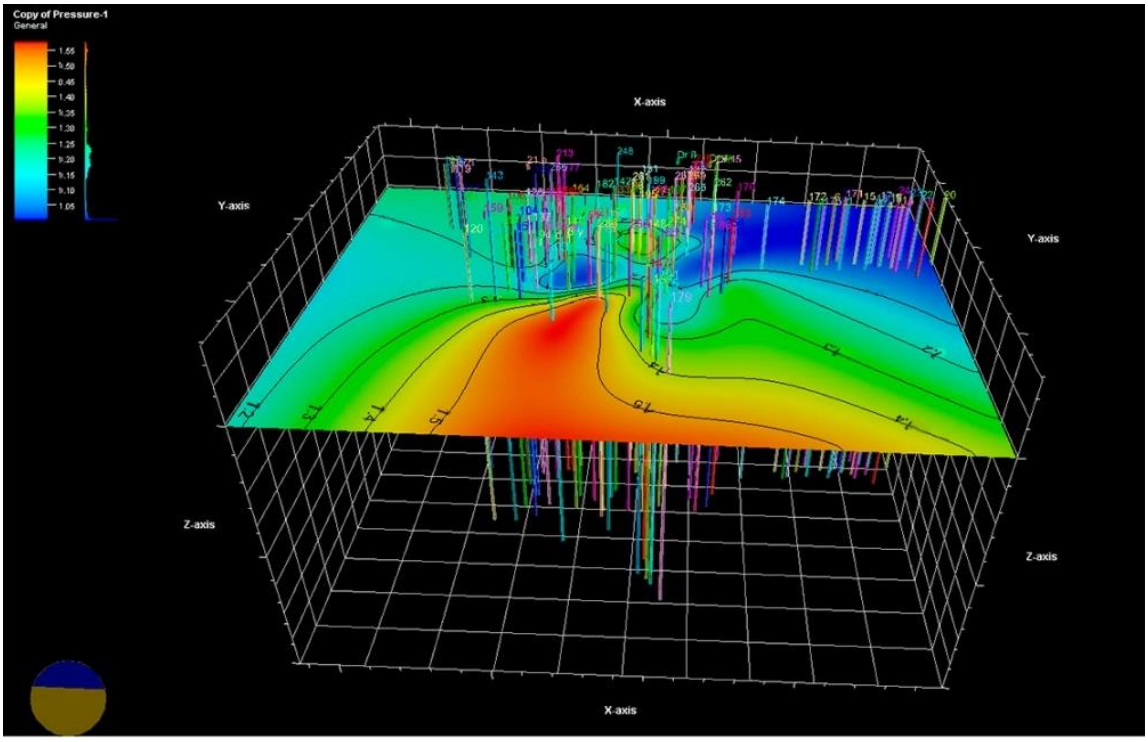

Figure 1 - The map of the pressure

3. METHODOLOGY

The main goal of the case study discussed below was to estimatethe possibility of creating three-dimensional model of the technogenic hydrocarbon lens in Petrel software. It is also aimed to create a conceptual model of spreading technogenic oil lens using professional geological software products.

Solving the problem of creating a digital model of man-caused deposits under one of the refineries, the entire scope of work was divided into two stages. At the first stage, the construction and analysis of man-caused hydrocarbon lens thickness maps for the period 2014-2016, 2018 and the beginning of 2019 was carried out. Surfer (GoldenSoftware) was used to build thickness maps. For constructions on this stage well heads and oil product levelswere used. The main objectives of this stage were:

• determination of the distribution boundaries of the man-caused oil lens;
• identify the period of static lenses;
• analysis of the dependence of the distribution and power of the lens on the time of year.

At the empirical part of the study, maps of the thickness of the oil lens with an interval of 1 month were constructed. Below is an example of the created maps for 2014 - 2015. It is worth noting that in the south-west of the analyzed area, it is impossible to perform reliable extrapolation of the data due to the lack of drilled wells.

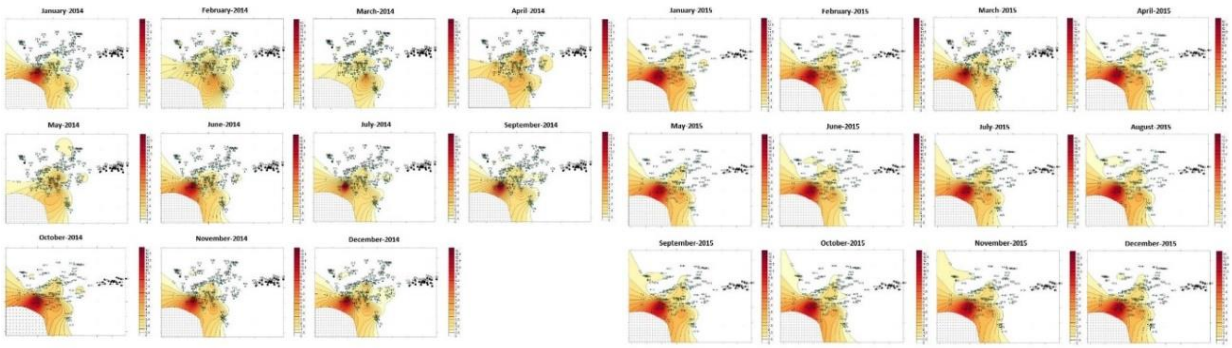

Figure 2 - Maps of oil product levels in observation wells for 2014-2015

Analyzing thickness maps, several patterns were revealed:

1. The movement of the lens depends on the season, and its migration is in the nature of pulsating changes, namely:

• in spring, when the groundwater level rises, the lens moves and becomes more extensive in the area;
• autumn, the lens has slight fluctuations, is more static.

Those, the lens spreads over of a year and then gathers over a smaller area.

2. It may be recommended to use Surfer software at the stage of creating a conceptual model of the technogenic oil lens as a preparatory stage for constructing a digital model.

3. Months have been identified with measurements suitable for use in creating the geological model in Petrel. The choice of such a “reference” month should be based on an analysis of the following criteria:

• the lens remains as static as possible;

• thickness values for the reference month should lie within the modal values for the current year.

The second stage of creating a digital model of anthropogenic deposits was implemented in the Petrel (Schlumberger) program. According to the results of the first stage, a month was chosen in which over the past years the lens had minimal fluctuations, was more static. Moreover, the thickness of the deposit in this period lies within the modal values for the analyzed period.

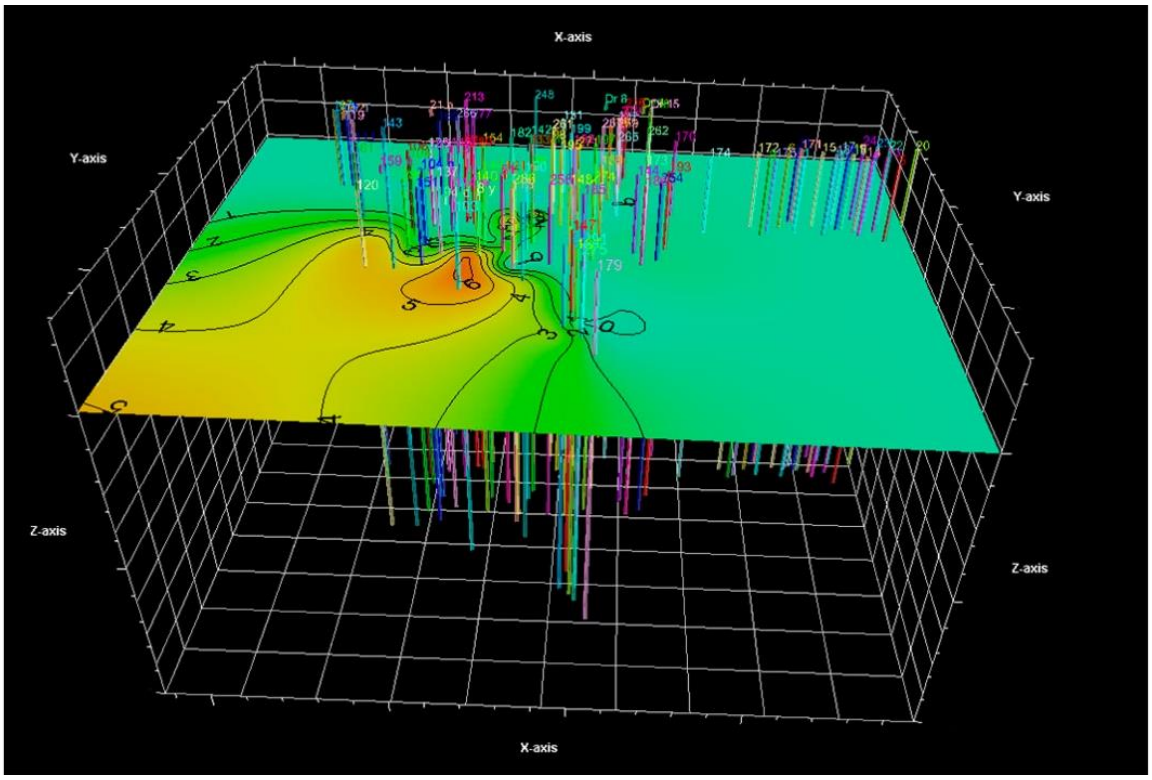

Figure 3 - Map of petroleum product levels made in the Petrel program

Besides, as part of one of the tasks of contouring aman-caused oil lens, a month when the spreading of the lens over the area was maximumwas determined. This is April 2014. These data were also uploaded to a digital model to visually display the limits of possible “spills” of the lens.For structural constructions digitized maps of the Kazan horizon were used.

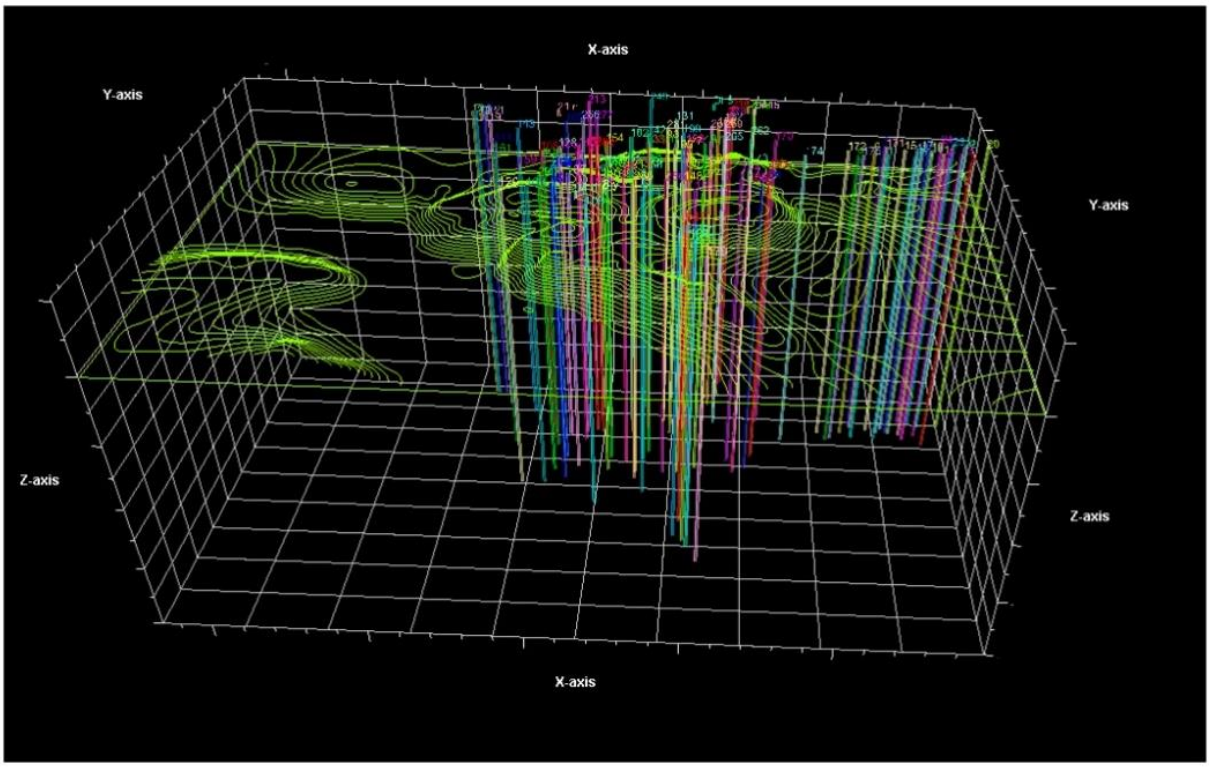

Figure 4 - Digitized contours of the Kazan horizon

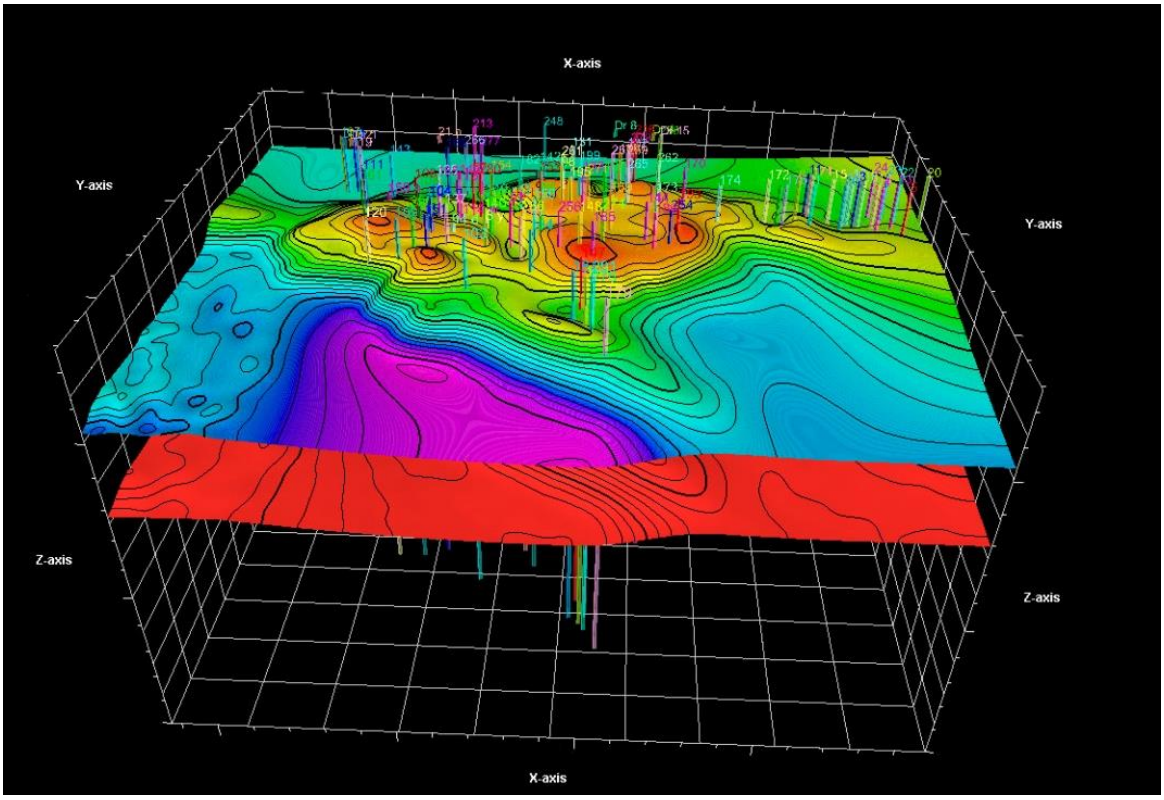

Figure 5 - Structure map of the Kazan horizon, made in the Petrel software

A side-by-side comparison shows that the new contour and structure map follow the same directional trends seen on the originals.

Traditionally, 3D geological modeling technology is presented in the form of the following main steps:

- Database;
- Conceptual model;
- Structural model
- Create a grid, averaging downhole data onto a grid;
- Facial (lithological) modeling;
- Petrophysical model;
- Map building and reserves calculation;
- Preparation of data for subsequent transmission to hydrodynamics for filtration modeling.

In addition to the features of the geological structure of the field, the quantity and quality of the source information largely determines the methods model building and the results obtained. Define the basic setsource data on the example of exploration refinery:

1. Wellhead coordinates, altitude, inclinometry - used to create well paths in the model.

In this case, we create artificial vertical wells in the model because of there is no data inclinometry, the coordinates of the well heads are taken equal to the coordinates of the intersections. It should be noted the depth of the drilled wells in the field does not exceed 100 m.

2. Stratigraphic well tops calculated by a geologist in project - are used as the basis for the formation of the structural framework.

4. Well-log curve - used for correlation constructions, lithotypes selection, character estimation of saturation and flow properties, facies analysis, binding of seismic data. The results of the GIS interpretation (RIGIS) are used in the construction of a 3D model for the distribution of properties - the construction of filtration-capacity cubesproperties (FES).

5. Working fluid contacts in wells - used for mapping fluid contacts (Fig. 6).

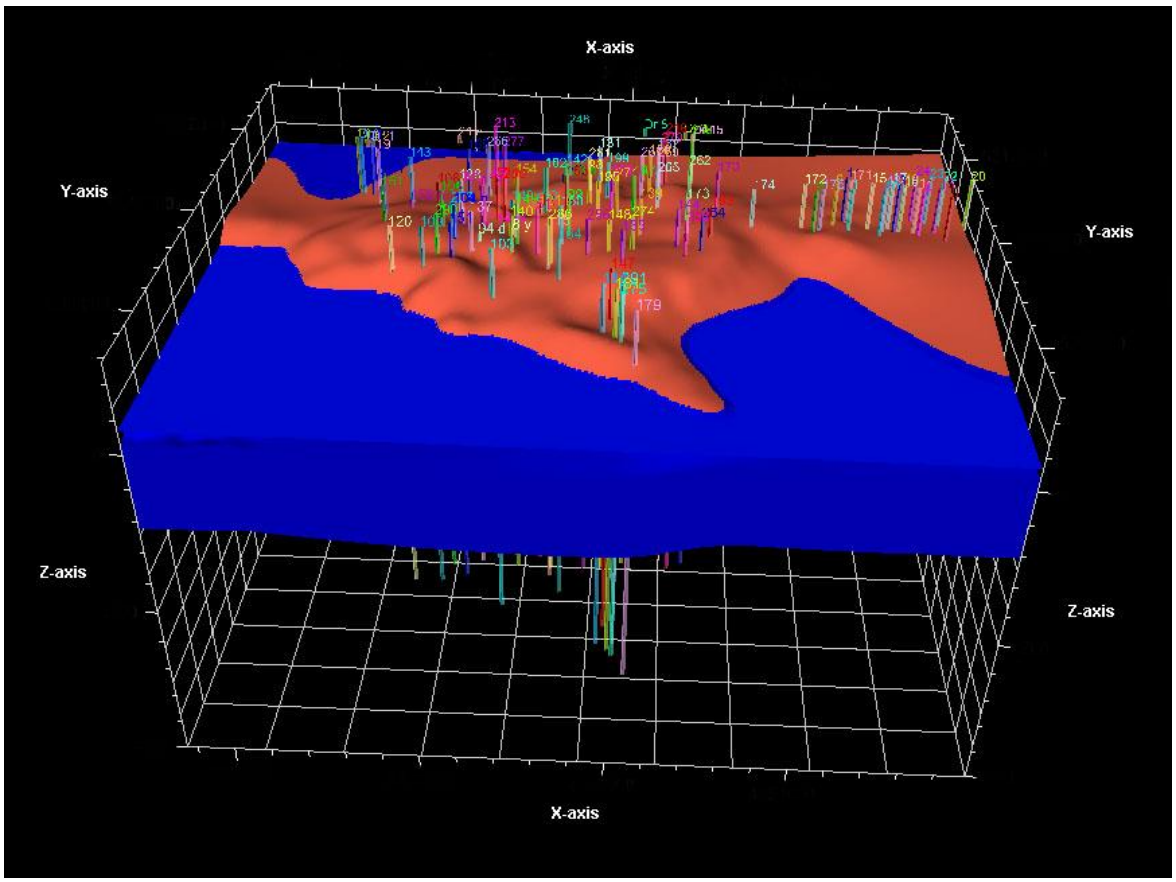

Figure 6 - Contact Set

The contacts in the model can have a constant level of depth or be represented by a surface. In the case of “classical” oil and gas fields, the first case is more common. Less often - tilting OWC.Usually in order to determine the level of oil water contact in the model, it is customary to do a justification scheme for OWC. In this project, the level of OWC was adopted at the level of the nearest water-collecting area. In addition, data were displayed in the well section window and correlation was realized. As a result, the data turned out to be consistent with the level of the water-collecting area, and in the model for further calculations, the OWC specified by one value was used.

5. The perforation intervals, the results of tests of wells are also used for validation and adjustments of the position of fluid contacts.

6. Seismic data. Structural map and surface irregularitiesaccording to the seismic, drilling and other techniques are usedfor the formation of the structural skeleton. Cards or cubes of seismic attributes are used to disseminate FES in the inter-well space. Unfortunately in this project this data were not provided by customer so the next point were more useful for modeling process.

7. The equations of petrophysical dependences of "core-core" andquantitative (definitions of Kp, Kpr, Kv) and qualitative (descriptions) of core research. They used for subsequent mass interpretation, as well as creating a conceptual model.

4. CONCLUSIONS

There were two primary goals of this project. First and foremost was to improve the understanding of technogenic oil lens occurrence, creating a conceptual model of its spreading using professional geological software products such as Surfer and Petrel. The second goal was to determine whether 3 Dmodeling is a worthwhile tool for evaluating technogenic oil lens under the refinery with limited and/or poor-quality data. A 3D model of the lens was created using Schlumberger's Petrel2019version. Results also showed the usefulnessof modeling in this type of scenario.

Summarizing the above, we can focus on the following main points:

High-quality modeling of anthropogenic deposits is impossible without a preliminary stage of monitoring the movement of the lens.

It is advisable to create a conceptual model based on the analysis of the constructed maps of oil product levels (in this project, the Surfer software package is used for this).

Modeling of hydrodynamic processes in the reservoir based on the listed parameters helps to optimize the choice of locations for new production wells with minimal capital costs.

Based on the significant differences in the geotopes of technogenic and natural origin, traditional modeling methods need to be adapted to the conditions of existence of the oil lens under the refinery.

«The benefit of a computer-generated model is that it allows for the integration of different types of data that can subsequently be updated, manipulated and changed quickly» [6].

Modeling allows identifying areas for which it is necessary to strengthen monitoring of lens migration.

The created model of the technogenic lens allows the initial assessment of hydrocarbons under refineries.

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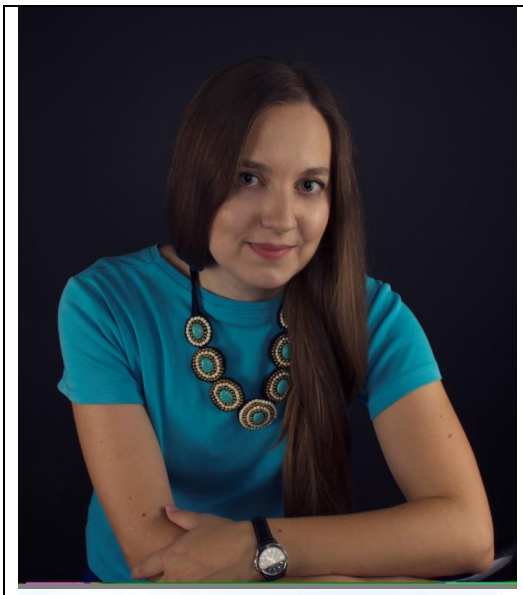
INFORMATION ABOUT THE AUTHORS



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SEVENTH INTERNATIONAL
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THE CONDITION OF OAK FORESTS OF THE URBANIZED TERRITORIES IN THE SOUTHEAST OF THE EUROPEAN PART OF RUSSIA

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ABSTRACT

Oak forests in the south-east of the European part of Russia have been in a critical state for a long time, which is more evident in the urbanized environment. The state of oak woods in the park areas of the city of Samara, having a natural origin and being the remnants of the native plant communities of the forest-steppe region has been studied. The characteristics of the main types of oak forests in the suburban area and in urban conditions are given. A vivid dependence of the degree of damage to oak stands on the location of oak groves near a large metropolis and at a distance from was not found. All of them are in a depressed state. However, within the city limits plant community is disturbed very much. In suburban forests they kept the natural characteristics so far.

Keywords: oak wood, park area, forest, urban conditions

Oak forests belong to the formation of summer-green forests, widespread mainly in the Northern Hemisphere in the temperate and temperate continental climate, with cold winters and warm summers. The main breed is *Quercus robur* L., which bioecological characteristics determine the existence and the development of oak forests.

Oak forests that occupy the most fertile soils are distinguished by the variety of species, the composition of lignosa, and hence the complexity of the interaction of the ligneous species growing in them. Oak forests of the central European forest-steppe are very dynamic and have a rather complex phytocenological make-up.

The modern area, distribution and condition of oak forests have been made up as a result of a long-term development under the influence of a complex of factors - historical, climatic, soil conditional, etc.

The oak forests of Russia occupy about 10% of the forested area; most of them are located on the plateau of the European plain between the Carpathians and the Ural Mountains. In addition, oak combined with small-leaved deciduous

species form sylva in river valleys, and also form the basis of ravine forest far beyond its main distribution [7].

At present, the degradation of oakery has reached a limit across a significant part of its distribution area, which has already been catastrophic in recent years. Nowadays potentially primary oak forests being in a close to natural state can be foundacross a small area, which is primarily due to multiple forest devastationfor the purpose of wood procurement.

The state of oak forests is getting worse due to the attack of various tree diseases that are increasingly spreading in Eastern Europe.

Since the beginning of the 80s years of the 20th century, the term “The Syndrome of Eastern European Forest Mortality” has been used in world science, by which we mean the unusual damage of *Quercus robur* and the loss of its capacity. The main characteristic features of this process are a transparent crown, a bundle-like arrangement of leaves at the tips of the shoots, dry tips of the shoots at the periphery of the crown. Shoots are often covered with yellow leaves. The crust usually cracks, sometimes with the release of mucus. A tree has a smaller increase in diameter, height, wood volume and stand; wood is damaged by pests and fomites.

According to visual observations, the drying of *Quercus robur* in growing stock can have a different sudden and chronic pattern.

In oakery communities the stand is noticeably thinned, the formation of leaf litter and tree waste is reduced, but the development of brush mat and grass cover naturally increases. This leads to a decrease in the protective and ameliorative functions of forests and their ability to regenerate [1-4, 6].

Growing stocks in urbanized conditions undergo a high anthropogenic load; theyare exposed to various kinds of pollution. The forests in the city and suburban areas are gradually being degraded under the influence of recreation, and their area is decreasing. Small woods are more vulnerable, their forest deterioration reaches 85-90%, in large ones it is up to 6-20%.

In order to determine the current state of oak forests in an urbanized environment in the south-east of the European part of Russia, we undertook a study of the remaining plant associations in the city of Samara and its surroundings.The study of forest plant communities was done using traditional research methods [5].

It was established that the oaks have mainly seed origin (84-87%), which indicates the natural origin of oak forests on the territory of the city of Samara. Vegetative origin characterizes 13-16% of trees. However, in our opinion, the amount of trees of vegetative origin is greatly detracted due to the long-term destruction of the incipient undergrowth. This also affects the age of oaks, which are mostly over 50 years old.

The deficiency of natural regeneration affects the general condition of the communities and reduces their stability in the urban environment due to the falling out of the young individuals from the oak population.

After analyzing the collected data, we have found out that the average age of Quercus robur trees in the parks of the city of Samara is 95-100 years, the

average height is 19-20 m, the average diameter of the trunks is 65-69 cm, and the maximum diameter of the trunks is 90-110 cm. At the time of study the tree crownwas thinned, the loss of leaves was about 25-32% on average. The individuals are in a depressed state, they belong to the 3th or the 4th categories on average.

The table below shows the way of the oak species'distribution according to the categories of their vital state. Neither healthy trees of the first category nor conditionally damaged plants were found in the studied parks of the city of Samara. Weakly injured individuals (1,6–2,5 points) were noted in 13% of cases in Zagorodny Park and 32% of them in Gagarin Park. The share of moderately damaged oaks (2,6 – 3,5 points) is up to 61% in Gagarin Park and up to 79% were noted in Zagorodny Park. Heavily damaged trees (3,6 – 4,5) are found in both parks (7-8% in each park). Dead oaks (4,6 - and more) are not registered, as they are quickly cut down by the park services. However, the amount of hemp indicates that about 3-4% of the stand grows per year.

Oaks have various damages. Every last tree in the city parks is infected with powdery mildew (100%), has a large number of drying branches (33-50%), transparent crown (100%), drying shoot tops (30-90%), tuft-like arrangement of leaves (80%), yellow leaves (90-95%). In a less degree, *Quercus robur* has spotting (20%) and leaf canker (14%).

Table 1

The Scale of Assessing the Vital Status of Tree Stands

Growing Stock Status Indicators	Growing Stock Status	Percentage of Trees, %	
		Gagarin Park	Zagorodny Park
1,0 – 1,5	Conventionally damaged	-	-
1,6 – 2,5	Weakly damaged	32	13
2,6 – 3,5	Moderately damaged	61	79
3,6 – 4,5	Severely damaged	7	8
4,6 – and more	Dead	-	-

About 15% of the trees in Gagarin Park and 43% of individuals in Zagorodny Park have various cracks in the trunk, caused mainly by frost (the percentage in Zagorodny Park is higher due to the higher average age of the trees, lower temperatures and high humidity of the microclimate, as well as worsepark improvements). The number of dried branches in the lower and middle parts of the tree crown is approximately the same and comes to 33-36%.

Oak restocking in parks is almost absent due to the number of natural causes and human activities. The decrease in stability and death of both seed and sprout

oak reafforestation is explained by its photophily. For quite a long period of time, young individuals exist under the forest canopy and do not pass into the regrowth layer. The situation becomes worse because of frequent epizootics, spread of fungal and viral diseases, freezing of *Quercus robur* in cold winters, rising of undergroundwater level, general loss of ecological situation. In parks regrowth suffers from trampling, creating lawns and caring for them, moving, etc.

In the course of studying the stand, we came to the initial conclusion that the condition of the *Quercus robur* trees in Gagarin Park is satisfactory, and in Zagorodny Park it is unsatisfactory. On the basis of the data obtained as a result of recalculations and assessments of the vital status of trees from sample area, the index of the vital status of tree stands (In) is calculated.

The index of the vital status of the stand in Gagarin Park is equal to 0,475; in Zagorodny Park it is 0,415. The vital status of the stand is consideredas "severely damaged" with an index from 0,49 to 0,2. Thus, oak forests in the forest-steppe of the southeast of the European part of Russia represent a zonal type of green cover, which loses its position in nature and economic significance nowadays. During the last century, oak forests of the Samara region have reduced the area by a factor of 2-3, giving way to other species.

The reasons for the loss of oak forests are different, irrational economic use and environmental pollution are coming to the fore. Against this background the oak is exposed to diseases and pests, high and low temperatures, waterlogging, etc.

The main types of damage of the *Quercus robur* trees in urban suburbs and the outskirts of the city of Samara are top drying and leaf damage caused by *Erisyphaceae* fungal attack. The research data showed an extremely wide spread of *Microsphaera* on oak leaves (up to 100%) and a fluctuation range of tree top drying from 5 to 90%.

The study of seed renewal of *Quercus robur* and related breeds made it possible to identify the inviability of sprouting and small oak regrowth, as a result of which the mentioned species are gradually replaced by other tree species. In conditions of low intensity of the anthropogenic factor, oak is replacing by *Acer platanoides*; being under anthropogenic stress, the oak is replaced by the adventitious *Acer negundo* species.

Nearly across all the studied areas we noted seed reafforestation during the period of 2 years, which indicates the yield of acorns in previous years. This gives the opportunity to artificial breeding of the most valuable tree species from the seeds of local oak populations.

We have not found a vivid dependence of the degree of damage to oak stands on the location of oak groves near a large metropolis and at a distance from it. All of them are in a depressed state. However, within the city limits plant community is disturbed very much. In suburban forests they kept the natural characteristics so far.

Among the main types of plant communities in city line and green field site the following kinds of oakery are noted:

1. *Aegopodium podagraria & Tilia cordata & Quercus robur*. The dominating *Quercus robur* is an ecosystem engineer in a forest stand. *Tilia cordata* applies for a role of co-edificator. Trees are old-aged, they reach 23-26 meters in height and 45-65 centimeters in diameter. Crown density equals 0,7 (or 70%). *Acer platanoides, Betula pendula, Populus tremula, Ulmus laevis* are singular. The shrub layer is vague. *Corylus avellana* and *Frangula alnus* are registered in a small number. The shrub layer shows well developedsubgrowth of *Tilia cordata*. Renewal of tree species is characterized as seed one. However shoots of *Quercus robur* and *Tilia cordata* are non-durable, the majority of plants dies out during the first year of existence. Plant stand has spotty character. *Aegopodium podagraria dominates, Carex rhizina, Galium odoratum* and *Stellaria holostea* are shown in places. Individuals of *Anemonoides altaica, Anthriscus sylvestris, Asarum europaeum, Bupleurum longifolium, Chaerophyllum bulbosum, Dryopterisfilixmas, Pteridiumaquilinum*, etc. are registered in singular. Rare and vulnerable floral species such as *Anemonoides altaica, Bupleurum longifolium, Cephalanthera rubra, Dryopteris filix-mas, Epipactis helleborine, Paris quadrifolia, Pteridium aquilinum* are noted.

2. *Herbae stepposae & Euonymus verrucosa & Quercus robur*. The dominating *Quercus robur* is an ecosystem engineer in a tree layer. Its average height of trunks is 19 meters and its diameter varies from 16 to 40 centimeters. The following tree species are singular: *Acer platanoides, Tilia cordata, Ulmus laevis*. Crown density of a forest stand is 0,6-0,7 (60-70%). There is a good seed renewal of an oak. *Euonymus verrucosa* becomes an ecosystem engineer in a shrub layer. *Corylus avellana, Rhamnus cathartica* are noted in singular. Clumps of *Caragana frutex, Prunus spinose, Rosa majalis* are quite often seen along the margins of such communities. Grass stand is characterized by a variety of species. *Brachypodium sylvaticum, Bromopsis inermis, Dactylis glomerata, Melica nutans, Poa angustifolia* play an important role. *Ajuga genevensis, Campanula trachelium, Clinopodium vulgare, Delphinium cuneatum, Euphorbia uralensis, Fragaria viridis, Fritillaria ruthenica Hypericum perforatum, Inula salicina, Lavatera thuringiaca, Phlomis tuberosa, Sedum maximum, Thalictrum flavum, Viola canina* are noted. Conspicuous is the fact of abundance of bean plants such as *Lathyrus sylvestris, Lathyrus tuberosus, Lotus corniculatus, Medicago lupulina, Medicago romanica, Securigera varia, Trifolium repens, Trifolium montanum, Trifolium alpestre, Trifolium pratense, Vicia cracca*. Rare and vulnerable floral species such as *Delphinium cuneatum, Hypericum perforatum, Fritillaria ruthenica, Euphorbia uralensis* are noted.

3. *Herbae stepposae & Caragana frutex& Quercus robur*. *Quercus robur* is an ecosystem engineer in a tree layer. Its average height of trunks is 17 meters and its diameter varies from 15 to 35 centimeters. Crown density of a forest stand is 0,6 (60%). *Betula pendula, Populus tremula* and *Ulmus laevis* are rare. *Caragana frutex* dominates in a shrub layer. *Amygdalus nana, Cerasus fruticosa, Chamaecytisus ruthenicus, Genista tinctoria, Lonicera tatarica, Rosa majalis, Spirae acrenata* are not so widespread. Among the cereals *Poa pratensis* and

Festuca altissima can be mentioned; *Aconitum lycoctonum, Adonis vernalis, Agrimonia eupatoria, Anemone sylvestris, Aster amelloides, Astragalus cicer, Centaurea pseudophrygia, Delphinium cuneatum, Galium aparine, Galium ruthenicum, Galium tinctorium, Geranium sylvaticum, Hypericum perforatum, Knautia arvensis, Lathyrus pallescens, Lathyrus vernus, Leucanthemum vulgare, Origanum vulgare, Potentilla argentea, Pyrethrum corymbosum, Polygonatum odoratum, Pulsatilla patens, Sanguisorba officinalis, Scabiosa ochroleuca, Seseli libanotis, Senecio czernjaevii, Senecio jacobaea, Senecio erucifolius, Serratula coronata, Solidago virgaurea, Tanacetum vulgare, Veronica longifolia, Vicia cracca, Xanthoselinum alsaticum* are the members of forbs. Rare and vulnerable floral species such as *Aconitum lycoctonum, Anemone sylvestris, Adonis vernalis, Delphinium cuneatum, Hypericum perforatum, Origanum vulgare, Pulsatilla patens* are noted.

It is necessary to have a concerted strategy of rational use of natural resources caring for forest community in urbanized conditions. It can be based on functional territorial zoning, providing allocation of areas (zones) having their own natural resource users. For example, providing various forms of spending leisure time against the background of restoration and maintenance of stability of forest biogeocenoses to certain influences has to become the priority direction in a recreational zone; in a forestry and landscape zone it is reforestation. In a rezervatogenic zone the reference direction of work is connected with the implementation of the principles of active protection of biological objects, which means the arranging of monitoring of the condition of phytocenotic fund of suburban forests of Samara and a plant population genofond.

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EXPERIENCE IN THE ASSESSMENT OF NOISE DOSE FOR THE CHILD POPULATION OF A LARGE URBAN SETTLEMENT

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ABSTRACT

The current methodological approaches to noise dose assessment characterize the multiplicity of excess and do not reflect the transition to the weighted average daily equivalent level for the tasks of assessing the risk to public health. In this paper we consider methodological approaches to establish the weighted average daily level of equivalent noise on the basis of the daily dose formation of noise according to instrumental measurements taking into account the number and duration of noise events. Assessment and prognosis of the health disorders risk were carried out using approved methodological approaches to assess the risk of exposure to traffic noise MR (methodological recommendations) 2.1.10.0059-12. The developed methodological approaches are tested on the example of children's pre-school institutions (DDU) in Perm. The risks of health disorders of the child population attending kindergarten in close proximity to transport infrastructure were estimated by means of calculations, as well as the subsequent residence in the investigated area. The study found that a self-induced noise forms the main contribution to the daily dose of the child population.

Keywords: noise exposure, noise dose, noise risk assessment, average daily noise dose, weighted average equivalent noise level.

1. INTRODUCTION

According to the results of acoustic zoning of the investigated area [2, 3] the number of the exhibited population is the indicator of unfavorable environment formation by noise factor. This indicator is population-based and does not reflect the individual characteristics of a person's stay in different noise conditions. Individual dose of noise can be used as an individual assessment of noise exposure; it describes the possible violations of individual organs and systems.

"Guidelines on environmental noise", published by the world health organization (WHO) in 2018 contains a review of scientific literature on the impact

of environmental noise pollution on human health and the development of evidence-based recommendations for the public health protection from the adverse effects of noise [10]. Health disorders associated with the impact of noise factor are confirmed by numerous studies [8, 9].

In connection with the domestic and foreign authorities concerns regarding the assessment of noise impact on public health, the noise exposure assessment based on the establishment of the noise individual dose is the most relevant and reliable tool for predicting the health of the exposed population.

The purpose of this study was to assess the noise individual dose of the children's population in the conditions of stay in the territory of a pre-school institution (DDU) within the large urban settlement boundaries, associated with high traffic congestion, for the tasks of assessing the risk of possible health problems caused by the noise factor.

As the study objects the placement territory of three pre-school institutions in the city of Perm were chosen, which are characterized by high load on all transport modes: road, rail, air.

2. RESEARCH MATERIALS AND METHODS

As a fundamental document in assessing the noise factor impact on the children's pre-school population, the method of assessing the noise load dose was used based on the instrumental measurements results of noise levels for certain periods of time or individual noise events, according to the MR project "Acoustic exposure assessment based on the individual noise dose measurement for health risk assessment tasks", developed by the FBSI "FRC for medical and preventive health risk management technologies" in 2018. The proposed methodological approaches are based on the calculation of the weighted average daily level of dose through duration and sound levels of noise events calculation.

During February – August 2018, in the three surveyed DDU, more than 300 instrumental measurements of the equivalent sound level inside the control unit and in the adjacent territory were carried out in order to assess the generated levels of traffic noise. The following objects were considered as objects for evaluating noise exposure: Municipal autonomous pre-school educational institution (MADUO) “Kindergarten No. 370” (it was characterized by the background influence of city noise and was chosen as the control territory); MADOU "Kindergarten number 80" of the city of Perm (characterized by the impact of road and rail transport), Municipal budgetary pre-school educational institution (MBDOU) "Savinskiy kindergarten "Sozvezdie" (characterized by the impact of air transport).

Measurements of noise levels were taken on week days during the day (7.00 - 19.00, (Lday)) to assess the noise levels during the stay of the children's population in the DDU. At the same time, it was accepted in the study that in the evening (19.00 - 23.00, (Levening)), rest at home) and at night (23.00 - 07.00, (Lnight)), sleep at home) the children were in conditions of acceptable level noise

load according to SN 2.2.4 / 2.1.8.562-96 [7], with a sound level of 40 dBA and 30 dBA, respectively.

The public health risk assessment was carried out on the basis of the calculated equivalent weighted average daily noise (Lden), which was introduced by the European Commission Directive 2002/49/EU of June 25, 2002 [1]. When calculating the weighted average daily level, 3 time intervals were taken into account: day (Lday), evening (Levening) and night (Lnight).

The study used a methodological approach to interface instrumental and calculated data on noise exposure levels. As the calculated data, the results of acoustic calculations were used on the territory adjacent to the DDU, taking into account third-party noise sources, in particular of transport origin. The calculations were performed using the specialized software product “Ekolog-Shum” version 2.4 (“Integral” company) with the subsequent visualization of the obtained results using geo-information technologies (GIS).

An individual dose level was formed as a weighted average daily noise level with a subsequent assessment of the risk to public health according to the results of interfacing data, in accordance with the methodology for estimating dose-related noise load, based on the results of instrumental measurements of noise levels for certain periods of time or individual noise events according to MR “Evaluation of acoustic exposure based on measuring individual noise dose for health risk assessment tasks”.

The assessment of the risk to the population health was carried out according to the methodological recommendations of MR 2.1.10.0059-12 through the calculation of the reduced risk index [4].

3. RESEARCH RESULTS

On the measurements basis, noise exposure levels were obtained at the places of the child population place of stay on the territory of the DDU (indoors and on the territory). Measurements of noise levels were carried out during periods of various events corresponding to the daily regime in the DDU. The measurement results are presented in table 1.

Generalized measurement data show that, for DDU No. 370, for example, noise exposure levels of up to 68 dBA are observed, including being outside. The selected increased levels are due to the high occupancy of the groups, which proportionally increases the noise exposure in the group in general, and affects the individual dose of noise in particular. The background noise level in the area adjacent to the DDU was 46,3 dBA. The total noise exposure level, including the children's walk, was 64 dBA.

The territory of DDU No. 80 was characterized by measured levels of 71 dBA, including the daily walk, which was characterized by the proximity of the DDU from the existing railway line. The value of background noise in the area adjacent to the DDU was 55,3 dBA. The total exposure level, including the children's walk, was 68 dBA.

Table 1

The results of instrumental measurements in DDU

No	Daily regime of children staying in DDU (07.00-19.00, according to section 1-15)	Event duration (hours)	Average for the period, dBA		
			DDU № 370	DDU № 80	DDU «Sozvezdie»
1	Arrival of children in DDU, free game, independent activity	1	67	71	69
2	Morning gymnastics	0,083	68	68	69
3	Preparation to breakfast, breakfast	0,5	56	59	58
4	Games, children's independent activities, individual work with children	0,417	60	63	65
5	Organized educational activities	0,667	56	56	61
6	Second breakfast, preparation for a walk	0,167	59	62	58
7	Walk	2	64	68	66
8	Return from a walk, independent activities	0,25	66	71	69
9	Preparation to lunch, lunch	0,417	64	63	53
10	Preparing for sleep, daytime sleep	2,5	31	31	47
11	Gradual rise, gymnastics after sleep	0,333	50	46	48
12	Games, independent and organized educational activities; individual work with children	0,667	68	71	70
13	Preparation to a big branch, big branch	0,333	55	57	59
14	Games, children's independent activities, individual work with children	0,667	66	71	68
15	Preparation for a walk, walk, going home	2	67	69	71
16	Rest at home 19.00-23.00	4	40	40	40
17	Sleep at home 23.00-07.00	8	30	30	30

Measurements in DDU "Sozvezdie" were formed at the level of 71 dBA in certain periods of children´s stay in the DDU. At the same time, the background noise in the adjacent territory was 52,6 dBA, the total exposure level, including

walk, was 66 dBA. It should be noted that the absence of increased noise levels during the periods of state aircraft flights is due to the absence of children in the adjacent territory to the DDU, the exposure inside the DDU is reflected in the measurement results.

4. RESULTS OF ACOUSTIC CALCULATIONS

For the purposes of noise exposure assessment it is advisable to use the acoustic calculations results in addition to the instrumental measurement in order to assess the impact of external sources on the levels inside and to account the other noise sources in the background [5].

The placement area of the DDU No. 370 is characterized by the zone of acoustic silence and the general background influence of city noise. DDU is located in the second echelon of capital construction objects relative to the nearest sources of noise - urban roads along the streets of Parkovyi Avenue, Podlesnaia str., Commissar Pozharskii str., Zheliabov str. The contribution of rail transport in the territory of the DDU is absent due to the significant distance from the railways.

According to the results of acoustic calculations, it was found that in conditions of high traffic intensity (on average, up to 24,336 cars per day pass through the most busy highways), the calculated noise levels in the area of the DDU location were set at 40–45 dBA, which corresponds to the established hygienic standards for residential areas [7].

DDU number 80 is located in an area that is characterized by the acoustic influence of the railway and background pollution of the city's largest highway. There is no significant accumulation of capital construction objects around the DDU, which excluded noise levels screening of transport infrastructure facilities on the DDU.

Acoustic calculations showed that in conditions of high traffic intensity (on average, up to 41,520 cars per day pass through the lane of the largest highway, Stakhanovskaia-Chkalov) and rather heavy traffic on the main line (up to 3 pairs of trains per hour), the estimated noise levels in the DDU's location were formed at the level of 60–65 dBA, which does not meet the established hygienic standards for the residential area [7].

The DDU "Sozvezdie" area was characterized by the acoustic impact zone of air transport and was located under the distribution of the take-off and landing zones of civil and state aviation at a distance of about 500 meters from the take-off course, and at a distance of 1400 meters from the RWY. The DDU was located in the village of Vaniuki, Perm district, on the Zelenaia str. The territory of the DDU location did not have a significant accumulation of capital construction objects, which excluded screening of noise levels of transport infrastructure facilities on the DDU, and namely the flights of civil and state aircraft.

The results of acoustic calculations showed that in conditions of high traffic intensity (on average, 38280 cars pass through the Perm-Kultaevo main hihgway per day), the calculated noise levels in the area of the DDU are at 55 - 60 dBA, which meets the established hygienic standards for residential areas (55 dBA) [7].

5. ESTABLISHMENT OF AN INDIVIDUAL NOISE DOSE

According to the developed methodological approaches, an individual noise dose in each DDU was calculated, based on the results of instrumental studies in places of children stay.

According to the results of the individual dose of noise calculation, according to the regime of children's stay in the DDU, for the investigated areas, the following results were obtained:

– children's population of DDU № 370 was characterized by an equivalent level of weighted average daily noise of 61,1 dBA, which formed an excess of the average daily dose of noise by 22,2 times;

– The children's population of DDU No. 80 was characterized by an equivalent level of weighted average daily noise of 64,3 dBA, which formed an excess of the average daily dose of noise by 46,6 times;

– the children's population of the DDU "Sozvezdie" was characterized by an equivalent level of weighted average daily noise of 63,8 dBA, which formed an excess of the average daily dose of noise by 41,8 times.

6. PUBLIC HEALTH RISK ASSESSMENT

Within the framework of this study, the health risk assessment of children visiting the DDU was carried out, according to MR 2.1.10.0059-12 [4] in order to justify the harmful effects of the noise factor.

The following results were obtained in the framework of the hygienic study "Public health Risk Assessment":

– for children attending pre-school educational institution No. 370 from the age of 3 and, in the long term, living in the exhibit area throughout their lives, the following risk levels were formed under conditions of an equivalent level of weighted average daily noise by 61,1 dBA: moderate risk of cardiovascular system disorders occurs by the age of 52, with a transition to a high by the age of 85, and an extremely high by the age of 87; moderate risk of nervous system disorders occurs at age of 65; moderate risk of hearing organs disorders is not formed.

– In DDU № 80 an equivalent level of weighted average daily noise was formed by 64,3 dBA, which formed the following risk levels, provided living from 3 years and throughout life: a moderate risk of the cardiovascular system disorders occurs by 25 years with a transition to high at the age of 57, extremely high at the age of 66; moderate risk of nervous system disorders occurs at the age of 56; moderate risk of hearing organs disorders is not formed.

– for children visiting the DDU "Sozvesdie" from the age of 3 and, in the long term, living in the exposed area throughout life, in conditions of an equivalent level of weighted average daily noise of 63,8 dBA, the following risk levels were formed: a moderate risk of the cardiovascular system disorders occurs at the age of 27 with the transition to a high at the age of 60, in an extremely high – at the age of

68; a moderate risk of nervous system disorders occurs at the age of 57; a moderate risk of hearing organs disorders is not formed.

Table 2 presents a summary table of the critical age points of risk transition from one category to another. It is worth noting that for the risk assessment purposes, the individual dose of noise is considered as a measure of human contact with the noise factor throughout life.

The highest level, equivalent to the weighted average of the daily noise was formed in the kindergarten № 80 and amounted to 64.3 dBA.

Table 2

Critical age points of risk transition from one category to another

Point number	Noise level, dBA	Age of transition from low to moderate risk			Age of transition from moderate to high risk			Age of transition from high to extremely high risk		
		Hearing	Cardiovascular system	Nervous system	Hearing	Cardiovascular system	Nervous system	Hearing	Cardiovascular system	Nervous system
1	2	3	4	5	6	7	8	9	10	11
DDU No. 370	61,1	-	52	65	-	85	-	-	87	-
DDU No. 80	64,3	-	25	56	-	57	-	-	66	-
DDU «Sozvezdie»	63,8	-	27	57	-	60	-	-	68	-

*A dash in the table “-” indicates that an unacceptable risk for a given organ or system under the influence of a noise factor is not formed.

7. CONCLUSIONS

The hygienic study results to assess the noise factor impact on the health of the child population attending DDU, using the methodology for estimating an individual dose of noise, led to the following conclusions:

– at all stages of the hygienic assessment according to the regime of the day of the DDU exceeding of the established hygienic standards for premises and dormitories in the DDU according to the SN 2.2.4/2.1.8.562-96 were observed, with the exception of daytime sleep (for DDU No. 370 and No. 80), due to the presence of children in the DDU, which is the main source of noise inside. Results of instrumental measurements show and prove that the main source of noise, in

particular indoors, is the self-induced noise typical for the person or group of persons;

– for certain territories levels of background noise pollution in the territory of the DDU without the presence of children were formed within the established maximum permissible levels (MPL) – 46,3 dBA and 52,6 dBA for the DDU No. 370 and the DDU “Sozvezdie”, respectively. Background noise pollution in the territory of the DDU No. 80 was slightly exceeded and amounted to 55,3 dBA. It can be concluded that the urban noise sources do not form significant excess noise levels;

– the total noise exposure on the territory of DDU (traffic noise and children stay) exceeded the MPL for all investigated territories: kindergarten No. 370 – 64 dBA, kindergarten No. 80 – 68 dBA, kindergarten "Sozvezdie" of 66 dBA;

– Exceeded levels of noise exposure in DDU No. 370 are due to the high occupancy of the groups; in DDU No. 80, they are due to the proximity of the railway. The absence of increased noise levels during periods of flight of state aircraft in the DDU "Sozvezdie" is due to the absence of children in the territory of the DDU during the period of the aircraft flight;

– assessment and management of noise exposure is truly individual in nature, associated with the mode of life of each person individually;

- the proposed methodological approaches allow to assess and make a forecast of the situation development when a person is exposed to noise with a subsequent reduction or exclusion of a person harmful effect.

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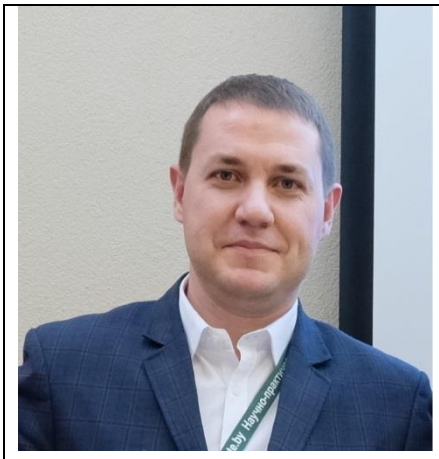

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ECOLOGICAL AND SOCIO-ECONOMIC SIGNIFICANCE OF THE STUDY OF THE "HABITAT - HYDROBIONTS" SYSTEM IN THE RESERVOIRS

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ABSTRACT

Water occupies a special position among the natural resources of the Earth, meeting the needs of ecological systems, the biosphere and a single biogeochemical cycle as a factor of continuity of life on the earth's surface, as well as the development of the economy and prosperity of mankind, food security and the preservation of humanity as a species on Earth. The ecological problems of the unique Volga basin with its catchment area, which makes up a third of the European territory of Russia, undoubtedly of national importance. The article is devoted to the problems that arose after the creation of reservoirs on the Volga; the main processes that threaten the environmental safety of water and aquatic biological resources of the Volga reservoirs are considered. A special role is played by the expansion of the network of environmental monitoring and research of the "habital – hydrobionts" system as a complex chain of interdependent links that determine the quality of water and aquatic biological resources.

Keywords: environmental safety, reservoirs, environmental monitoring, hydrobiont, system, quality, water

The results of ecological experiments obtained based on a large number of hydrological, hydro-chemical, hydrobiological data by methods of mathematical modelling are considered. The prediction of optimal water levels in different phases of the water regime of the largest Kuibyshev reservoir in Russia and Europe per the environmental requirements for water quality and criteria favorable for the reproduction and conservation of fish stocks. In General, the data obtained indicate the consistency of the optimal level regime of the reservoir both in terms of water

quality requirements and criteria favorable for fish reproduction. The predicted average optimal water level of the Kuibyshev reservoir corresponds to the category of water “moderately polluted”. For the category of “clean” water, the predicted water level exceeds both the normal and forced retaining level and is unrealizable, as it can lead to emergencies at hydroelectric power plants.

The low water period generally contributes to an increase in the level of water pollution in reservoirs. In combination with favorable temperature conditions, it contributes to the development of eutrophication processes and water pollution with a wide range of toxic metabolites - cyanotoxins, dangerous for fish, near-water animals, for humans, which are not taken into account in monitoring programs.

The multilevel system for assessing the status of fish populations of various ecological groups under the conditions of regulated runoff under the RFBR grant and increasing pollution levels, developed by the authors of the article, requires new approaches to the subsystem for monitoring surface water quality, which is the first level of the system for assessing the status of fish populations. The development and implementation of “biologically early warning systems” (BEWS), designed for the rapid detection of emergency and emergency environmental situations, makes it possible to control a greater number of chemical compounds and integrated risk assessment from environmental pollution by unaccounted for chemical compounds, to obtain a direct response biological system for habitat quality, hazard registration at the earliest stages. Of considerable interest is the use of the characteristics of the behavior of fish as biosensor organisms in the prototype of the biological monitoring system TrackTox-Fish, developed at the Department of Applied Ecology, Kazan Federal University.

A general characteristic of the habitat is the first level of the system for assessing the status of fish populations and precedes the next ichthyological analysis, combined with a massive pathological study of individual fish individuals. The creation and implementation of the new “TrackTox-Fish” biologic-electronic water quality registration system to the first level of the system for assessing the status of fish populations using fish as test objects will be useful for prompt response to the current situation in order to prevent a decrease in fish reproduction and the proportion of individuals with anomalies in development in reservoirs.

Water security is one of the basic human needs on Earth. Water occupies a special position among the Earth's natural resources, satisfying the needs of ecological systems, the biosphere and the unified biogeochemical cycle as a factor of “continuity of life on the Earth's surface”, the basis of life on the planet [1, 2], as well as the development of the economy and the prosperity of mankind, ensuring food security and the preservation of humanity as a species on Earth. Consequently, sustainable development, preservation of the biosphere and life on Earth are impossible without understanding in society of the special irreplaceable role of water as one of the greatest values. Therefore, the most important task is to attract the attention of the scientific community to solving problems of improving

the ecological state of aquatic ecosystems, preserving biodiversity and improving the conditions for reproduction of aquatic biological resources, drawing public attention to the special role of water in life on Earth, to the need for its economical and reasonable use, and preventing its pollution. Further ignoring water security issues is a real threat to sustainable development [3].

Russia a special responsibility before humanity for the preservation of this indispensable natural resource. Ecological problems of the unique Volga basin with the catchment area [3], which makes up one-third of the European territory of Russia, are of undoubted national importance. Prevention of pollution of the Volga basin, improvement of the ecological state of the Volga and its tributaries, restoration and improvement of the quality of its waters are envisaged by the priority federal project "Improvement of the Volga" operating in Russia in accordance with the list of instructions of the President of the Russian Federation V.V. Putin dated 05.12.2016 No. Pr-2346. In this regard, the idea [4] of adopting the federal law "On the Protection of the Volga River" (similar to the federal law of 1999 "On the Protection of Lake Baikal") is of great importance for the comprehensive and systematic consolidation of measures aimed at ensuring environmental recovery and preserving unique water Volga river systems.

Beginning in 1935, after the construction of hydroelectric power plants and the conversion of the Volga into a cascade of reservoirs, the usual course of the river was forever violated, its properties radically changed, the quality of water sharply worsened, and the self-cleaning of the Volga decreased. The pressure on the Volga many times exceeded the load on water resources on average in Russia [5]. The pressure on aquatic ecosystems, essentially of the “producers” of natural water, has increased; hydrobionts, including migratory fish populations (sturgeon, salmon), which were blocked from spawning places, and this is direct damage to the country's former wealth.

In connection with the problems arising after the creation of reservoirs on the Volga [5, 6], including Kuibyshevsky, a special role was played by the expansion of the network for monitoring the state of their aquatic and aquatic biological resources [7, 8]. A wealth of experience has been accumulated in scientific and technical support of technical, technological and economic solutions, taking into account the requirements for the quality of aquatic and aquatic biological resources.

The level regime of reservoirs as one of the most important factors determines the quality of surface water resources, leading to increased pollution with a low-level regime [9]. Of interest are two independent environmental experiments carried out by the authors of the report in recent years at the Kuibyshev reservoir - a reservoir of seasonal regulation of the water level [10, 11]. Based on a large array of hydrological, hydro-chemical, and hydrobiological data, the methods of mathematical modeling are used to predict the optimal water levels in different phases of the water regime in accordance with environmental requirements for water quality, on the one hand, and criteria favorable for the reproduction and preservation of fish stocks, on the other.

Based on the forecast model of the influence of the level regime of the Kuibyshev reservoir on the formation of water quality, the optimal level regime of 52,5 – 51,5 m BS (Baltic Height System), as well as the minimum permissible water level (50,5 m BS) under environmental quality requirements are scientifically substantiated water (except in winter due to fewer monitoring data).

Based on many years of comprehensive research, a model of the influence of the level regime on the formation of fish stocks in the Kuibyshev reservoir has been obtained. The optimal level regime of the Kuibyshev reservoir, favorable for fish reproduction, was in the range of 53,4 – 49,0 m BS.

The optimal level regimes of the Kuibyshev reservoir in different phases of the water regime that meet environmental requirements for water quality and are favorable for fish reproduction are shown in the table.

The optimal level regime in different phases of the water regime of the reservoir, meeting environmental requirements for water quality and favorable for fish reproduction, is presented in table 1.

Table 1

The optimal level regime in different phases of the water regime of the reservoir

Phases of the water regime of the reservoir	Level mode *) taking into account the main environmental requirements for the quality of water resources, m BS	Level mode **), favorable for the reproduction of fish, m BS
Spring flood/ high water	avg. 52,0; min 51,0	53,0
Summer-autumn low water level (baseflow)	avg. 52,0; min 50,0	-
Summer period	-	≥ 52,0
Autumn period	-	Early discharge of the water level in the reservoir - up to 51,0
Winter period	51,0*)	The gradual discharge of the water level in the reservoir - ≥ 49,0

Note. *) Since information on monitoring water quality in winter is limited, the result obtained for this time of the year should be considered only as preliminary and requires additional research.

The water quality of the reservoir is most affected by the water level during the flood and summer-autumn low-water periods, while during the winter low-water period, level fluctuations have a weak effect on water quality. Accordingly,

the desired optimal water levels of the Kuibyshev reservoir differ according to the constructed models for different hydrological regimes.

In general, the data obtained indicate the consistency of the optimal reservoir level regime both in terms of water quality requirements and criteria favorable for fish reproduction, i.e. the “habital – hydrobionts” system as a complex chain of interdependent relationships - reacts similarly to the external influence of the same factor (water level) in full accordance with the ecosystem concept.

The predicted average optimum water level of the Kuibyshev reservoir corresponds to the category of “moderately polluted” water. For the category of “clean” water, the predicted water level exceeds both normal and forced support level (FPU) and is unrealizable, because excess FPU can lead to overflow over the crest of the dam and to other emergencies at hydroelectric power stations.

The low water period generally contributes to an increase in the level of water pollution in reservoirs. In particular, in combination with a favorable temperature regime, it contributes to the development of eutrophication processes, an increase in the number and biomass of cyanobacteria, with one or more species dominating in the species composition [12, 13]. The course of these processes contributes to water pollution with a wide range of toxic metabolites - cyanotoxins, dangerous for fish, near-water animals, and also for humans [14, 17, 18]. Cyanotoxins are still not included in the program of extended tests of water quality in eutrophic freshwater water sources [19], as if they do not officially exist, therefore, at present, the content of these unaccounted-for hazardous compounds is determined only for research purposes.

The authors of the report developed a multilevel system for assessing the status of fish populations of various ecological groups under the conditions of regulated runoff RFBR grant and increasing pollution levels require new approaches to the surface water quality monitoring subsystem, making it possible to control a greater number of chemical compounds, including chemicals, information on the content of which is absent in the water, taking into account the integrated assessment of risks from environmental pollution to assess the direct response of biological their systems, including the status of fish populations, and making adequate decisions habitat monitoring is the first level of a system for assessing the status of fish populations.

One of the solutions to this problem may be the development and implementation of “biologically early warning systems” (BEWS), designed for the rapid detection of emergency and emergency environmental situations [20]. In the development of early biological warning systems, the principle of instrumental bio testing is applied, when test organisms, biosensors, serve as operational alarms for the occurrence of a dangerous level of water pollution, and the functional indicators of organisms are recorded automatically in the hardware part of the system without operator intervention. Fish, mollusks and crustaceans are mainly used as bioindicators in early warning systems [21], and the parameters of heartbeat, the optical density of the medium, and movement of organisms or body parts are most often recorded as functional indicators.

Such an approach makes it possible to identify a dangerous situation when traditional methods of physicochemical monitoring are insufficient or may fail. This is because existing approaches are focused on the definition of a regulated limited list of indicators. In the case of the appearance of ingredients in water that are not taken into account in standard control, the level of environmental risks increases, which can lead to harm to ecosystems, aquatic biological resources and human health. Biological monitoring approaches based on an integrated assessment of environmental quality can register a hazard at the earliest stages, for the widest list of pollutants, thus ensuring the possibility of an operational response to the current situation and, as a result, ensuring environmental safety of the environment and lowering the level of environmental risk [22].

Of considerable interest is the use of fish behavior characteristics as biosensor organisms in the prototype of the TrackTox-Fish biological monitoring system (Figure 1), developed at the Department of Applied Ecology, KFU [23]. The system is designed for continuous monitoring of water quality in both flowing and static modes. Organisms are monitored on-line using computer vision technology implemented in a specialized program [24].

Figure 1 - Components of the TrackTox-Fish bioelectronic water quality registration system

The system consists of a climate chamber (1) providing stability of thermal and light conditions, inside which an aquarium with analyzed water is placed (2), the parameters are controlled from an external computer station (3). The analyzed water, which has undergone initial aeration and filtration (4), is pumped (5) to the aquarium and evaluated by test objects, which are continuously monitored using a video system (6). As organisms-biosensors are fish (7), in our case *Danio rerio* (Cyprinidae), but it is possible to use other species, for example, guppies or aboriginal representatives of ichthyofauna. The behavior of test organisms is evaluated using computer vision technology by an external computer station. The main recorded reaction is the speed of swimming; additionally, the following indicators are estimated: the distribution of fish in the aquarium (coordinates, depth

of swimming), the distance traveled, and the orientation of the fish body in space. Incoming information is automatically processed, water quality assessment is formed and visualized on the screen (8). In case of danger detection, an alarm is triggered.

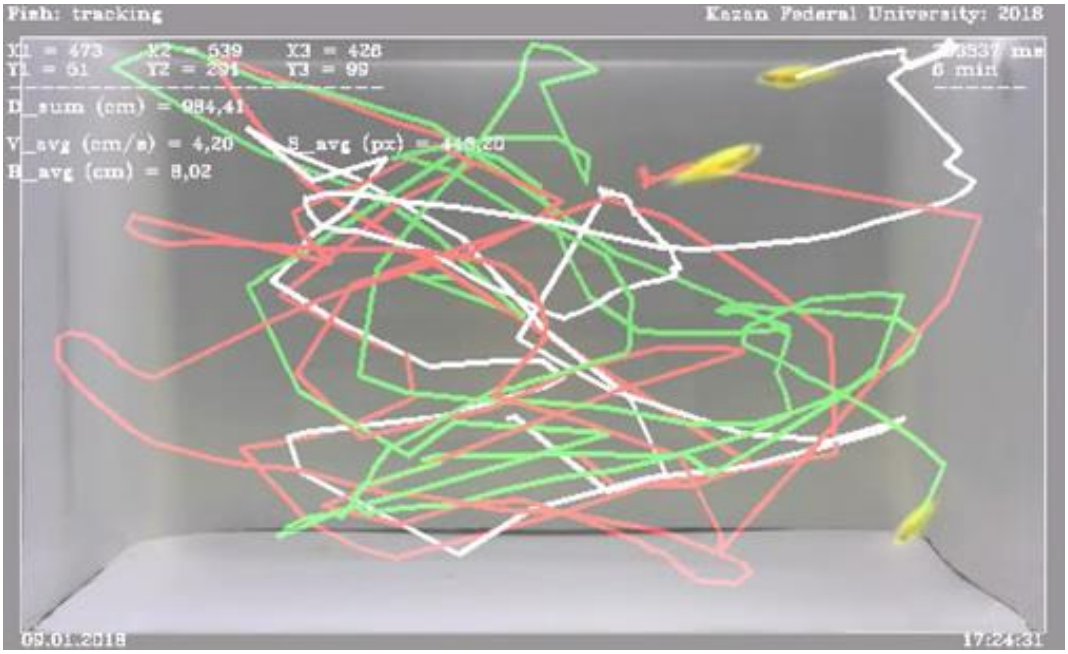

Figure 2 - Visualization of the movement tracks of three zebrafich in control conditions

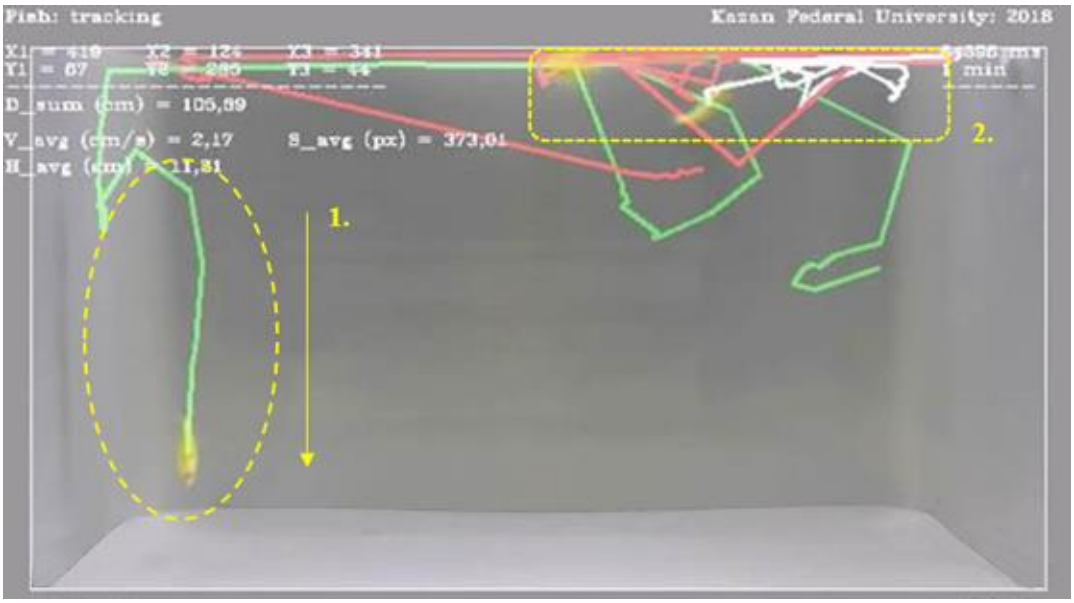

Figure 3 - Visualization of the movement tracks of three zebrafich in conditions with a toxicant (characteristic changes in movement: 1 - “sinking” movements, 2 - concentration at the surface)

As an example, tracks of fish swimming for 1 minute under normal conditions (Figure 2) and under conditions of toxicant entry into the aquatic environment (esfenvalerate pesticide at a concentration of 0,03 mg L^{-1}, Figure 3) are given.

The developed bioelectronic system “TrackTox-Fish” allows you to quickly detect hazardous pollutants (in the above example from the first minutes after the addition of the toxicant) and as a result – to ensure the environmental safety of surface waters by reducing the level of environmental risk

The implementation of the early biological warning system will allow to achieve: increasing objectivity in environmental monitoring; informing about the state of the environment in real time; the possibility of taking into account the danger of unaccounted substances; integrated assessment of risks from environmental pollution, taking into account the multi-component, combinatorial effect between substances; increasing the interpretability of the data, due to the direct response of biological systems to the quality of the environment.

General characteristics of the environment is the first level of the system of assessment of fish populations and is preceded by the following ichthyological analysis, combined with mass autopsy study [25] separate species of fish.

The creation and implementation of the new TrackTox-Fish biologic-electronic water quality registration system at the first level of the fish population assessment system using fish as test objects will be useful for a quick response to the current situation in order to prevent a decrease in fish abundance and the proportion of individuals with anomalies in development in reservoirs.

ACKNOWLEGEMENTS

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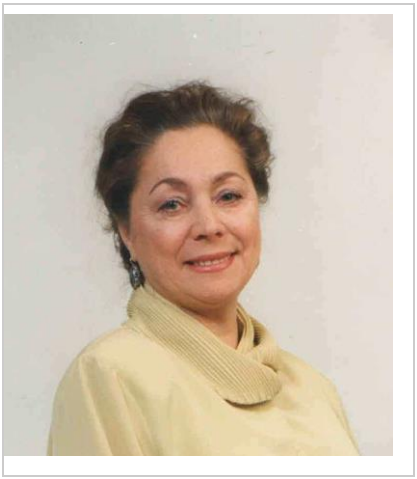

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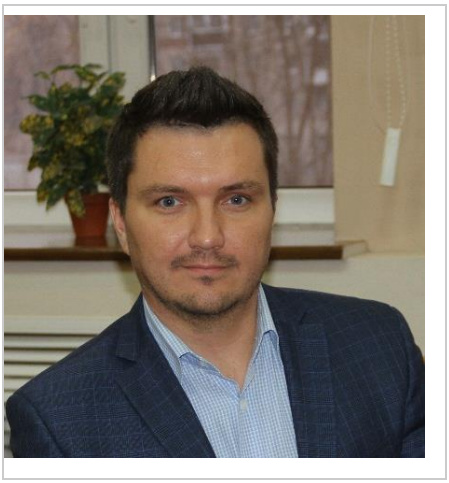

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SEVENTH INTERNATIONAL
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INTERNATIONAL APPROACHES TO INFRASOUND MONITORING AND MAPPING

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ABSTRACT

Today the acoustical noise pollution, especially in the medium high frequencies, is well modeled and monitored, especially in open space and in the urban environment. Also its auditory and extra-auditory effects are known. On the contrary the infrasonic region of the spectrum is still under investigation. The first study on the presence of the infrasound in air is going back to the end of the 19th century and its effects on the human beings are still investigated. Infrasonic wave has the property to have low attenuation while propagate in the atmosphere and this physical characteristic has been exploited to geo locate natural and man-made sources. This paper is a comparison of two methodologies used to report information on infrasound able to evaluate risks on human beings.

Keywords: Infrasound, noise, estimation, mapping, exposure, risk

1. INTRODUCTION

Infrasonic waves are acoustic waves whose frequencies are below the audible frequency band, ranging from 20 Hz to 20 kHz. They are produced by a variety of natural and man-made sources such as sea waves wind turbulence, meteors, exploding volcanoes, earthquakes, nuclear and chemical explosions, land and air transport, rocket launches industrial plants etc.

One of the characteristics of the infrasound waves is that they can propagate in air for several kilometers, as shown in table 1, due to their low frequencies and related low air absorption.

Table 1

Infrasound sources, their main frequency band and detection distances

Event type	Main Frequency band	Distance from source	References
Small nuclear explosions	0.01–0.4 Hz	250 km -5300 km	[1 Whitaker2006]
Volcano Etna	> 0.5 Hz	600Km	[2 Tailpied 2013]
Rocket	0.1-10Hz	9 km	[3 Stubbs 2005]
Sea wave/surf	1-9Hz	< 10 km	[4 Le Pichon2004]
Earthquake	0.1 Hz	1800km	[5 Cansi 2008]
Bridge	6-8 Hz	8 km	[6 Donn 1974]
Rock fall	7.5-20 Hz	< 1 km	[7 Johnson 2015]

When the infrasound sound pressure level is sufficiently high, humans can feel the near infrasound both as hearing and as tactile sensation or vibration [8]. In fact at 20 Hz the audibility threshold is around 85 dB and gradually increase as frequency decreases [9].

Infrasound produce negative effect on humans and the first studies on the effects of the human exposition to high level infrasound go back to the World War II [10]. Effects due to lower pressure level infrasound, under the hearing threshold are still under study.

In the next paragraphs will be shown two methodologies we have adopted in order to present data of the infrasound pollution able to evaluate risks on human beings.

2. INFRASOUND MODELING AND MAPPING

2.1 Infrasonic descriptors

The units and the descriptors used in the infrasound band are defined according to the scope of the measurement or assessment of an infrasound event such as nuclear explosion, volcano eruption, atmospheric event, power plant, wind turbine, etc.

For example in the ISM station the Pascal and its submultiples are used to quantify the amplitude of the infrasound wave recorded.

In acoustic environmental monitoring the weighted and un-weighted equivalent level are widely used to quantify the total sound energy measured over a stated period of time. For example In Russia Infrasound legislation specifies of using the un-weighted equivalent level [11], while in Italy the assessment criteria are not yet defined.

As in acoustics sound is filtered in order to correlate measured sound pressure level with the subjective human response, for the infrasound it has been

introduced the G filter or G weighting curve that emphasize the low frequency below the 20 Hz.

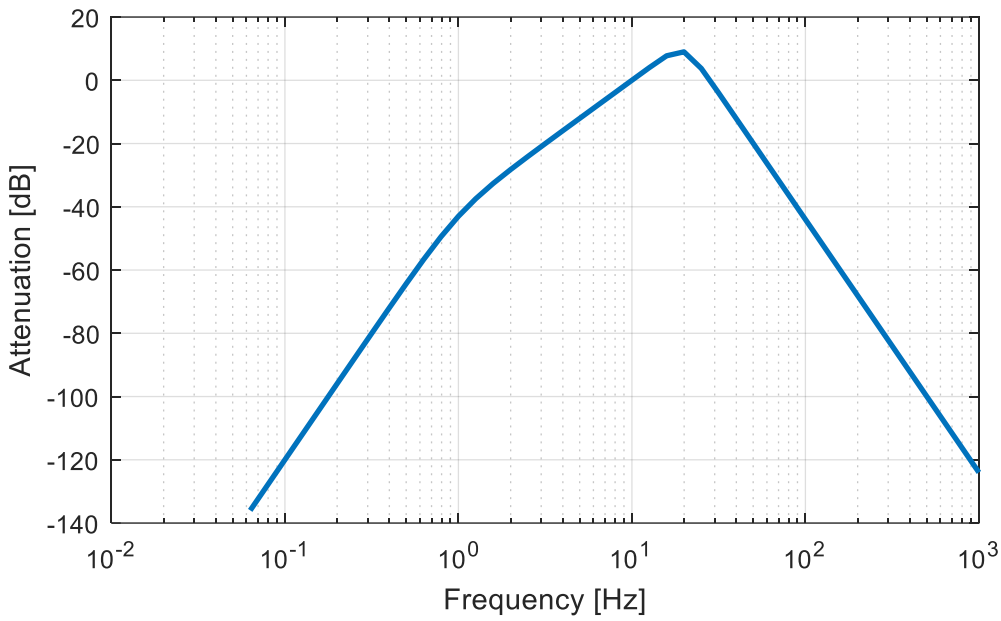

Figure 1 - G Weighting curve

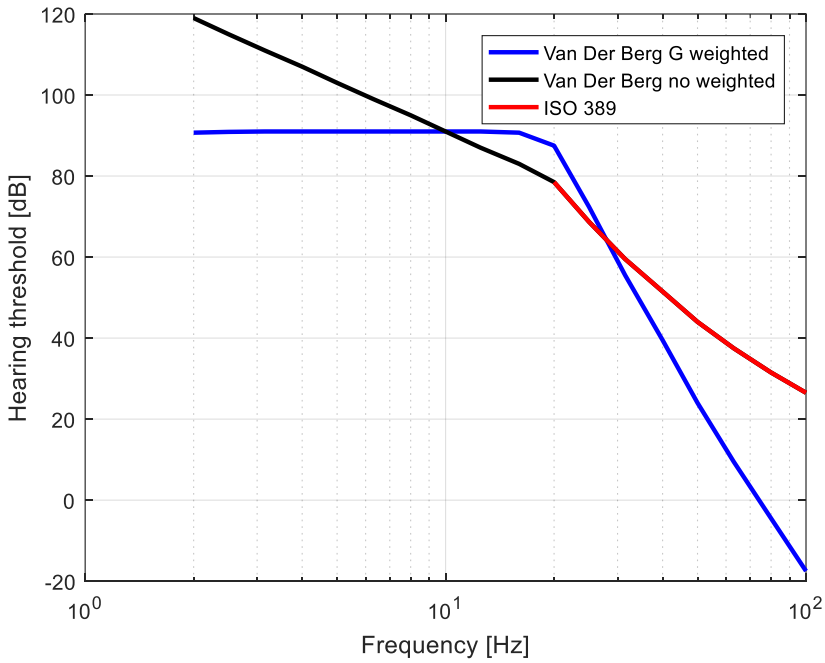

Figure 2 - Infrasonic hearing threshold level: un-weighted black, blue weighted G in blue

The introduction of the weighing curve G [12] by the International Organization for Standardization (ISO) was dictated by the need to make up for the ineffectiveness of the weighing curve A for the evaluation of noise with strong low-frequency spectral components [13,14].

The curve G has a slope of 12 dB per octave from 2 Hz to 20 Hz, as shown in Figure 1, in order to compensate the curve described by the hearing threshold of the human ear in the infrasonic interval [15] [9]. This choice is useful to match the response of the human ear and to have an evaluation that most resembles the human perception of low frequencies including infrasound.

Figure 2 shows the curves corresponding to the audibility threshold according to the values reported by Van den Berg for the 50% of the examined sample [15] and the values defined by the standard ISO 389-7 [16]. The values in the infrasonic interval keeping the slope of -12 dB / octave as defined by Møller [9]. Then the curves were weighed with the G filter. It is observed that the curves in the 2 Hz ÷ 16 Hz range were linearized to about 91 dB(G).

According to Roberts [17] the audibility threshold level is between 95 ÷ 100 dB(G), for each band 2 Hz ÷ 16 Hz, while levels between 85 ÷ 90 dB(G) should not be heard.

2.2 Infrasound propagation model

Infrasound, as a sound, propagates by mean of the air. The properties of sound propagation in the atmosphere are depending mainly by two atmospheric properties: temperature profile and dissipative processes. The vertical temperature profile of the atmosphere sets the variation of the sound velocity with height [18] and the dissipative processes determines which acoustic frequencies can propagate. Another factor that influences propagation path is the wind field that changes the temperature profile [3].

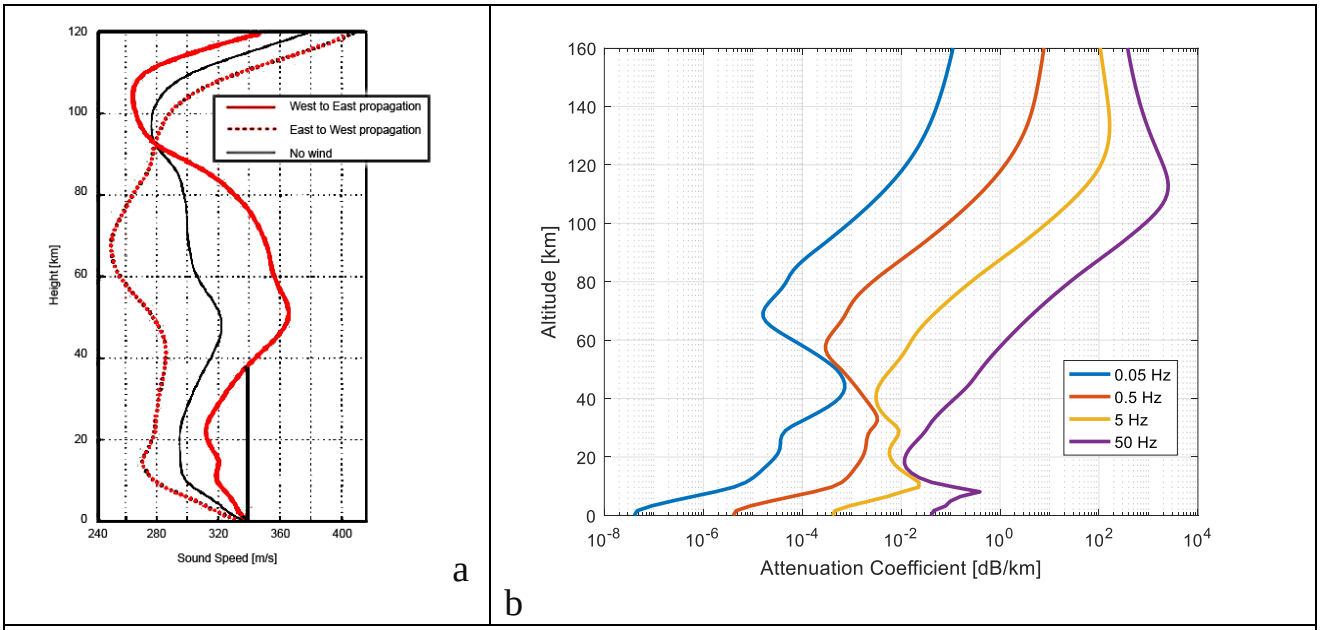

Figure 3 - a) Vertical sound speed profile affected by wind; b) Infrasound and sound attenuation during vertical propagation at different frequencies calculated according to Sutherland and Bass formulas [17]

In order to model the infrasonic wave attenuation along the ray path dissipative and adiabatic processes have been considered other than temperature, humidity and pressure.

ISO 9613-1 model for the air absorption is not suitable to evaluate the right attenuation at very low frequency and altitude over 10 km [19]. The condition of frequency to pressure ratio greater than 0.0004 Hz/Pa is not satisfied for frequency less than 40 Hz at 1 atm. Sutherland and Bass developed an appropriate model [18] for low frequency and vertical propagation up to 160 km.

It is a more complete model than the ISO standard in that it includes additional absorption mechanisms that were previously neglected. This model considers four primary gas components, O_2, N_2, CO_2, and O_3. Typical profiles of attenuation coefficient at frequencies of 0,05, 0,5, 5 and 50 Hz, calculated according to Sutherland and Bass formulas [18], are shown in Figure 3.

Using Matlab [20] and implementing the atmospheric absorption, ATM, given by eq. 1 and eq. 2 it is possible to evaluate the absorption along a ray path, for each frequency, in order to create a map frequency dependent.

$$ATM = \int_{\gamma} \alpha \frac{dr}{1000} \quad [\text{dB}], \tag{1}$$

$$\alpha = \alpha_{cl} + \alpha_{rot} + \alpha_{diff} + \sum_{i} \alpha_{vib,i} \quad [dB/km], \tag{2}$$

where γ - the infrasound ray path;

α - the atmospheric attenuation coefficient, expressed in dB / km;

α_{cl} - the classical losses;

α_{rot} - the rotational losses;

α_{diff} - the losses due to diffusion;

α_{vib} - the vibration relaxation losses due the ith constituent gas of the air, whose values depend on the frequency, on the atmospheric temperature and relative humidity conditions along the wave path (vertically and horizontally);

r - position vector.

2.3 Infrasound 3D mapping

Usually mapping is performed by numerical simulation based on 3D ray-tracing, parabolic equation (PE), time-domain parabolic equation (TDPE), finite element (FE) [21, 22]. They can be time dependent or frequency dependent propagation model.

The frequency-dependent propagation model has the advantage to consider effects such as diffraction and scattering that are not explained by geometric approximations or ray-tracing method. The accuracy of the simulation of long range infrasound propagation depends on the fidelity of the atmospheric

characterization that is affected by temperature, humidity, wind speed, and wind direction.

Short range propagation depends by diffraction and scattering due to obstacle or surface shape.

Simulation validation is performed comparing the results with spot measurements taken in different points of the simulation area.

A 2,5D engine for infrasound propagation simulation using PE equation has been developed in MATLAB by authors. It is still under test and validation.

In our simulator, waves are assumed to travel as planar waves. The refraction in the atmosphere, due to the sound speed changes in the vertical profile, and the reflection at ground are responsible of the propagation of infrasound over many thousand kilometers as shown in figure 4, where the colors represent infrasound pressure level.

It is been evaluated considering a sound profile of Figure 3a with no wind, the attenuation coefficients of figure 3b, a monochromatic source emitting a SPL of 100 dB at the frequency of 0,05 Hz placed at ground level and only six rays starting with different angles, respectively 1°,5°,15°,30°,45° and 60°, from ground.

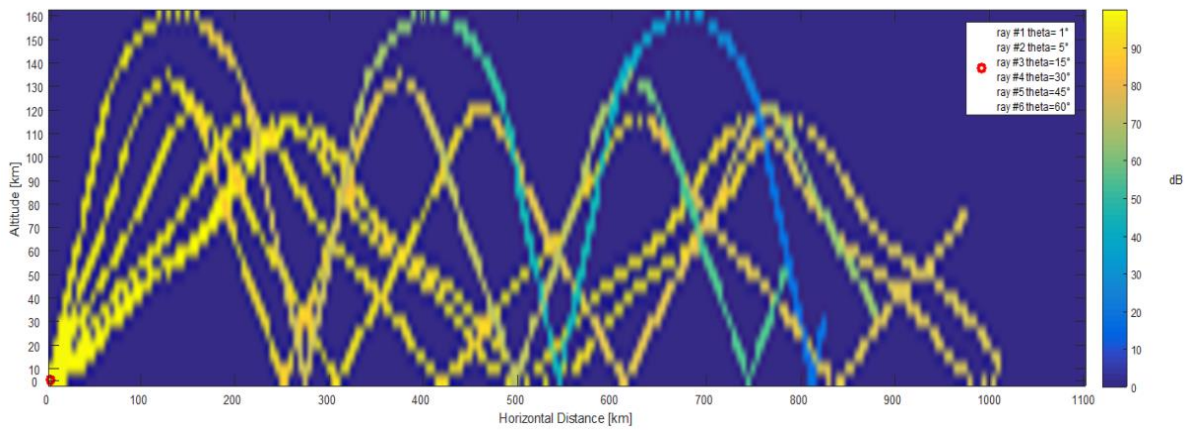

Figure 4 - Example of acoustic ray tracing of six rays with different starting angles from a monochromatic source of 100 dB at 0,05Hz placed at ground level

The data shown by simulator can be also weighted using the G curve in order to assess the risks related to the pressure level of the infrasound.

But nowadays there is international disagreement on which are the infrasound levels that generate annoyance or disturbance and hence there are no standard roles to evaluate the exposure of the population to the infrasound [23, 24].

Figure 5 represents a simulation result of a wind turbine modeled with a spherical source placed 30 meters over valley floor surrounded by mountains located in the Benevento province (Italy).

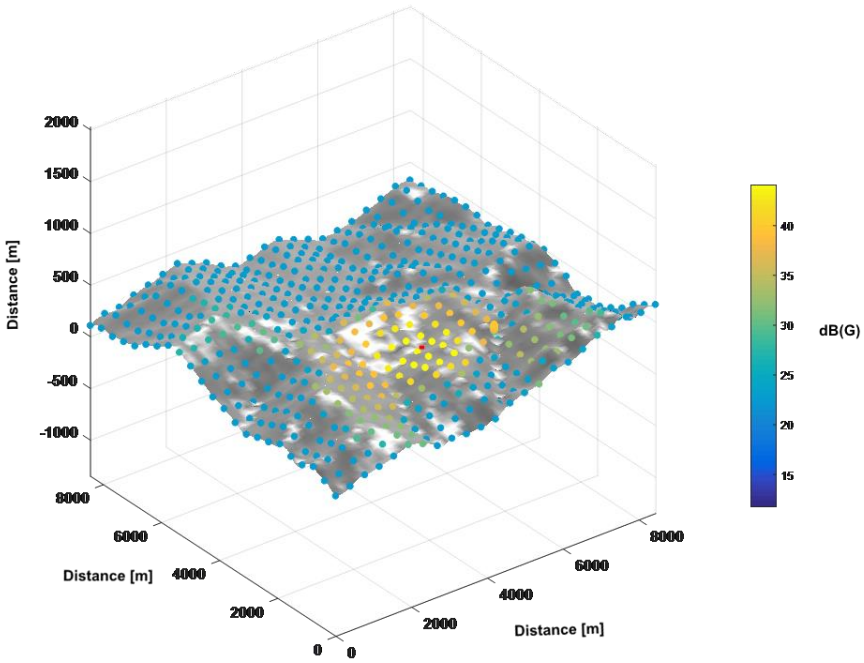

Figure 5 - G-weighted sound pressure level map as a result of the simulation of noise propagation emitted by a wind turbine in Benevento province (Italy)

2.4. Russian approaches to infrasound and low frequency noise modeling of propagation

There are the different methods of infrasound mapping. One of them 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, infrasound dangerous zones are marked. There is possibility of infrasound situation forecasting in the living territories which are similar to the investigated territory. The scale of map may be completely different and depending on the required task: city map, districts maps, neighborhood units maps and even living houses maps. Rapid development of computing technique allows to automate the process of infrasound maps creation. Modern computers with high velocity proceeding huge volume of information as static, as graphical. As result, a lot of companies are suggesting different types of city noise and infrasound maps. For example, there are well known «LIMA» and «SoundPLAN» program provision.

The signing of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) [25] on 24 September 1996 and the establishment of the International Monitoring System (IMS) for Treaty verification has led to a rapid development in the use of infrasound monitoring technology for the detection of nuclear explosions. The IMS includes a 60-station infrasound monitoring network that is designed to reliably detect infrasonic signals from a 1-kiloton atmospheric nuclear explosion at two or more network stations. The stations in this network are located uniformly over the face of the globe. Each station consists of an array of high-sensitivity microbarometer sensors arranged in an optimal configuration for the detection of signals from atmospheric explosions. Fundamental design principles for IMS

infrasonic array stations with an emphasis on the recent developments in array design, improvements in infrasound sensor technology, and advances in background noise reduction are described by Christie D.R. et al. [26].

For propagation estimation of environmental low frequency noise and infrasound it is necessary to model propagation in the open space. In fact it is a difficult task due to the numerous acoustical effects like diffraction, refraction, reflections, superposition etc. That is why it is necessary to select appropriate methodical approaches for environmental low frequency noise and infrasound modeling. For example, concerning transport low frequency noise and infrasound evaluation it is better to model not infrasound of separate cars, but transport flow infrasound. Formalization and modeling of transport flows are easily represented using the influence diagrams. Such diagrams are usually describing some formalized presentation of modeled categories (objects, processes, properties etc.) in a form of multitude of graphical symbols (assemblies, vertexes) and relations between it. In Russia the most popular types of influence diagrams are flow graphs, trees of events and functional nets [27, 28]. Flow graphs are including the variety of vertexes and a set of regulated and of unregulated couples, used for visual presentation of modeling process.

Recently semantic or functional nets are rapidly developing, which are present graphs, but with additional information in it assemblies and rib. The most popular functional nets PERT (program evaluation and research technique) and GERT (graphical evaluation and review technique). For mathematical description of street-road nets of city methods of graph theory have been taken. Carriers of information about city street-road net geometry may be automobile road schemes, road atlases, drawings etc. But for infrasound maps creation it is necessary to convert graphical information to analytical. The following work have been done by the authors:

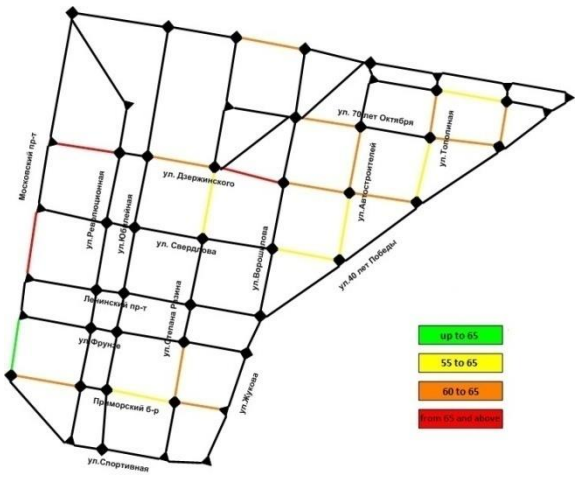

Figure 6.1 - Graphical presentation of transport of networks of Avtozavodsky district of Togliatti city

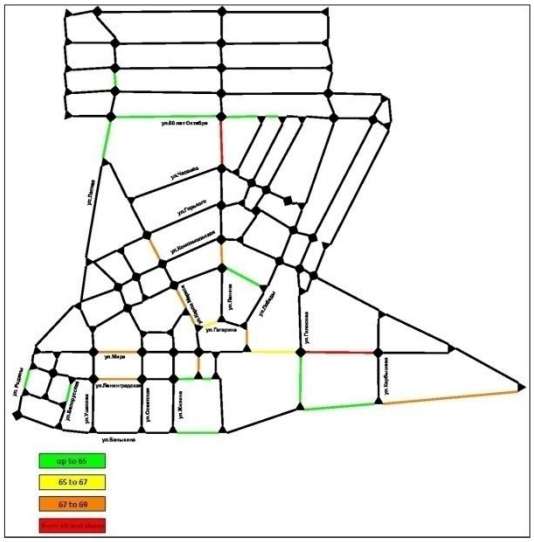

Figure 6.2 - Graphical presentation of transport networks of Central district of Togliatti city

1. Mathematical apparatus of description have been analyzed and mathematical model of street-road transport nets have been worked out.

The influence diagram is a flow graph described by variables and constants corresponding to assembles-vertexes. To each variable is associated a set of meanings, its probability distribution density and a set of function that works on variables.

For indication of relations between variables corresponding symbol mass data are using. These mass data may be presented as: multitude of ribs, connecting assembles, vector of bows-predecessors and successors, vector of probability of transition between assembles i and j, vector of resource spends (e.g. time) during transition from assembly i to assembly j.

Geometry of two-side graph G is determined by incidence matrix (setting a numbers of vertexes) and corresponding coordinates matrix {y(i)}. To each rib {x(i1) , x(i2)} of graph G numerical characteristic are comparing, which are describing street-road net:

n - number of traffic paths;
α - road profile;
β - quality of road surface;
γ - directives about structure and dynamic of transport flow;
δ - meteorological conditions;
ε - surrounding landscape;
θ - other characteristic (lighting, presence of traffic distribution zones etc.).

Thus, graph is totality of vertexes and ribs. Information about graph structure is determined by matrix form.

2. By using of developed mathematical model street-road transport nets have been created. Transport nets are consisting of the roads with intensive load (marked in the program by black bold strip) and a net of local roads.

3. Algorithms of coding and of information restoring about street-road graph structure was created. Software have been developed to investigate infrasound situation in Togliatti city (Russia) streets and roads. Graf networks of the transport mains of Avtozavodsky and Central districts are shown in figures 6.1 and 6.2.

3. CONCLUSIONS

Several studies there are in literature about infrasound and their use to detect explosion or impulsive shock events, thanks to their characteristic to have low absorption in atmosphere so that they can propagate also around the Earth many times.

Local sources, especially in urban areas or close to them require measurement systems portable and easily installable, allowing spot measurements in different points of large areas or cities in order to create detailed map and to validate simulators.

Different methodologies are used to show the result of the infrasound emission assessment such as noise mapping or influence diagrams, the latter especially adopted in Russia.

Those methods of infrasound modeling and mapping need to be improved following the growing demand of environment monitoring pollution, related to physical agents.

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She has been involved in several research and pilot projects, such as LIFE+2008 HUSH (Harmonization of Urban noise reduction Strategies for Homogeneous action plans), LIFE+2010 QUADMAP (QUiet Areas Definition and Management in Action Plans) and LIFE+2015 MONZA (Methodologies fOr Noise low emission Zones introduction And management). Since 2018 she collaborates with Vie en.ro.se Ingegneria, mainly in the European project group, taking care of the monitoring of national, European, International calls for funding and of Projects' drafting.

SEVENTH INTERNATIONAL
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SAPROPEL EFFECTIVENESS EVALUATION IN THE PROCESS OF HEAT POWER PLANTS ASH AND SLAG WASTES RECLAMATION

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ABSTRACT

The efficiency of sapropels of lake Bolshoy Berchikul in the reclamation of JSC "Novokemerovskaya CHPP" ash-slag waste [ASW] was studied with use of *allium-test*. During the work both liquid and granular forms of the sapropel in various combinations were applied on theASW surface. The chemical composition of lake Bolshoy Berchikul [B. Berchikul] sapropel corresponded to the 1-st class of suitability in accordance with GOST [State Standard] 54000-2010. It was established experimentally that ASW suppress the mitotic activity of *Allium cepa L.* roots meristems. Adding of Lake B. Berchikul liquid sapropel in combination with black soil and liquid and granulated sapropel combinations stimulates the cytotoxicity of ASW reducing, that leads to increasing of *Allium cepa L.* root system cells mitotic index, caused by phase indexes changes: a metaphase index decreasing and anaphase and telophase indexes increasing. It was found that the process of *Allium cepa L.* root meristem cells division to a greater extent was stimulated by the adding in ASW liquid sapropel complexes with black soil as well as liquid sapropel with its granulated form.The obtained results give reasons to recommend sapropels of lake B. Berchikul as a soil-forming agents to reduce ASW toxicity, increase fertility and the phytocenoses productivity.

Keywords: Sapropel, *Allium test*, meristem cells, mitotic index, toxicity, phytocenosis productivity

1. INTRODUCTION

At the present stage of the energy power industry development, waste disposal of heat power plants [HPP] is a global problem. In Russia at the present time no more than 5-10% of ASWis recycled in Russia in different sectors of construction and industry, meanwhile the rest part is stored without using. For the perspective, taking into account the increasing needs for electricity and the insufficient rate of other sources of its production development, the amount of stored ASW is expected to be increasing [1]. In areas of storage of ASW there are

adverse geoecological processes and phenomena, breaking the ecological balance. According to data from literature sources, ASW can pollute the environment with heavy metals [2]. The problem of ASW, aggravated recently due to the occupied areas increasing and their negative impact on the surrounding areas has made it particularly important to study the toxic effects of elements and compounds contained in ASW on living natural objects and the selection of technologies for their reclamation. The main requirements for black soil formers used for biological reclamation are their high fertility, lack of toxicity, sufficient sorption activity, the ability to neutralize toxic effects, the prolongation of the action and the minimum amount of application.

Black soil formers based on organic sapropel corresponds to all above listed properties [3]. Sapropel consists of fine-structured colloidal deposits of water reservoirs. The prospects for its use are determined by highamount of organic substances represented by amino acids, carbohydrates of a wide range, hemicellulose and nitrogen-containing compounds, humic acids. Sapropel is rich in vitamins of group B [B1, B12, B3, B6], E, C, D, P, carotenoids, many enzymes, for example, catalases, peroxidases, reductases, proteases. They are able to reduce acidity, improve soil aggregate composition, adsorb radionuclides and heavy metals. Because of a slow solubility of the substances acting in sapropel, a balanced nutrition of plants with all elements of nutrition is provided, the mechanical, aggregate and agrochemical composition of soils is improved. Balanced nutrition of plants with all elements, improvement of mechanical, aggregate and agrochemical composition of soils is provided due to slow solubility of the substances acting in the sapropel.

The purpose of this study was to investigate the effectiveness of lake B. Berchikul sapropel in the reclamation of JSC "Novokemerovskaya CHPP" ASW with the use of *Allium test*.

2. MATERIALS AND METHODS

The studies were carried out on the territory of JSC "Novokemerovskaya CHPP". It is one of three power plants of the Kuzbass regional center and supplies heat to about a third part of the housing stock located in the left-bank part of Kemerovo, as well as provides steam supply to some industrial enterprises [Ltd. Khimprom and JSC SBU Azot]. Coal is the main fuel used at this CHPP.

The object of the research is ASWof the 1-st ash dump, which volume increases every year. This dump is characterized by harsh environmental conditions associated with a lack of moisture and increased insolation of open spaces. The mechanical composition of the dump’s substrate is represented by unbound ash particles with the inclusion of light or dark gray colored slags. The gross chemical composition of the substrate corresponds to aluminosilicate formations [SiO_2 – 60%, Al2O3 – 20,8%]. In the ash there is no nitrogen, no organic matter, the content of mobile phosphorus 0,11 %, potassium oxide 2,61 %. Thus, the chemical composition of the ash can be attributed to substrates

unsuitable for growing plants. To create long-term productive phytocenoses, agro technical measures are needed to improve the properties of the ASW substrate for the purpose of plants growing.

Laboratory studies were performed in the laboratory of environmental monitoring the ecology and natural resource management Department of Kemerovo state University. The samples were placed in plastic containers with various options of sapropel introduction:

option 1: 10 cm thick ASW+2 cm thick liquid sapropel + 10 cm thick black soil

option 2: 10 cm thick ASW+2 cmthick liquid sapropel + 2 cm thick granular sapropel

option 3: 10 cm thick ASW +2 cm thick granular sapropel

option 4: 10 cm thick ASW+ 2 cm thick liquid sapropel

option 5 [control]: 10 cm thick ASW +10 cm thick black soil [selected according to the recommendations of GOST 17.5.1.02-85 [4] to perform the technical stage of re-cultivation].

During the work lake B. Berchikulsapropel was used, geological resources of which are about 23 million tons. The liquid sapropel moisture content was corresponding to naturalmoisture indicators [W=89-97%], granular sapropel had a moisture content no more than 20%.

For sapropel sampling and determination of its chemical composition indicators – total nitrogen, phosphorus, potassium, calcium, iron and sulfur, the mass fraction of organic matter, acidity the guidelines for agrochemical analysis of sapropels were used [5].

The effectiveness of added into ASW ingredients' evaluation was determined by the *Allium test* recommended by WHO [World Health Organization] experts as a standard in cytogenetic environmental monitoring. This test constitutes a cytogenetic method with a high sensitivity in evaluating the mutagenic and toxic effects of ash and slag dumps. The analysis of mitotic cycle disorders reveals early changes in the cytogenetic system of plant organisms in the absence of phenotypic manifestations and allows evaluate the impact even at a small level of pollution [6, 7].

The plantof onion used in the work [*Allium cepa L.*] has 16 well-stained chromosomes [2n=16]. The cell cycle lasts approximately 17,8 hours. Mitotic index can vary in different roots of the same plant, but the average data are quite stable. The mitosis duration in different *Allium cepa L.* roottissues is identical and does not change along the length of the root. The selectedplant test system is economic and simple, it is possible to register all types of genetic damages [genomic, chromosomal, gene], it allows to identify mutagens that directly damage DNA.

For each option, repetitions were used in accordance with the guideline of the modern standard for experiments using the *Allium - test* method [8]. The bulbs germinated for 7 days. For the purpose of cytological analysis crushed acetocarmine agents were prepared. Roots 0.5-1 cm long were fixed in acetic spirit for 24 hours, roots were stained with an acetocarmin solution, then washed, the

root tips were placed on the slide in a drop of 45% acetic acid, closed with a cover glass, distributed by pressure in a monolayer, the edges of the cover glass were poured by a varnish. Cell counts at mitotic cycle's different phases were carried out in several fields of view.

Table 1

Evaluation of lake B. Berchikul sapropels' chemical composition's compliance with GOST54000-2010

Designation of the indicator	Norm for sapropel, mg/kg dry matter, not more than		
	1-st class of compliance	2 –nd class of compliance	lake B. Berchikul sapropel
Cadmium	3	3-9	0,07
Zinc	30	300-600	82,5
Lead	50	50-150	2,05
Copper	100	100-300	22,5
Mercury	1,0	1-6	0,004
Manganese	500	500-1500	360
Nickel	50	50-200	2,27
Chrome	100	100-260	3,24
Cobalt	20	20-60	2,2
Molybdenum	20	20-200	0,23
Organic matter, %	30-50	5-15	56,56
pH	6	5	6,6
-general nitrogen, not less than	1,0-1,5	0,1-0,5	2,4
- total phosphorus (P_2O_5), not less than	0,2-0,4	0,1	0,76
- calcium (CaO), not less than	0,1-0,5	10-20	0,36
- sulfur (SO_3), not more than	3	7	0,48
- potassium total (K_2O), not less than	0,3-0,5	0,1	3,4

ASW cytotoxicity was evaluated using theroot system cell proliferation index – mitotic index [MI, %], defining as the ratio of the dividing cells number of to the total number of considered on the specimen cells [9]. During the analysis, 800 cells were examined under a microscope, among them the number of cells at different mitosis' stages and the number of indivisible cells (interphases) were counted.

With the purpose of identifying the causes of changes of mitotic activity, the duration of each mitosis' phase was analyzed and phase indices [PI, % - prophase

index, MI, % - metaphase, AI, % - anaphase and TI, % - telophase] were determined as the ratio of the cells number being at the stage of prophase, metaphase, anaphase and telophase to the total number of analyzed mitoses. The proportions of different phases in the control and experimental options were compared. Statistical treatment of the results was carried out using the software package *"Statistica-10"*.

3. RESULTS AND DISCUSSION

Analysis of lake B. Berchikul sapropels' chemical composition shows their high richness of basic nutrients for plants – totalnitrogen, phosphorus, potassium, sulfur, calcium, organic matter; the content of heavy metals is in accordance with the standards. Comparing the obtained data of the chemical composition to GOST 54000-2010 [5] we can make a conclusion about the compliance of lake B. Berchikul sapropel with the 1-st class [Table 1].

One of the main mitotic activity characteristics of apical meristem's cells of *Allium cepa L.* is mitotic index. Mitotic activity of cells violation is a potentially dangerous phenomenon, because it can lead to serious deviations from the normal growth and development of the plant. Table 2 presents data about mitotic activity and the value of phase indices of *Allium cepa L.* meristem cells' roots of different options of the specimen. Analysis of the mitotic activity revealed the mitotoxical effect of onion roots' meristem cells in the control option [ASW+black soil] and the stimulating effect of root system cells proliferation when adding liquid sapropel in combination with black soil [option 1] and liquid sapropel in combination with its granular form [option 2] to ASW.

Table 2

Values of mitotic and phase indices of *Allium cepa L.* roots meristem's cells

Specimen's option	option 1	option 2	option 3	0ption 4	option 5 [control]
MIn, %	22,3±1,12*	19,7±0,67*	13,3±0,53	15,2±0,68	13,9±0,35
Interphase, %	77,7±3,49*	80,3±4,21*	86,7±2,94	84,8±2,59	86,1±3,37
PI,%	63,7±4,84	66,5±2,83	69,7±2,64	67,5±0,21	66,1±0,63
MI, %	14,9±0,76*	14,1±0,76*	15,2±0,41*	17,4±0,49	17,0±0,11
AI, %	12,6±0,15*	11,5±0,31*	9,9±0,28	8,9±0,33	10,4±0,23
TI, %	8,80±0,36*	7,90±0,23*	5,2±0,22	6,2±0,21	6, 5±0,21

Note: * - valid differences from the control at $p \leq 0.05$

The values of the mitotic index in 1 and 2 options significantly exceeded the control by 1,6 and 1,4 times, respectively [Table 2, Fig.1]. The depressive nature of mitotic activity of onion root system without adding the sapropel is probably

associated with unfavorable for the growth of plants mechanical and chemical composition of the substrate under study [control], while in this option, the maximum number of cells in the prophase is revealed. In science literature there is information about the cytotoxic effect of chemical pollutants on the onion's root meristem's cells [9]. The increase in MI under the action of pesticides was revealed [10]. The increase in MI caused by pesticides was revealed [11]. A number of authors revealed a negative cytogenetic effect of heavy metals on the test system of *Allium cepa L.* [11, 12]. S. Chandra with coauthors [2005] observed an increase of the time spent by the root meristem's cells at the prophase stage by 1,7 and 2,7 times, respectively, during onion germination in solutions of Zn and Cd salts [13]. H. Kocik with co-authors found that zinc is able to accumulate in the cells of onion's meristem, causing a decrease in MI and slowing of the roots' growth [14]. R. Liman with co-authors found a significant increase in the prophase index and a decrease in other phases' indices in the *Allium test* against the background of growth of MI during pesticide testing [15].

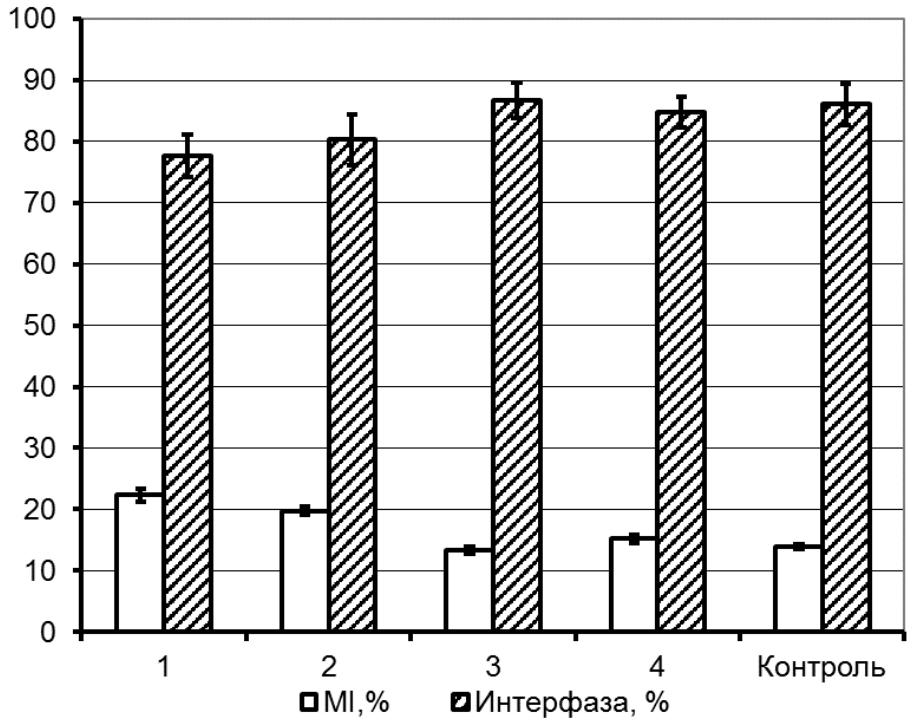

Figure 1 - Mitotic indices [MI] and the indivisible cells' number (interphase) in root meristem cells of *Allium cepa L.*

Experimental data show that in the control option without adding the sapropel, *Allium cepa L.* has a higher percentage of cells in the interphase, during which DNA and proteins are synthesized and preparation for cell division is carried out. Adding a sapropel liquid form in combination with black soil [option 1] and combinations of liquid and granular sapropel [option 2] contributes to the acceleration of acceleration of cells preparation process to division: the number of

cells in the interphase was significantly lower in comparison with the control by 11% and 7% respectively [Table.2, Fig.1].

Analysis of duration of mitosis phases according to the values of the phase indices allowed characterize the features of ASW mycotoxic actions of and mitosis-modifying effect of the sapropel additives.

The proportion of cells' entering mitosis [PI] in all options is not significantly different from the control option. In the control option [without sapropel], *Allium cepa L.* has a higher metaphase index [MI] against the background of low mitotic activity [MI], that indicates the genotoxic effect of ASW on the mitotic apparatus of the cell. The anaphase index [AI] significantly increases in the options with the liquid sapropel + black solid adding [1 option] and a combination of both liquid and granular sapropel [2 option]; in these options, *Allium cepa L.* telophase index [TI] significantly increases([table 2, Fig.2].

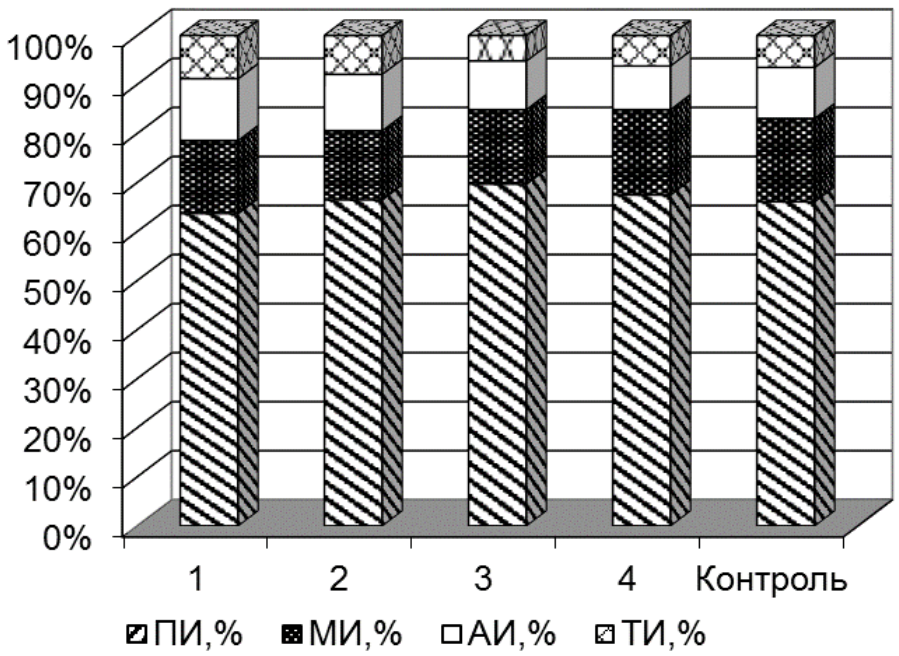

Figure 2 - Relative values of phase indices in *Allium cepa L.* meristem's cells

4. CONCLUSIONS

1. It was experimentally established that ASW inhibit the mitotic activity of *Allium cepa L.* root meristems.
2. The analysis of lake B. Berchikul sapropel chemical composition shows their compliance with the 1-st class of suitability according to GOST 54000-2010.
3. The adding of lake B. Berchikul liquid sapropel ina combination with black solid and a combination of both liquid and granular forms of the sapropel helps to reduce the mitotoxicity of ASW, that is expressed in an increase of cells mitotic index of the root system of *Allium cepa L.*, determined by the changes in phase

indices - a decrease of the metaphase index and an increase of anaphase and telophase indices.

4. It was established experimentally that the cells division process in *Allium cepa L.* root meristemis to a greater extent stimulated by the adding liquid complexes of sapropel with black soil and liquid sapropel with its granulated form to ASW.

5. The obtained results allow recommend lake B. Berchikul sapropel as a soil-forming agent to reduce the toxicity of ASW, for fertility and productivity of phytocenoses increasing.

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ENVIRONMENTALLY FRIENDLY AND RESOURCE SAVING TREATMENT OF ROLLED PRODUCTS MADE OF PEARLITIC STEEL PRIOR TO METALWARE UPSETTING

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ABSTRACT

Resource saving and environmental safety become a prevailing requirement in the conditions of the modern level of production development. Reliable operation of metal products should be provided with technologies that meet the requirements of environmentally sound policy of rational use and economy of materials. Widely used hardware products manufactured by cold heading of alloy steels must have special structural and mechanical characteristics. Metal rolled products must have a certain quality along the entire length – a sufficient plasticity, uniform structure and parameters of technological properties, absence of any flaws. Hardware manufacturers receive the initial blank for the manufacture of various fasteners in the form of hot-rolled stock, which is impossible to use for high-strength hardware upsetting due to poor-quality structure and surface layer.

Therefore, the calibrated rolled stock is subjected to intermediate heat treatment before drawing, which should guarantee the quality of the metal products at the transitions of cold heading. Further, the upset products of strength class 8.8 and above made of alloy steels must be subjected to hardening with subsequent tempering. However, such thermal operation is not environmentally friendly and resource-saving and often leads to decarburization of the surface, cracking and warping of finished products, which increases energy intensity, labor intensity and, consequently, the final cost. The paper proposes an eco-friendly and resource-saving method for the preparation of rolled stock made of steel grade 38X and 38XA, excluding from the process the recrystallization annealing and hardening with the release of finished bolted products, and ensuring compliance ofM8 bolts and studs mechanical properties parameters with strength class 9.8 requirements.

Key words: environmental safety, surface condition factor, heat treatment, structure, mechanical properties, processability, performance properties

Trouble-free operation of metal products is due to the nature of the material [1-3], operating conditions [4-6] and processing modes [7, 8] forming the structure and properties of the materials used [9-11], which, ultimately, are provided by the choice of appropriate modes of technological processes [12, 13]. Core mold hardware products manufactured by cold heading of alloy steels, must have special structural and mechanical characteristics [14]. The most common method of manufacturing bolted metal products with high structural and mechanical properties is their cold heading from rolled products, which must have a uniform (along the entire length) zero-defect quality, ductility, appropriate structure and manufacturability [15-17].

Hardware products such as bolts, studs and screws, for which specific requirements for strength properties are not regulated, are usually made of steel grades according to GOST 1050-2013, GOST 4543-2016, as well as GOST 380-2005, in which the structure and condition of the metal surface during the passage through the die holes and upsets are not regulated. This causes the risks of deformation cracks and warping in finished metal products [18-20].

Chemical composition and parameters of mechanical characteristics of rolled products for cold heading of bolted products of different strength class are regulated by GOST 10702-2016. For high strength metal hardware the mechanical properties must comply with ISO 898-1:1999. In this case the necessary strength is determined by the steel grade [21,22] and metal heat treatment mode before upsetting of the finished products [4, 23].

Rolled metal products made of pearlitic steel class are supplied as non-thermally treated items and have a "pearlite+ferrite" structure. The formation of the required microstructure and the state of the rolled surface [24-26], which guarantee the quality of the core products at all transitions of the cold heading [27-29], is carried out by appropriate modes of heat treatment and drawing prior to upsetting.

According to GOST 1759.4-87, fastening rod products of strength class 8.8 and higher, headed in this way from alloy steels, should be subjected to hardening and tempering, provoking the appearance of decarburization, cracking and warping, which reduces the environmental friendliness of the process, increases its labor intensity, energy intensity and, consequently, the final cost of production.

The authors have proposed a method of isothermal mechanical treatment of the rolled pearlitic steels 38X and 38XA structure, excluding from the process the energy and labor intensive recrystallization annealing of the rolled stock and hardening- tempering of the finished bolt products that, apart from increasing the environmental friendliness of the process, leads to the elimination or mitigation of the rolled stock and final products warping and decarburization risks. The proposed method allows ensuring the rolled stock mechanical characteristics and surface quality that fully comply with GOST 10702-2016.

Based on the analysis of the results obtained during the study of the rolled steel samples of pearlite class 38X and 38XA, widely used in the manufacture of critical fasteners of motor, body and other groups of automotive and special

equipment, a flow chart of the rolled product isothermal mechanical processing has been provided for the purpose of obtaining improved long-length rod products with low head and various pin products corresponding to strength class 8,8 and above without hardening and tempering.

The rolled metal product isothermal mechanical processing for the investigated steels consists of the initial rolled stock heat treatment, etching in the acid solution after annealing, drawing, isothermal treatment at 470°C, etching in acid solution, drawing, upsetting of high-strength bolts and pins.

The formation of the required microstructure of the rolled stock for the upsetting of bolts with a diameter of 7,8 mm was carried out by annealing of the 2nd kind. In a saltpeter bath with a temperature of 470°C, the transformation of austenite of these steels occurs in the temperature range of the sorbitic transformation (650-470°C). The austenite obtained in this mode is of eutectoid type. Isothermal thermal cooling at 470°C of the calibrated rolled stock after drawing is proposed before upsetting short, medium and long length bolts with a die molded head and pins of various lengths.

A design limitation of saltpeter bath length during the rolled stock isothermal treatment determines the rolled stock exposure that would not exceed 5-6 minutes. At the same time, to complete the austenitic transformation, the cooling time of the rolled products (diameter 8,2–8,6 mm; the temperature of the saltpeter bath 470°C) is 3.9 minutes. The samples were drawn to diameters 8,1; 8,2; 8,3; 8,4; 8,5 and 8,6 mm with subsequent isothermal treatment (saltpeter bath; 470°C). The final drawing was carried out to diameter of 7,8 mm with different degrees of compression in the die of the drawing mill. The finished products were tested for rupture according to GOST 1759.4-87.

The chemical composition and mechanical properties of the steels in the as shipped state corresponded to GOST 10702-16. The microstructure of the initial rolled steel products was "pearlite+ferrite". The rolled stock mechanical properties after isothermal treatment are shown in table 1.

Table 1

Mechanical properties of the isothermally treated rolled stock

Steel grade	Characteristics			
	Fracture strength, $\sigma_в$	Yield point, $\sigma_{0,2}$	Modulus of elongation, δ	Contraction ratio, ψ
	MPa		%	
35X	878	630	20,5	57
38XA	882	637	20,1	57

After the isothermal treatment, the samples of rolled metal products made of the investigated steels with a diameter of 8,1, 8,2, 8,3, 8,4, 8,5 and 8,6 mm at a temperature of 470 ° C of the salt bath have a structure of "sorbite-like pearlite". The samples of steel grade 35X in this case have hardness HB 249, and the

samples of steel grade 38XA have hardness HB 254. Strength and plastic properties of rolled products after isothermal treatment at 470 ° C and subsequent drawing with different compression rates are shown in table 2.

Table 2

Strength and plastic properties of rolled steel products with different compression rates to diameter 7,8 mm after isothermal mechanical treatment 470 ° C

Compression rate, %	Material	Characteristics			
		Fracture strength, $\sigma_в$	Yield point, $\sigma_{0,2}$	Modulus of elongation, δ	Contraction ratio, ψ
		MPa		%	
4,9	35X	878	769	16	54
	38XA	918	797	15,5	53,1
7,2	35X	896	791	15,8	53,8
	38XA	922	807	15	53
9,5	35X	905	801	14,5	53
	38XA	931	813	14,1	52,7
11,6	35X	916	810	14	52,5
	38XA	959	835	13,5	52,1
14,2	35X	928	831	13,2	51,8
	38XA	991	863	13,0	51,0
15,7	35X	944	862	13,1	51,1
	38XA	1003	901	12,4	50,4
17,7	35X	971	887	12,5	50,0
	38XA	1067	948	12	49,1

It was found that with the increase in the degree of drawing compression from 4,9 to 17,7%, the strength parameters of the rolled products isothermally processed at 470 ° C constantly increase. Thus, the limit tensile strength of calibrated rolled steel grade 38XAat compression ratio from 4,9 to 17,7% increases from 918up to 1067MPa, and that of steel grade 35X only from 878up to 971MPa.

Conventional yield strength of the steels after isothermal mechanical technological treatment also increases. So, the yield strength of the rolled stock prior to cold upsetting with a change of compression ratio from 4,9 to 17,7% increases in 35X steel from 769 to 887MPa, and that of steel grade 38XA - from 797 to 948MPa.

Isothermal mechanical treatment of rolled steel products with subsequent drawing with compression ratio from 4.9 to 17,7% leads to a monotonic decrease in the modulus of elongation from 15.5 down to 12,0% for 38XA steel and from 16 to 12,2% for 35X steel.

The rate of contraction after isothermal mechanical treatment of rolled steel grade 35X with a change of compression rate from 4.9 to 17.7% decreases from 54 to 50%, and that of steel grade 38XA - from 53.1 to 49,1%.

Short and long bolts M8 with a low cut head and pins M8, upset in the cold heading machine, were made of rolled steel grade 35X and grade 38XA after isothermal mechanical treatment, and the tensile tests were carried out to identify the strength and plasticity characteristics of these.

The test results are provided in table 3.

Table 3

Tensile test results for bolts made of steel grade 35X and 38XA

Item	Material	Q-ty, pcs	Fracture strength, $\sigma_{в}$, MPa	Contraction ratio,Ψ, %	Modulus of elongation,δ, %	HB
Bolt, M8	38X	21	820	44,5	10,7	254
	38XA	17	950	44,5	10,7	286
Pin, M8	38X	18	912	44,5	10,7	248
	38XA	25	938	44,5	10,7	277

CONCLUSIONS

This paper has studied a potentially more eco-friendly and resource-saving isothermal mechanical treatment of rolled stock having diameter of 7,8 mm made of pearlitic steel grade 35X and 38XA for cold upsetting of bolts with low head and pins with strength class 8.8 and above without hardening and tempering applied.

It has been demonstrated that the proposed treatment method for the rolled stock made of these steel grades, excluding from the process the energy and labor-intensive recrystallization annealing and hardening to obtain finished bolt products, ensures compliance of M8 bolt and pin mechanical property parameters with strength class 8,8 and 9,8 requirements.

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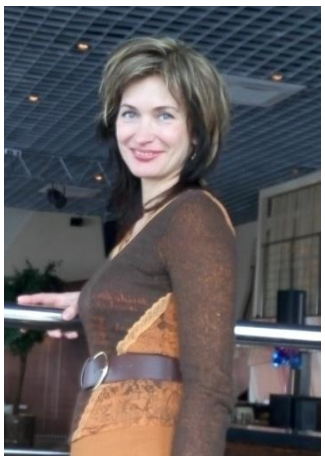

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"SPLENDEURS ET MISÈRES" OF INNOVATION-ECOLOGICAL DEVELOPMENT

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ABSTRACT

With the development of scientific, technical, and socioeconomic processes in industrialized countries in the second half of the twentieth century, a new multidisciplinary scientific direction was "brought to life" and was related to the effective use of the results of research and development aimed at improving the quality of human life – innovation. Naturally, the quality of life of a person cannot be considered in isolation from the state of the natural environment in which this person lives, works, and rests. The goal of the study is to show a close interaction, apparently, of the main sciences of the twenty-first century – ecology and innovation and integrated influence on man. In the contribution, the aspects of innovation activity in ecology (ecological rationing, new methods of biological indication and biological monitoring, waste utilization, ecological audit of the territory, public health, etc.) are considered in detail. The issues of innovation management of nature protection activities aimed at improving the quality of life of the population are discussed in detail. The authors examined "from start to finish" aspects of the interaction between innovation and ecology. The main conclusion is that a program of step-by-step innovation activity is needed that can describe the content and sequence of the planned measures and set the ultimate goals of the reform of the environmental management system, activities.

Key words: innovation, ecology, regulation, waste management, biological indication, environmental audit, public health

1. INTRODUCTION

The quality of human life cannot be considered in isolation from the quality of the natural environment in which this man lives (it is obvious that the quality of

the environment directly affects the development of the demographic potential of a nation, and the health of the population, and is an indicator of the attitude to the future of the country). The scientific, technical and socio-economic development of industrialized countries in the last quarter of the XX century "brought" to life a new multidisciplinary (interdisciplinary, superdisciplinary) scientific direction related to the organization of the effective use of the results of research and development aimed at improving the quality of human life – innovation. It would seem that environmental-innovative activity would have to become the main one when our country's economy moved to a qualitatively new level, which was postulated by its leadership (Decree of the Government of the Russian Federation No. 1662-p dated November 17, 2008 "On the Concept Federation until 2020"). Moreover, many provisions of this kind of leadership are spelled out in a number of government documents (Constitution of the Russian Federation [adopted on December 12, 1993], Concept of National Security of the Russian Federation [approved by Presidential Decree of December 17, 1997 No. 1300], Law of the Russian Federation "On Environmental Protection" No. 7-FZ of January 10, 2002; Environmental Doctrine of the Russian Federation [order of the Government of the Russian Federation of August 31, 2002 No. 1221-p]). However, an analysis of the scientific literature suggests that, unfortunately, this issue receives much less attention than, for example, directly innovative activities in industry or education [1].

The purpose of this message is an attempt to answer the question "*cui prodest – who benefits*" closer interaction, apparently, the main sciences of the XXI century – ecology and innovation.

2. ENVIRONMENTAL NORMALIZATION

It should be noted that environmental regulation is a key issue in the formation of environmental safety. More than two decades ago, Russia raised the question of the need to determine permissible environmental loads and adequate restrictions (rationing) of the existing anthropogenic impacts, taking into account the totality of the possible adverse effects of many factors and the natural specifics of the objects [2].

Ecological rationing involves taking into account the so-called maximum permissible load on the ecosystem. Such a load is considered permissible, under the influence of which a deviation from the normal state of the system does not exceed the natural changes and, therefore, does not cause undesirable consequences in living organisms and does not lead to deterioration in the quality of the environment. Unfortunately, as it happens too often in our lives, it is much easier to write a law or give a fundamental definition than to develop a method for measuring particular indicators enshrined in the law. For example, who can decide at least on a seemingly simple definition of what the "normal state of the ecosystem” is and what is its “range of natural changes" [3]. Therefore, to date, only some attempts are known to substantiate "environmental MPCs" [3-5, etc.],

mostly for communities of fisheries of fisheries. In more detail with the problems of environmental regulation of water bodies (and, especially, with the new proposed methods) can be found in the already cited work [3].

3. SOME INNOVATIVE APPROACHES TO ENVIRONMENTAL MANAGEMENT

Interest in the application of innovative approaches in environmental management has arisen (especially in our country) relatively recently [6, etc.], although indirect indications of their importance have been encountered earlier.

New methods of bioindication and biomonitoring. An important component of the sustainable development of regions is the sustainable development of large river basins. Using the example of the Volga River Basin, the largest river in Europe and the most man-made river in Russia (the basin area is 1,36 million km^2 and includes the territories of 39 entities of the Russian Federation and two Kazakhstan, with more than 40% of the Russian population lives here), the authors illustrated the new methods of biological indication and biological monitoring of anthropogenic influences [7]:

- a system for a comprehensive assessment of the state of health of the environment by impaired homeostasis (morphogenetic, cytogenetic, immunological, physiological, toxicological and biochemical development of organisms – BIOTEST);
- original microbiological methods for assessing the ecological state of water bodies based on the analysis of the microbiological relationships of the associative symbiosis of aquatic organisms;
- risk assessments of invasions of alien species into inland water bodies, information systems for invasive species, which have been tested in the Volga River Basin as the main Northern European invasive corridor.

Waste disposal methods. In accordance with the Law "On Environmental Protection" (Article 54), production and consumption wastes are subject to mandatory collection, use, neutralization, the conditions and methods of which should be safe for the environment. In the Federal Law "On Production and Consumption Wastes" of June 24, 1998 No. 89-FZ, one of the basic principles of economic regulation in the field of waste management is to reduce the amount of waste and to involve it in economic circulation. In the "Ecological Doctrine of the Russian Federation" among the main directions of state policy in the field of ecology are "the development of systems for the use of secondary resources, including recycling".

We indicate only a few new efficient technologies for waste processing. For example, the Non-Profit Partnership "Ecology" in the city of Cheboksary is the largest enterprise in the Chuvash Republic that is able to solve the problems of waste disposal in a complex way, possessing modern equipment and technologies (a wide range of industrial, oily, construction, medical, biological and pharmaceutical wastes is disposed of).

Another example of the use of new technologies in the recycling of waste is demonstrated by the Foundation for the Promotion of Research and Development and the Introduction of New Types of Environmental Techniques and Technologies "World of Man" (Togliatti, Samara Region). For example, in the course of the production activity of the Limited Liability Company (LLC) "Togliatti-Rubber", slurry of spent aluminum-chromium catalyst is formed, which has been stored for almost 20 years in a slurry storage facility on the territory of the enterprise. In connection with its filling, the project of a new storage facility with the area of about 34 thousand m^2 was prepared. This is an extensive waste collection route; "World of Man" together with the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan has the processing technology (intensive approach) of these aluminum-chromium catalysts, the implementation of which will not only reduce the amount of waste, but also "re-extract" chromium and aluminum almost on an industrial scale.

Automated information management system for managing payments for a negative impact on the environment. The payment for the negative impact on the environment is established by the Law "On Environmental Protection" (Article 16). The procedure for calculating and paying environmental payments, their maximum amounts, is set forth in Government Resolution No. 632 of August 28, 1992 "On Approving the Procedure for Determining Charges and Its Maximum Levels for Pollution of the Natural Environment, Waste Disposal, and Other Types of Harmful Exposure".

There are several automated information systems for this kind of activity (Krasnodar, Kazan, Voronezh, Nizhny Novgorod, Kirov, etc.; [http://www.airsoft-bit.ru/index.php/programecologs/111-eco-admin], [http://www.aieco.ru/programms-info_pay10.html]. A software product was developed in Togliatti [8]. Its implementation, while complying with all the requirements, regulations and guidelines contained in the regulatory acts of the federal and regional levels, allows for effective environmental management in the territory.

Ecological audit of the territory. Environmental audit (EA) is defined as "an objective, independent analysis, assessment, development of appropriate recommendations and proposals on the actual results of any environmentally significant activity conducted by small groups of independent specialists in a short time" [9, p. 28]. Obviously, it is most preferable to develop EA in a direction based on a systematic integrated approach to defining goals, essence, organization and procedures for conducting EA as an organizational and legal mechanism for ensuring security and investment attractiveness of an enterprise or other object of environmental audit. At the same time, the criteria for assessing the environmental safety of an object are reduced to the socio-ecological and economic characteristics of environmental management - the volume of pollutants entering the environment, the scale of the resources seized, the damage caused to nature and society, and taking into account feedback – the impact of polluted environment on the object of environmental audit.

The environmental audit of the territory (EAT; [10]), as a special case of EA, is a tool for solving problems related to the state of the environment on the territory of anthropogenic impact of different scale (city, other administrative entity, river basin, etc.). The EAT procedure is determined by the peculiarities of the territory – infrastructure, geographical and climatic characteristics, especially the economy, social sphere, ecological situation, etc. The implementation of EAT contributes to the increase of the investment attractiveness of the region.

To obtain a comprehensive picture of the environmental situation of the study area within the framework of the EAT, it seems reasonable to base on the basis of information data with indicators of the ecological status of territories of different scale. The problem of environmental audit within the boundaries of administrative zoning requires solving the following complex tasks [7]:

- identification of audit sections taking into account the cartographic capabilities of aerial and satellite imagery;
- selection of key indicators characterizing the assessment of economic activity in the region;
- presentation of a set of cartographic indicators of agro-industrial enterprises and the entire region determining the environmental activities;
- analysis and evaluation of environmental indicators included in the audit data.

The following sections of the regional environmental audit are intended: legal, economic, environmental, cartographic.

Ecological audit of the territory is one of the new and promising tools for regulating activities in the field of environmental management and environmental protection. The experience of EAT implementation using the REGION expert information system developed at IEVRB RAS, which allows creating environmental atlases, is available for territories of different scale: for the Volga River Basin [11], Samara Region [12], Togliatti [13].

4. INNOVATION IN ENVIRONMENTAL MANAGEMENT ACTIVITIES

In the modern innovative economy (knowledge economy), the center of interests is rather quickly shifting to intangible assets or intellectual capital. According to analysts of the World Bank, the national wealth of developed countries is only 5% natural resources, 18% – material, produced capital, and the main place – about 77% – are knowledge and the ability to dispose of them [14]. Knowledge, intellectual resources are the main condition for economic growth, outpacing factors such as labor, capital, natural resources and many others. The organization of their use, implementation in products, services and innovations is one of the most difficult problems of modern management, the solution of which requires new approaches both to the actual management and to the training of managerial personnel. That is why the management of intangible resources becomes the leading paradigm of XXI century management.

In Russia, an attempt to "enter" this paradigm resulted in plans for the ambitious construction of a "technology city from scratch" – Skolkovo ("the project

from above"). This innovation center should simultaneously engage in research in all five priority presidential areas for the modernization of the Russian economy – energy (energy saving), information technologies, telecommunications (based on space technologies), biomedical (mostly pharmaceutical) and nuclear technologies. In the context of this work, first of all, we should talk about ensuring environmental safety in the context of any modernization of the economy – unfortunately, in the "Skolkovo project" these crucial (especially for Russia) problems were not found. This became the basis of the IEVRB RAS to initiate and create the Non-profit Partnership "Interregional Association for Ecological Safety (NP IAES)" – a kind of "Skolkovo project", but "moving from the bottom". The pretentiousness of this project is not in the technical and construction creation of a certain special (attractive for science and innovation) urban infrastructure, but in the creation of a no less attractive "intellectual infrastructure". NP IAES united, at the first stage, a half dozen academic organizations, universities, small and medium business organizations, public organizations of the Samara region and the Chuvash Republic with the goal of assisting members of the partnership in their activities to protect the habitat, to develop and implement the necessary technologies aimed at neutralizing the harmful effects on the environment and the rehabilitation of anthropogenically deformed areas [15].

5. BRIEF SUMMARY

So, the catch phrase Honoré de Balzac (1799-1850), made in the title of this article, looks completely fair. Indeed, innovative activity based on modern ecological knowledge is practically absent in our country (misères, poverty; perhaps the exception is the methods of utilization of waste, which are systematically introduced in all regions, life forces). On the other hand, environmental science has accumulated a huge store of knowledge about ecosystems of various scales (splendeur, brilliance), which makes the next step inevitable - the transition to environmental technologies. But on this path one should listen to the fair words of a specialist in the strategy of marketing opportunities and leadership, Professor Gene N. Landrum: «large-scale innovations are never created by those who wish to save their own peace» [16, p. 242].

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BIONANOTECHNOLOGIES FOR THE WASTE WATER TREATMENT

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ABSTRACT

Taking into account the need to increase the efficiency of the designed and existing biological treatment facilities, a complex of nanomethods and nanotechnologies is considered. They are aimed at the further use of the biological potential of microorganisms such as destructors of wastewater components. The generalized characteristic of the effective use of reagents based on nanostructured iron and its salts as well as nanostructured natural minerals (zeolite, clinoptilolite, etc.) and other adsorbents, membrane oxygen transfer from the air mixture to the aqueous phase to support biological processes and remove a wide range of pollutants from water and the improvement in the properties of microbial communities involved in water purification is given as well as the accentuated use of molecular diagnostic methods for assessing the status of wastewater treatment processes is reviewed.

Keywords: waste water treatment, bionanotechnology, microbial communities

1. INTRODUCTION

The wastewater treatment remains an urgent problem of our time, the solution of which is associated with the implementation of a set of tasks for the disposal of wastewater in the processes of oxidation and transformation of their components.

The main product of bioconversion of wastewater components (substrates) is biologically treated water, by-product is biomass of activated sludge or biofilm. Currently operating municipal wastewater treatment plants often don’t provide a balanced development of the main groups of microorganisms-destructors of wastewater components, don’t meet modern requirements for treated water, and in many cases are the cause of organic pollutants, especially nutrients (nitrogen, getting into natural water bodies) and phosphorus), thereby causing the processes of eutrophication of water bodies.

An equally important problem in the operation of microbiocenosis of activated sludge in biological treatment plants is to ensure its stable separation from purified water by sedimentation as well as the further disposal of excess biomass of activated sludge.

In addition, in the conditions of development of production complexes, an extremely urgent problem is the removal of biologically resistant pollutants in industrial wastewater. To this end, biological wastewater treatment systems should be supplemented with physicochemical steps and processes, in particular, nanosorption and membrane technologies.

One of the factors in the development of innovative technologies in the field of biological treatment of industrial wastewater is the development and use of methods of operation and diagnostics of processes for removing pollutants from wastewater based on nano-objects, the size of which is determined in the range from 1 to 100 nm.

When implementing bionanotechnology for wastewater treatment, a set of tasks for the operation of treatment facilities are solved:

1. Technological challenges. Investigation of the biological wastewater treatment process with analysis of the activity of microorganisms of a biofilm or activated sludge (enzymatic, respiratory, etc.)

2. Physicochemical challenges. Characterization of the polymer matrix of the microbial aggregate (biochemical and physicochemical parameters). Microbial exoenzymes in biofilms.

3. Microbiological and molecular biological challenges. Characterization of the distribution of microorganisms involved in the biotransformation of the substrate - wastewater components with identification of the main microbial groups (FISH, Quorum sensing, etc.).

2. TECHNOLOGICAL CHALLENGES

First of all, it should be noted that in advanced home and world practice, reagent wastewater treatment is used to deeply remove phosphorus compounds and other water components, as well as to improve the sedimentation of biomass and efficiently utilize its excess amount in combination with biological treatment.

Nanotechnology is widely used for the treatment of aqueous solutions (wastewater treatment, water preparation) with deep removal of phosphorus compounds on base the use of nanoscale iron [1]. This is due to its magnetic and catalytic properties. Extensive laboratory studies have shown that nanosized iron particles can catalyze the conversion of a wide range of pollutants: chloromethane, ethane, ethene and benzene, organochlorine pesticides, chlorinated phenols, PCBs, organic dyes, various inorganic compounds and metal ions [2]. Due to the high specific surface and the large redox potential, nanosized iron particles are extremely active in the conversion of pollutants [3].

A study was carried out of the dependence of the sizes of activated sludge aggregates on the particle sizes of the nanostructured reagent preparations based on

particles of iron salts in the process of complex biological and reagent wastewater treatment [4]. It was shown that morphologically larger agglomerates are formed in the sample with the Nanofloc A644 dephosphating reagent compared to the sample with the Biokat P500 reagent, which is also used to remove phosphorus compounds from wastewater. As a result of experimental studies of aggregation (flocculation) processes in the presence of the reagent preparation VTA Biokat P500, it was noted that a solution with a working concentration of VTA Biokat P500 50 μl/l is characterized by a homogeneous particle size, which, in turn, leads to the formation of sizes of activated sludge flakes, favorable for biological oxidation and satisfactory sedimentation.

It was suggested that the particle size of the reagent in the working solution in a fairly narrow range from 30 to 40 nm may be decisive for the morphology of sludge flakes formed in contact with such reagent solutions. Moreover, the biooxidative and enzymatic activity of microorganisms in activated sludge aggregated in the presence of Biokat P500 10 and 50 μl/l turned out to be high [5]. It should be noted that it is for the indicated dosages of the reagent that the particle size in the range from 30 to 40 nm (from 43 to 100%) is characteristic.

The most important aspect of technological improvement of biological wastewater treatment is the use of nanostructured natural materials (zeolite, clinoptilolite, etc.) to remove a wide range of pollutants from water and fundamentally improve the properties of microbial communities involved in water treatment. The use of such reagents in the technologies of the so-called biosorption (combined physico-chemical and biological) wastewater treatment determines the prospects for their development, the creation of new and modernization of existing treatment facilities without significant capital costs.

The adsorbents used in biological wastewater treatment systems are zeolites and other minerals, activated carbon, and ash from thermal power plants [6]. The effect of combined biological and adsorption wastewater treatment is determined by the adsorption of substances on the surface and in the micro(nano)pores of the adsorbent, as well as the immobilization of microorganisms on its surface. As a result, the processes of biooxidation of organic substances, nitrification, sedimentation of activated sludge biomass are improved, the stability of the treatment facilities in “salvo” modes increases when concentrated wastewater flows, as well as during the start-up period.

Another major factor in the biooxidation process during wastewater treatment is the provision of microorganisms with the necessary amount of oxygen.

An effective oxygen mass transfer for breathing aerobic microorganisms can be achieved using nanostructured membranes with selective oxygen permeability from a gas-air mixture. In this case, molecular oxygen transfer through the membrane is realized without the formation of gas bubbles. An additional advantage of bubble-free oxygen supply of biological treatment plants for wastewater treatment of chemical and petrochemical enterprises is the prevention of blowing off of volatile organic substances from wastewater and secondary air pollution.

3. PHYSICOCHEMICAL CHALLENGES

The use of the adsorption method for the deep purification of wastewater from dissolved organic substances is advisable for enterprises of organic synthesis, oil refineries, pulp and paper mills, enterprises of the textile industry and in many other industries. At the same time, alternatives to activated carbons have not yet been found.

It should be noted that the cost of purification is determined primarily by the costs of regeneration of adsorbents. In many cases, water purification on high-quality sorbents, including activated carbon, is practically impossible for economic reasons without their regeneration. The currently used process of thermal regeneration is very energy-intensive (reactivation temperature is 650-1000 ^{0}C) and therefore expensive procedure. It is also necessary to take into account the replenishment of carbon losses from burning and abrasion in each regeneration cycle up to 10%. In addition, the products of thermal regeneration in most cases are dibenzodioxins and -furans. In this case, additional neutralization of the desorption products is required. All this leads to the search for a more efficient and simple technology of regeneration, which will significantly increase the efficiency of the adsorption method of wastewater treatment and reduce the amount of activated carbon.

Further, it should be noted that extracellular and intracellular enzymes are native nanoobjects of a biological (biochemical) nature. Biological wastewater treatment processes are traditionally based on the realization of high enzymatic activity of microorganisms as destructors of pollutants, thus participating in redox biocatalytic degradation reactions of wastewater components. In a number of cases, an increase of biological activity in activated carbon filters was noted, which may be associated with an increased concentration of the substrate on the carbon surface, and adsorption is the main reason for the increase in the oxidative power of the wastewater treatment process using microorganisms [7].

One of the most important reasons for the biological regeneration of a sorbent is the degradation of a substance adsorbed in nanopores under the action of extracellular enzymes. Since the size of bacteria is large for their penetration into the true nanopores of activated carbon, biodegradation in the pores occurs through extracellular enzymes that can easily penetrate the narrowest pores and interact with the adsorbed substrate. These extracellular enzymes contribute to its hydrolytic decomposition. Due to the weakening of the adsorption affinity of the decay products, they are desorbed and become available for cellular biodegradation on the outer surface of the activated carbon.

In the described processes, the structural features of microbial aggregates formed by a matrix of extracellular polymeric substances should be taken into account. The biofilm matrix is known to limit the diffusion rate of both high molecular weight and low molecular weight substances [8]. Limited diffusion in the biofilm matrix volume leads to concentration gradients of substrates and

metabolic products of bacteria, as well as oxygen causing spatially heterogeneous growth of biofilm microorganisms.

It is known [9] that activated carbon can be biologically (by enzymes) regenerated to varying degrees by removing various organic substances from the pore space, including xenobiotics: phenol, 2-chlorophenol, benzene, p-cresol, trichloroethene, dichloromethane, 3-chlorobenzoic acid, thioglycolic acid, 2-mercaptobenzenethylthiazole (captax), complex aromatic compounds such as naphthalene, phenanthrene and anthracene, as well as from dye molecules and ions, water-soluble polymers, surfactants.

For bioregeneration, both pure and mixed microbial cultures can be used. Pure cultures are effective for surface regeneration from monosubstrate in the case of carbon filters for separate adsorption treatment. Mixed cultures, for example, adapted activated sludge, can be successfully used for the regeneration of carbon saturated with various substances (carbon filters for the treatment of mixed run-off).

4. MICROBIOLOGICAL AND MOLECULAR BIOLOGICAL CHALLENGES

In this case, we are talking about the molecular biological diagnosis of microbial communities of treatment facilities, which is carried out according to the main microbial groups, genera, and species in the composition of communities (nitrifying agents, phosphate accumulating, flocculating, filamentous bacteria, etc.), which determine the effectiveness of the wastewater treatment process.

The main problem that arises in the study of microbial aggregates is the inconsistency in the structure and composition of aggregates developing in real systems. Microbial aggregates formed in wastewater treatment systems consist generally of water (often more than 90%), extracellular polymeric substances (which can make up to 90% of the total amount of organic substances), cells, various inorganic particles, sorbed ions, polar and nonpolar organic molecules.

Significantly facilitate the task of monitoring biofilm methods that allow *in situ* analyzes, i.e. directly in the research system. The work of creating simple, accurate and non-destructive methods for monitoring microbial aggregates in real time is very relevant.

From the point of accessibility and reliability of the results obtained, the method of fluorescence *in-situ* hybridization (FISH) can be widely used in wastewater treatment practice.

The FISH method allows the identification of individual bacterial cells by incubating a biofilm or granule slice directly on a glass slide with a solution of gene probes. A gene probe is an artificially obtained complex consisting of a fragment of a specific RNA as an oligonucleotide containing from 10 to 18 nucleotides, and a fluorescent marker molecule [10, 11].

When cells are incubated with a solution of gene probes, hybridization occurs between the denatured DNA of the cells and the single-stranded RNA of the

probe, i.e. the formation of a duplex of DNA-RNA as a result of the interaction of complementary nucleotides. In the process of microscopy, it is necessary to establish a wave length that activates the fluorescent marker molecule, and hybridized cells can be observed in the microscope field. At present, gene probes have been developed that make it possible to distinguish between groups of microorganisms at all phylogenetic levels.

The FISH method is most accurate for identifying microorganisms in biofilms or other microbial aggregates. In addition, several consecutive hybridizations with various gene probes can be performed on a single preparation. Thus, it is possible to identify various groups of bacteria in microbial aggregates, as well as to determine their localization inside the aggregate during observations using confocal laser scanning microscopy (Confocal Laser Scanning Microscopy - CLSM).

In order to recreate the picture of the spatial succession of microorganisms inside the microbial aggregate and the quantitative counting of cells, special software for a personal computer for processing images obtained using CLSM should be used.

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STUDYING OF THE TERRITORIES STATUS IN THE ZONE OF INFLUENCE OF ROADS

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ABSTRACT

The paper presents integrated assessments of the contamination degree of the roadside areas soil cover (for example, in Orenburg). The quality of the territories was assessed by the concentration level, the index of chemical soil pollution, and ecotoxicological index. The assessment of the state of atmospheric air using morphometric studies of plant leaves indicators showed that plants growing in the roadside area, have a large fluctuating asymmetry (disturbed mechanisms of development) in relation to plants in the Park area. The leaf area of the roadside plants is much larger than the leaf area in the Park area. In the roadside zone coniferous trees have a smaller increase, but a greater number of needles on them.

Keywords: roadside area, pollution, concentration factor, heavy metals, indicator plants.

There are several types of technical geological system in the city of Orenburg: transportation and communication, industrial, residential, agricultural and recreational [1]. Transport and communication type of technical geological system is a predominantly linear form of anthropogenic impact.

We consider the city of Orenburg as an urban environment in which the main elementary spaces are the streets, the length of which is about 1514 km [2]. The streets of any city are a long source of emissions of exhaust gases and dust.

Distribution of traffic flows on the streets and roads of Orenburgis carried out in accordance with their purpose.The main streets are formed more sophisticated and withstand heavy loads, as well as traffic with high speeds.

Due to the high density of construction, the share of the Orenburgcentral historical part accounts for a minimum percentage of roadside areas, because many of the main streets of the city center roadside areas are completely absent, and the construction line is located directly at the roadbed (1-2 m). On other streets the width of the roadside space is 10 - 15 meters. In the new neighborhoods of the city

roadside areas have a maximum area. Here houses on the main streets are at a distance of 50 - 100 meters from the roadway and separated from the roadway plantations of shrubs and trees.It should be noted that due to the difficult environmental situation green spaces play an important role in the life of any modern city. However, in the most depressed state is the vegetation cover of streets with heavy traffic (these are main streets of citywide and district values, where there is a maximum intensity of traffic), boulevards of the central part of the city.It is in such placesa variety of compounds of natural and anthropogenic origin areaccumulated in the soil; itleads to pollution and toxicity of soil [3, 4, 5, 6].

Many technical and environmental decisions require an assessment of the roadside [7]. In this regard, the integrated assessment of the soil cover in the area of roads influence isof a great scientific and practical interest. That is why the purpose of this work is the environmental assessment roadside territories on the example of Orenburg.

In accordance with the purpose in the course of this study the following tasks were solved:

- soil sampling in the zone of highways influence was carried out;
- the analysis of soil samples for the content of heavy metals anddifferent groups of ions was carried out: chloride ions and bicarbonate ions, the hydrosulfideions, calcium and magnesium ions, sulfate ions, ammonium ions;
- ranking of the studied territories by ecotoxicological indicator;
- the assessment of pollution degree of roadside territories on the concentration ratio and the total index of chemical soil contamination;
- the assessment of morphological changes of plants in thezone of influence of the roads was performed.

To determine the state of the soils of the roadside area, soil extraction was studied for a group of ions: chloride ions, bicarbonate ions, hydrosulfide ions, calcium and magnesium ions, sulfate ions, ammonium ions in accordance with the approved methods [8].

Determination of the concentration of heavy metals (iron, lead, chromium, nickel, zinc) in the soil was performed with the help of atomic absorb spectrometer (modifications of the MGA-915, MGA – 915M, the MGA – 915MD).

Samples of the soil cover were selected, transported and stored in accordance with GOST 17.4.4.02-84 "Methods of sampling and preparation for chemical, bacteriological, helminthological analysis» [9].

Sampling was carried out on the streets of different purposes in various districts of the city by the envelope method from each site by mixing point samples to obtain a combined sample, for comparison samples were also taken in residential and park areas.

The results of the study showed that the priority pollutants of the roadside area of streets for various purposes are among acid-forming ions chloride ions, their concentration ranges from 532,56 mg/kg to 1670 mg/kg and hydrocarbonates from 250,78 mg/kg to 1823,37 mg/kg depending on the category of roads. Data on the concentration of pollutants are shown in figure 1.

As it can be seen from the data in figure 1, the average concentration of chloride ions in the soil of the residential zone is 3 times lower, it is 6 times lower in the park zone, the content of hydrocarbonates are 3 times lower compared to the roadside area. In the roadside zone, the soil has a pH value from 7,07 to 7,98, which characterizes it as a zone with a relatively satisfactory situation for this indicator [10].

A comprehensive assessment of the degree of soil contamination by the concentration factor showed that the maximum excess compared to background samples are observed on the main streets of the city and district value:

- magnesium ions from 10 to 22,5 times;
- by calcium ions from 3,4 to 9,5 times;
- on the hydrocarbons of 2 to 8 times;
- chloride ions from 2 to 5 times (figure 2).

The increased content in the soil and the excess background of these pollutants is associated with the use of anti-icing materials and emissions of exhaust gases of cars.

To assess the state of the roadside soils, the chemical soil contamination index (CCI)was calculated using formula:

$$\mathrm{CCI}_n = K_1 + K_2 + \cdots + K_n = \sum_{i-1}^{n} K_i = \frac{C_i}{C_b}, \quad (1)$$

where Ki - the concentration coefficient of the i-th pollutant;

Ci – concentration of the i-th pollutant, mg/kg;

Cb – background concentration of the i-th component, mg/kg.

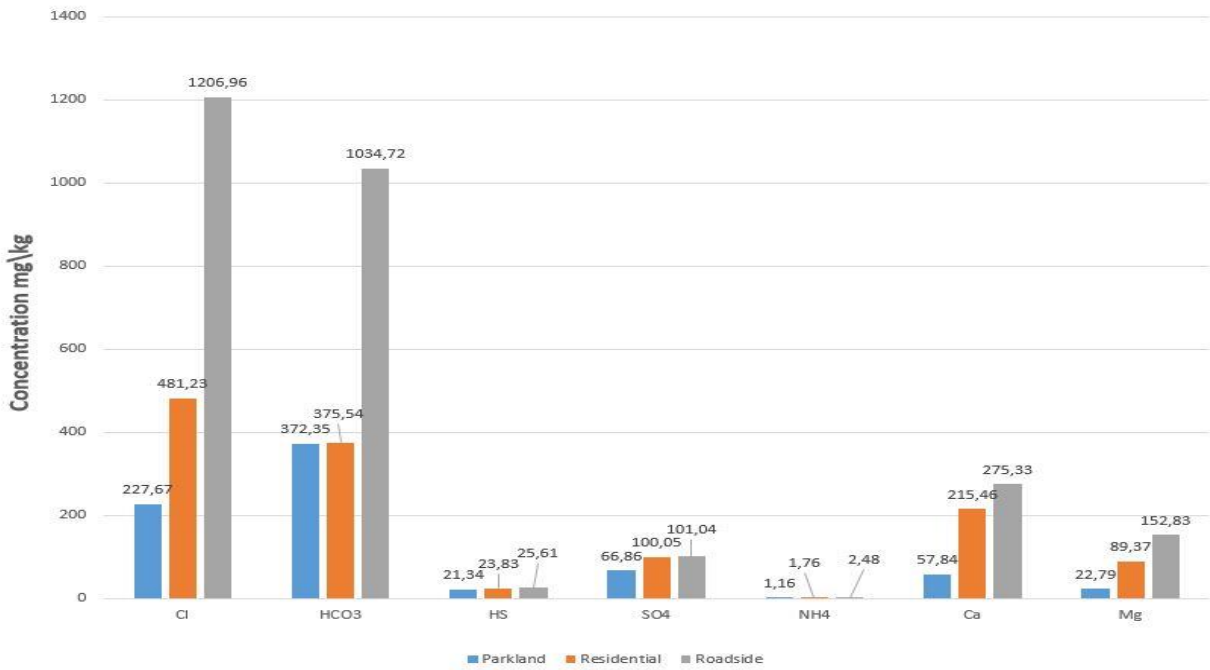

Figure 1 - Average concentrations of pollutants in the soil of different functional areas of the city

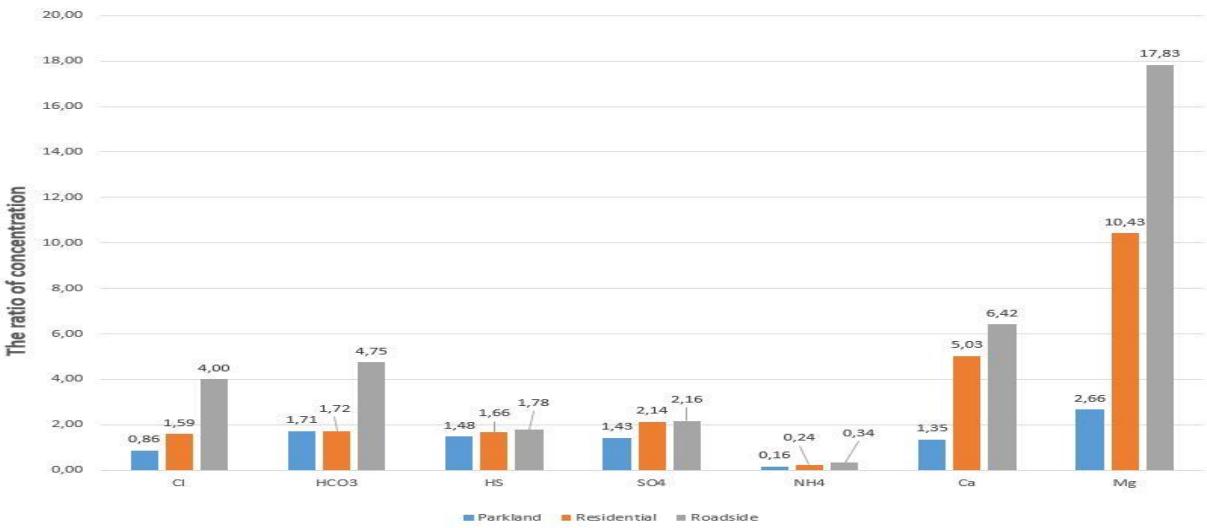

Figure 2 - Results of the average values of ratios of concentrations of pollutants in soil extract

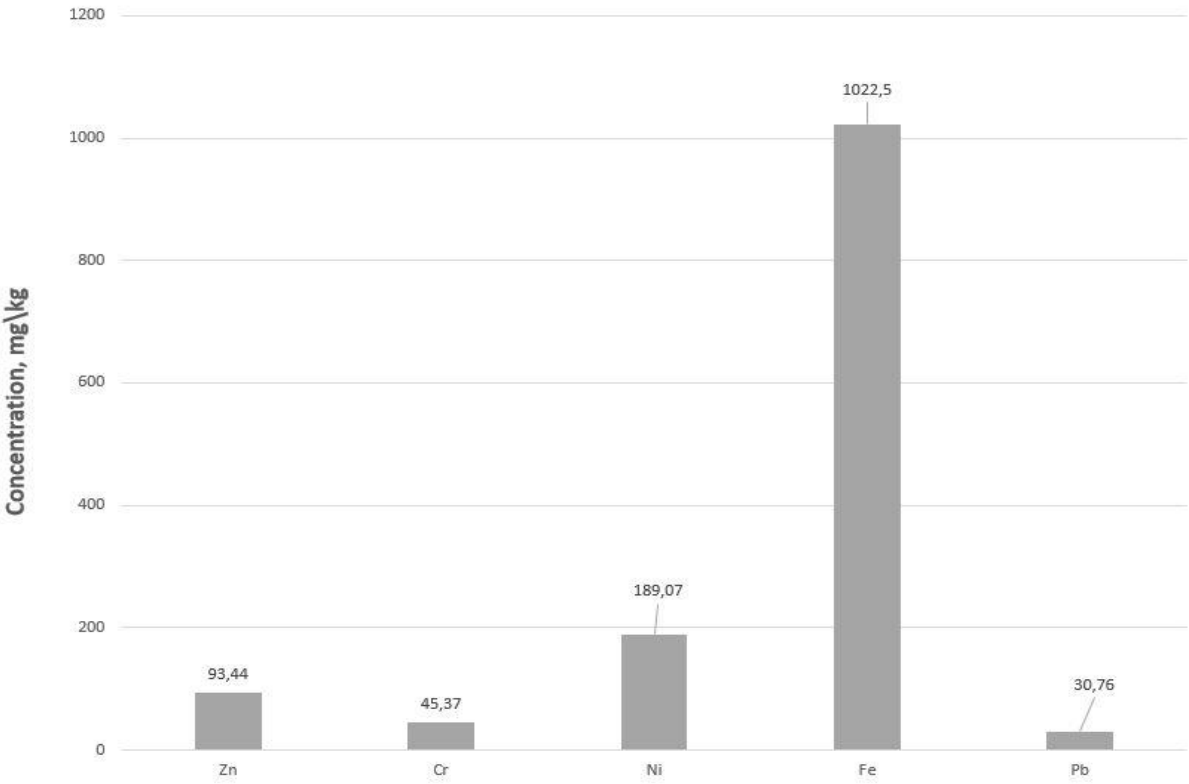

Figure 3 - Heavy metal content in roadside soils

On the basis of the criterion (CCI) presented in table 1, it was found that there is an emergency environmental situation in the study areas, since the CCI values range from 32,5 to 44,98, with the exception of some main streets of district value (with lower traffic intensity), where the CCI values range from 26,9 to 30,3, which corresponds to the tense (critical) environmental situation.

Table 1

Criteria for assessing the degree of chemical pollution of environmental objects [11]

Indicators	Characteristics			
	Ecologicaldisaster	Environmental emergency	Tense (critical) environmentalsituation	Relativelysatisfactorysituation
CCI	> 128	32-128	16-32	< 16
pH	5,0-5,6	5,7-6,5	6,6-6,9	>7

Studying of heavy metals has shown that lead content in roadside soils ranges from 19,7 mg/kg to 40,9 mg/kg, zinc from 32 mg/kg to 126,8 mg/kg, chromium from 25,7 mg/kg to 60,4 mg/kg, Nickel from 34,8 mg/kg to 68,9 mg/kg, iron from 516 mg/kg to 1186 mg/kg (figure 3).

Ecotoxicological indicator (EI) of soil quality [12] was also calculated, which represents the multiplicity of excess of the maximum allowable ratio (MAR)of a specific pollutant, differentiated for substances of different hazard classes (Criteria of ecological state of soils) (table 2).

According to the ecotoxicological indicator (EI) of heavy metals of hazard class 1 (EI = 1,15) and hazard class 2 (EII = 1,09), the studied roadside area belongs to the territory with a critical environmental situation.

Table 2

Criteria for soil ecological status

Indicators	Stateparameter			
	Ecologicaldisaster	Environmentalemergency	Tense (critical) environmentalsituation	Relativelysatisfactorysituation
EI	>3	2-3	1-2	<1
EII	>10	5-10	1-5	<1
EIII	>20	10-20	1-10	<1

The main types of trees used for landscaping the city of Orenburg, including roadside areas are: elm, common beech, cherry, poplar, birch, pedunculate oak, common lilac, small-leaved elm, rowan, ash lanceolate, maple, lombardy poplar, silver birch.

To assess the state of the components of the environment, we have chosen the following types of indicators: ash lanceolate (Fraxinuslanceolata) is sensitive to sulfur dioxide, birch (Bétulapéndula) is an indicator of NO_2, especially in combination SO_2, common lilac (Syríngavulgáris), which is sensitive to the content

of exhaust components in atmospheric air, which is manifested by a change in the color of leaves from dark green to light green.Thus, the selected plants are sensitive to typical pollutants of the urban environment and are quite common in the city.

The most common method of bioindication is the assessment of morphological changes in plants. Common methods were used in the research [13].

The results of the evaluation of morphological changes of plants showed that the percentage of leaves exposed to chlorosis and/or necrosis in the roadside zone was 30% in lilac. For comparison, in the park area it was 5%. About 25% of the leaves on the roadside are damaged by chlorosis and/or necrosis, and only 7% in the park zone. In ash lanceolate in the selected samples of leaves were found damaged 27% on the roadside and only 8% in the park area.

For the studied tree species, the magnitude of fluctuating asymmetry was estimated (FA). Fluctuating asymmetry means minor non-directional deviations from strict bilateralsymmetries as a consequence of imperfection of ontogenetic processes. It is the result of the inability of organisms to develop in the exact certain way.

To determine the asymmetry of the sheet plate, measurements were taken on the left andto the right of the main vein of the leaf on the signs of:

1 - width of the left and right halves of the leaf;

2 - the length of the vein of the second order, the second from the base of the leaf;

3 - the distance between the bases of the first and second veins of the second order;

4 - the distance between the ends of these veins;

5 - the angle between the main vein and the second one from the base of the leaf vein of the secondorder.

The fluctuating asymmetry is calculated by the equation:

$$\mathrm{FA} = \frac{1}{n*m}\sum_{j=1}^{n}\sum_{i=1}^{m}\frac{|Lij-Rij|}{(Lij+Rij)}, \qquad (2)$$

where Lij and Rij are the value of the j-th parameter of the I-th leaf, respectively left and right of the plane of symmetry;

m - number of analyzed features;

n –sample size.

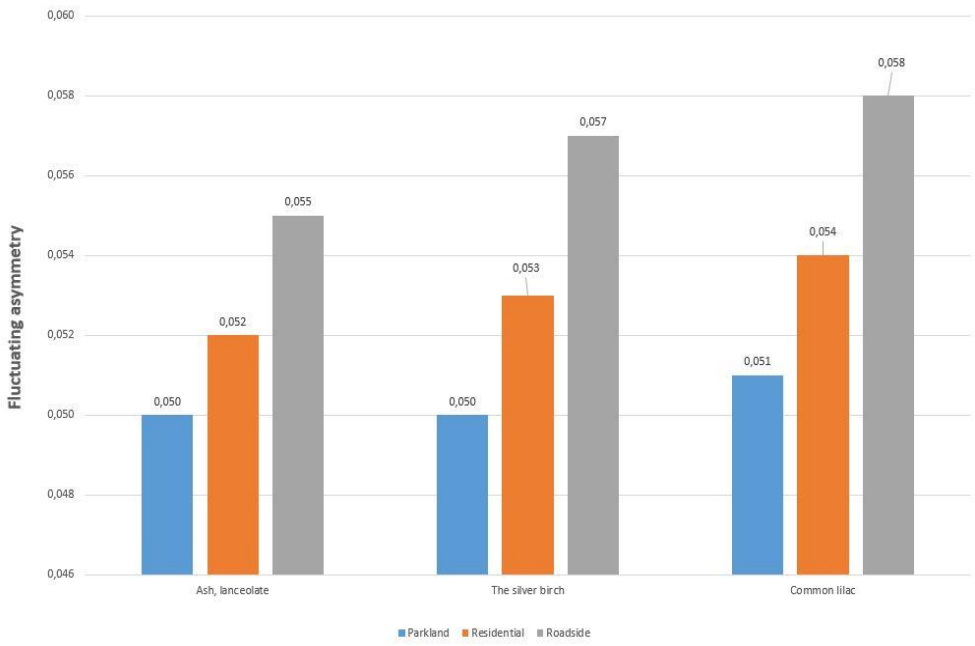

Figure 4 - Average values of fluctuating asymmetry for different types of indicator plants

The assessment of environmental quality in terms of fluctuating asymmetry (table 3) showed that for ash lanceolate this indicator is from 0,052 to 0,055, for birch hanging from 0,052 to 0,057, for lilac from 0,053 to 0,058 (figure 4). This indicates a critical state of the environment in the roadside area.

Table 3

Scale of environmental quality assessment by fluctuating asymmetry

An indicator of the level of fluctuating asymmetry (FA)	Point	Environment quality
<0,040	I	Normal
0,040-0,044	II	Initial deviations from the norm
0,045	III	Average deviation from the norm
0,050-0,054	IV	Significant deviations from the norm
0,055 >	V	Critical condition

Thus, the assessment of the state of atmospheric air using morphometric studies of plant leaves indicators showed that plants growing in the roadside area, have a large fluctuating asymmetry (disturbed mechanisms of development) in relation to plants in the Park area. The leaf area of the roadside plants is much larger than the leaf area in the Park area. In the roadside zone coniferous trees have a smaller increase, but a greater number of needles on them.

From the results of determining the concentration factor of pollutants in the soil, we calculated the CCIand obtained that in the roadside there is an emergency environmental situation (CCI – 37,495). According to the concentration of heavy metals in the soil, the excess of relatively permitted concentration (RPC) is not recorded, but according to the ecotoxicological index of heavy metals of the first and second class there is a critical environmental situation in the roadside zone.

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ANTHECOLOGICAL STUDIES OF NATURAL AND DISTURBED LANDSCAPES PLANT COMMUNITIES IN NORTH-EAST ASIA

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ABSTRACT

Comparative pollination ecology research of the typical species of arctic, alpine and forest plant associations, most of which are circumpolar or almost circumpolar were carried out in the North East of Asia. Data obtain shows importance of wind and insect pollination, sexual separationbetween and within plants, and various breeding systems related to plant growth form and habitat in extreme condition. The studied species with highly specialized pollination systems and generalized pollination biology, self-pollination and agamospermy were investigated. Flexibility of seasonal and daily rhythms of flowering and pollination, high fertility of the generative sphere of flowers were determined. Dichogamy and another alternative ways of pollination, as autogamy, geitonogamy and xenogamy are guarantee for successful fruiting ofnorthern species. Results ofresearch demonstrate that there arespecies in the native flora, which are useful for revegetation of disturbed sites, as well as for creation of seeding meadows in permafrost regions.

Keywords: disturbed sites, native species, introduction, soil-vegetation complexes, seeding meadows, biological reclamation

1. INTRODUCTION

Severe climatic conditions of the North East Asia, permafrost landscapes, low summer temperatures are typical environmental circumstances of plants habitats in region of our research. In such extreme environments seed propagation is the main way for the northern angiosperms reproduction.This fact defines the high actuality of their ontogeny studies. Being a critical stage of plant life cycle, flowering and fructification has been a subject of permanent researchers' attention for a long time, beginning with Charles Darvin. The most prominent reviews on

reproductive biology were made by H. Kugler (1970), K. Faegri, L. Pijl (1979), and for anemophilous plants by A. N. Ponomarev (1964, 1970).

A considerable contribution to the study of the reproductive ecology of the tundra plants in Russia was made by V. F. Shamurin (1966), who carried out flowers and pollination research in the Arctic zone, mainly in Yakutia. Studies of the insect and flower relationships in the Canadian High Arctic, on Ellesmere Island, were carried out by P. G. Kevan (1970, 1972). Pollination ecology of the entomophilous species was studied on a highly methodical level and reached good results. Our research was performed inthe plant communities of natural and disturbed landscapes in Chukotka, Magadan region and Kamchatka Peninsula (Levkovsky, 1978; Pugachev, Tikhmenev, 2011; Tikhmenev, Tikhmenev, 2018).

2. RESULTS AND DISCUSSION

Comparative research on pollination ecology and adaptation to extreme habitats of the common northern speciesin arctic, alpine and forest communities of different natural conditions permafrost region of North Eastern Asia. We'll consider below the data obtained about specific peculiarities of plant generative sphere adaptation to extreme habitats in different areas of North Eastern Asia.

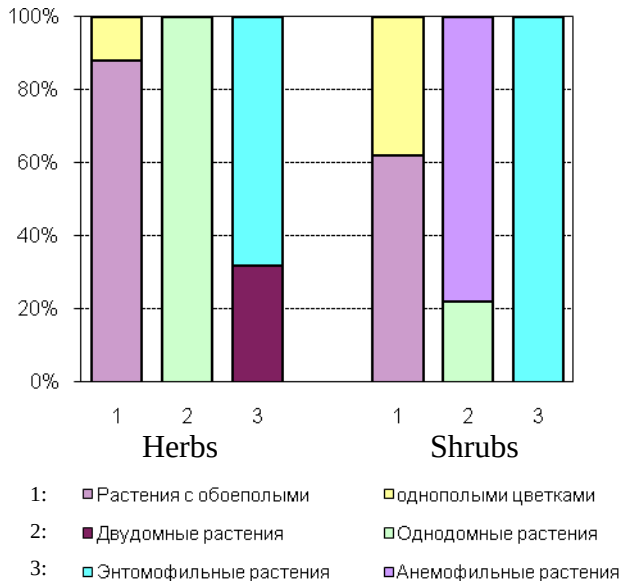

Figure 1 - The sexual expression and pollination system of the arctic tundra plants of Wrangel Island (a), based on floral lists of Petrovsky (1973)

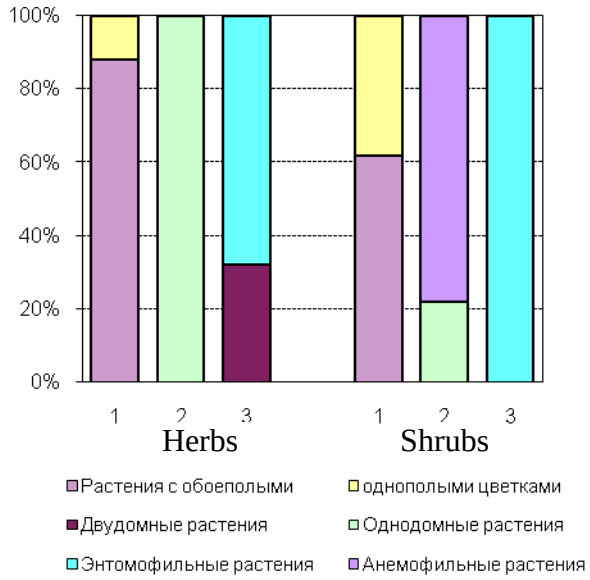

Figure 2 - The sexual expression and pollination system of the alpine tundra plants of the Kolyma river basin, based on floral lists of Yurtsev and others (2010)

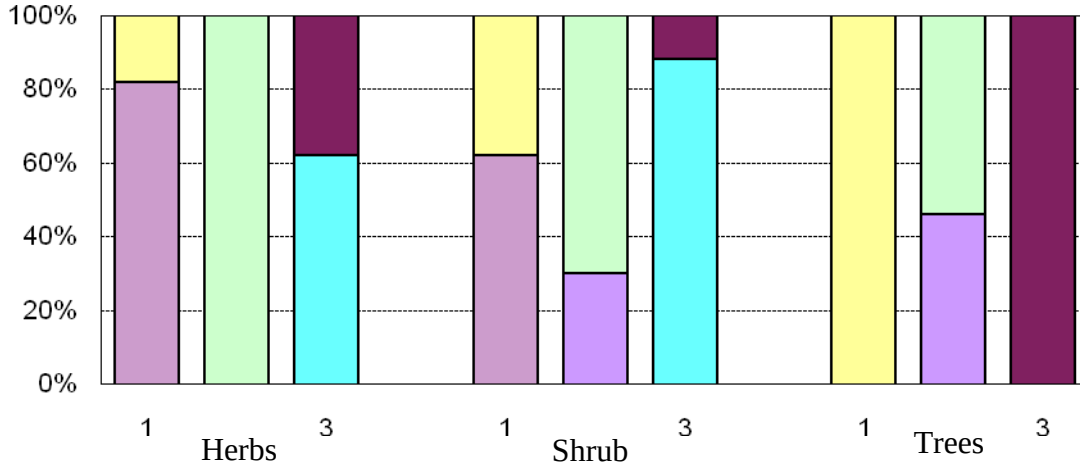

Figure 3 - The sexual expression and pollination system of the Larch forest communities of the Kolyma river basin, based on Checklist of Flora and vegetation (2010)

The designations are the same as in Fig. 1, 2.

If examine the floral lists of the North East of Asia (Yurtsev and others, 2010; Flora and vegetation…, 2010) we can easily state (Figures 1, 2), that herbs and shrubs of arctic and alpine tundra possess similar sexual expression and pollination systems. The herbs have mostly bisexual flowers [1], they are hermaphroditic [2] and mainly (more than 70%) entomophilous [3]. Among Wrangel Island shrubs the number of unisexual flowers is increased [1], they are mainly unisexual plants [2] and entomophilous only (3). In alpine shrubs the share of hermaphroditic plants is slightly higher [2] and 10% of them are anemophilous they are entomophilous only (3) and 10% of them are anemophilous (Fig. 2). Besides, we have not found any differences in pollination system and sexual expression between alpine herba and shrubs, so as in larch communities as well (Fig. 3).

The specific feature of pollination is that there are a group of northern species is well adopted forcross-pollination. Natural associations of entomophilous species comprised of no less than 2/3 of the species of floral lists of the territorystudied. The most specialized pollination mechanism sare common for the Fabaceae and Scrophulariaceae, well adapted to pollination by anthophilousinsects. Fruiting of *Astragalus*, *Oxytropis* and *Hedysarum* species of this area completely depends on pollination by specialized insects, such as bees and bumble-bees. The speculiarities of pollination mechanisms of studied speciesare also typical of those genera elsewhere in theHigh Arctic, alpine and forest communities (Shamurin 1966; Kevan 1970, 1972; Kevan and others, 1993). Nevertheless, there are data, showing that some arctic and subarctic Fabaceae are self-pollinating. On the other hand, many antophilous insects are constant visitors of the legum species, where an abundantfood supply is available, such as nectar and/or pollen. This is a rather small group of obligate entomophilous species, mainly of *Fabaceae*, *Salicaceae* and *Scrophulariaceae*, as well as some species of other families that have an

inherent specialization in pollination by bees, bumblebees and flies. Itpossesses high pollen viability, produces much nectarand/or pollen and has usually large, bright flowers, andforms dense groups (clones), due to those features it isvery attractive for pollinators.

The other group, much more numerous of entomophilous species, with simple flowers is available to various pollinators, including unspecialized ones. Most of these species require insectvisitation for more abundant fructification. In case of deficiency of pollinators or their absence this group can readily pass to self-pollination in the form of autogamy or geitonogamy, as an alternative manner of pollination process, guaranteeing regular fruiting. They usually do not form any dense clones in natural habitats and have scattered distribution in the plant communities.

The interrelationship between plants and antophilous insects in arctic, alpine and forest habitats demonstrated many commonfeatures. The main groups of pollinators are *Hymenoptera* and *Diptera*, while *Coleoptera* and *Lepidoptera* have not great significance in pollination. No less than eight bumblebees and ten butterflies species were recorded on Wrangel Island and 12 species of bumblebees in alpine communities on the Kolyma Upland (Tikhmenev 1997). Diptera species are very common and abundant there. Manyplant species may have little or no absolute use for insects, however insects are responsible for outcrossing, providing population diversity in these species. The relation between plants and antophilous insects in arctic and alpine habitats show many common features. In studied area areas, main groups of pollinators are *Hymenoptera* and *Diptera*, while *Coleoptera* and *Lepidoptera* are not of great significance in pollination of northern plants.

The data obtained show us that the daily rythms of flowering in the majority of entomophilous species are close correlated with daily dynamics of temperatures. Maximum of pollination intensity occurs in the warmest midday hours. Close correlation of daily periodicity of blooming and pollination process with dynamics of temperature is characteristic for all the studied species of *Fabaceae, Scrophulariaceae, Salicacese, Polygonaceae, Ranunculaceae, Saxifragaceae, Rosaceae* and many species from other families (Tikhmenev, 1997; Pugachev, Tikhmenev, 2011). The density of antophilous insects during the massive blooming period is rather high and sufficient to provide cross pollination. To evaluate the significance of pollinators for the plant association, we have examined 7 different plant communities in alpine tundra. Out of 52 species of angiosperms, 35 species are entomophilous and 9 of them obligate lyentomophilous *(Astragalus alpinus, Oxytropisczukotica, O. evenorum, Pedicularis oederi, P. lapponica, Salix sphenophylla, S.tschuktschorum, Sieversia pusilla, Bistorta elliptica*). Polytrophy of pollinators permits them to exist dueto numerous nectar and/or pollen producers, while prosperityof *Fabaceae, Scrophulariaceae* and *Salicaceae* species directly depend on the pollination activity of bumble bees, wasps and *Syrphidae*. The data obtained show that the ratio between density of antophilous insects and quantity of simultaneously functioning flowers makes it possible to suggest deficiency of food for insects rather than lack of pollinators for successful pollination of these species.

Besides, the role of insect pollination in the prosperity of separate species is of no doubt, while significance of pollinators for stability of the plant communities is rather small. The entomoplilous plants compose one third of the phytomass of the investigated associations, while the obligate lyentomophilous- 0.1 to 2.9% of the total phytomass only. Approximately the same proportion was observed inarctic and alpine habitats (Pugachev, Tikhmenev, 2011).

The study of reproductive features of anemophilous species was focused on the pollination dynamicsand the flower biology of natural and disturbed sites species associations. Dynamic anemophily provides high adaptive capabilities and takes part in sympatric speciation of grasses (Ponomarev, 1970). In temperate zone anemophilous plants are usually characterized by a strict daily flowering rhythm, specific foreach species. In arctic and alpine habitats this feature of the pollination process in the *Poaceae* and *Cyperaceae* species is seldom realized; itbreaks usually down under the impact of unfavourableenvironmental factors – rain and low temperature. It was found that thedaily rhythm of blooming of northern anemophilous plants usually closely correlate with the temperaturedynamics, much in the same manner for most entomophilous species. More orless strict daily rhythm of the pollination was observed only for a few species: *Hierochloe alpine* and *Alopecurus alpinus* with massive pollen release occurringinthe morning and for *Festuca auriculata*, *F. brachyphylla*, *Trisetum spicatum* and *Phippsia algida* with massive pollen release in the afternoon and evening time (Levkovsky, 1978; Levkovsky, Tikhmenev, 1982).

One of the remarkably features of pollination of northern anemophilous plants is the ability of the generative elements of flowers to keep fresh and ready to be fertilized through 30-36 hours or more, while for many ofthe wind-pollinated species of the temperate zone this period varies from a few minutes to 1-2 hours. Our data also show that the pollination process occurs at low airtemperatures (+3,0...+6,0 °C in arctic tundra and +5,0...+8,0°C in alpine habitats). Especially low threshold temperaturesof the flower activity are characteristic of arctics pecies (Levkovsky, 1977; Levkovsky, Tikhmenev, 1973).

Table 1

Pollination systems of the species investigated in plant communities of the North-East of Asia (I - anemophilous, II – entomophilous plants)

Pollinationsystems	Arctictundra		Alpinetundra		Larchforest	
	I	II	I	II	I	II
Obligateoutcrossers	3	22	3	17	4	18
Facultativeoutcrossers	22	18	16	22	23	17
Predominantlyautogamics (apomictics)	3	8	4	8	7	3
Obligateautogamies	-	-	-	-	-	-
Numberofspecies	28	48	23	47	34	38

The pollen viability was found to be high in the holegroup of widespread grasses, e.g. *Alopecurus alpinus*, *Hierochloe alpina*, *H. pauciflora*, *Poa abbreviata*, *Dupontia fisheri*, *Arctagrostis arundinaceae*, *A. latifolia, Deshampsia glauca* and other ones. Many of them are obligate or facultative outcrossers. The duration of pollen viability is more than 24 hours in natural surroundings. The pollenfertility of other grasses (e.g. *Poa arctica*, *P. glauca*, *Festuca auriculata)* is much lower with ranges from 9 to 28%, and the pollen life duration is a few hours. Obligate outcrossers are uncommon in anemophilous plants (Table 1).

For a better understanding of succession processes direction on the disturbed sites, we carried out comprehensive reproductive biology research for formation of plant communitis (Pugachaev, Tikhmenev, 2011$ Kapelkina and others, 2014). Peculiarity of reproduction systems of forest species allows complete regulary ontogeny cycle despite specific conditions of the environment (Kevan and others, 1993). At the earlier stages of successions among the sparse vegetation cover at the disturbed sites anemophily easily occurs. Therefore disturbed sites are actively become reseeded with grasses, sages and other wind pollinating species.

Anthecological research pointed, that regular and thick seeding is common for *Poaceae* species: *Alopecurus alpinus, Hierochloe alpina, H. pauciflora, Poa abbreviata, Poa arctica, P. pratensis, Dupontia fisheri, Arctagrostis latifolia, A. arundinaceae, Deschampsia borealis, Elymus fibrosus, E. sibiricus, E. mutabilis, E. confusus, Festuca rubra, Calamagrostis holmii, C. langsdorffii.* Thus, these species are highly valuable for revegetationdisturbed sites purposes (Tikhmenev, Tikhmenev, 2018; fig. 4). Regular and thick seeding at the disturbed sites is typical for some arboreal and shrub species of the Salicaceae family: *Chosenia arbutifolia*, *Populus suaveolens*; *Betulaceae*: *Betula. exilis, B. middendorffii, B. platyphilla, Duschekia fruticosa),* typical anemophilous species are widely spread at the disturbed sites as well. Hereby, the high level of generative systems adaptation to the severe environment of the natural and disturbed plant communities is typical for large majority of northern angiosperms. Pollen of native species is well mature, high fertile, and save fertility 2-3 days during flowering period. Most of species under consideration are self-pollinating easily when xenogamy becomes a difficulty in naturalhabitat. Such featureof generative sphere are guarantee of regular seeding in the terms of possible lack of pollinating insects ore in the disadvantageous weather conditions occur. They typically grouped and dense form growth what helps to provide the success of wind and insect pollination for regular seed production of northern plants.

Figure 4 - Revegetation with local flora species at the Kubaka Gold Mine in basin of Kolyma (Omolon river)

Obligatory enthomophilous species of forest association are very common for Fabaceae, Scrophulariaceae and Salicaceae family, which need pollinators for a successful seed reproduction. In the beginning stage of succession percentage of enthomophilous species in plant communities of disturbed sites rather small. *Salix pulchra, S. schwereni, Populus suaveolens* and *Saxifragafunstonii* have showed more higher level of seeds production and its viability.

3. CONCLUSION

Similar environmental surroundings and history of flora formation of North Eastern Asia have defined the similarity of forms andtendencies of the plant adaptation process to extremeconditions. The specific feature of the region under observation is such that there is a group of species well adopted for cross-pollination. This is relative small group of obligate entomophilous species, mainly of *Fabacea*, *Salicaceae* and *Scrophulariaceae*, as well as some species of other families which have an inherent specialization in pollination by bees, bumble-bees and flies. It possesses high pollen viability, produce mach nectar and/or pollen and has usually large, bright flowers, and forms dense groups. Due to those peculiarities it is very attractive for pollinators. The other group much more numerous of entomophilous species with simple flowers is available to various pollinators, including unspecialized ones. Most of them require insect visitation for

more abundant frictification. In case of deficiency of pollinators or their full absence antophilous insects these species can readily pass to self-pollination in the form of autogamy ore geitonogamy, as alternative means of pollination process, guaranteeing regular fructification. They usually do not form any dense clones in natural habitats and have scattered distribution in the plant communities. The relative value of wind- and insectpollination, sexual separationof flowers between and within plants, and various breeding systemsare related to plant growth form in severe habitats.

Flexibility of seasonal and daily rhythms offlowering and pollination, high fertility of the generative sphere of flowers, dichogamy, and availability of alternativemanner of pollination, such as autogamy and geitonogamy are guaranties a successful fructification ofnorthern plants insevere condition. Self-pollination, periodically occurring in the studied plants, to be considered only asthe result of infringement of the pollination process underthe impact of the external factors.Marked by amazing flexibility of the plant pollination mechanism providing high level of fruiting and quite abundant seed production. It has been established that the natural communities of the northern territories there are all background for successful xenogamy, i.e. cross-pollination. Self-pollination in the form of genetically equivalent auto- and geitonogamy, being a reliable reserve, ensures the success of the cross pollination process, very commonfor species in different families under investigation, being an effective factor of biodiversity and stability of plantcommunities.

The studied species of *Fabaceae, Scrophulariaceae* and *Salicaceae*, as well as some species of other families are obligate entomophilous. They are well adopted to cross-pollination. A much more numerous group compose entomophilous species which may have little or no use for insects in their reproductive cycle. Nevertheless, the density of antophilous insects in massive blooming period is usually high and sufficient to provide the cross-pollination. Obligate outcrossers are uncommon in northern anemophiloius plants. In addition to outcrossing, most of them are capable of autogamy, cryocleistogamy and geitonogamy as alternative means of pollination, but no species that may be considered as obligate autogamics. Self-pollination, periodically occurring in studied anemophilous and entomophilous species is considered as an effective factors of plant diversity and community stability. Thus, the arctic, alpine and forest species have defined the similarity forms and tendencies of the plant adaptation to extreme condition of permafrost region.

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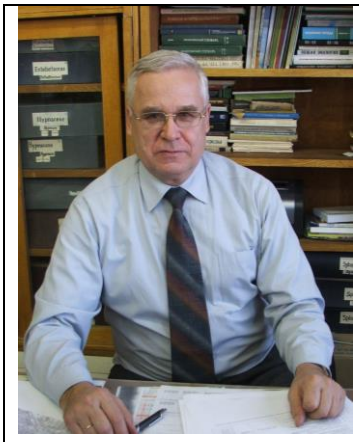	**Eugene A. Tikhmenev** is Ph.D in Biology, Professor of Biology and Chemistry Departament, North-Eastern State University. Head of Geobotany Laboratory, Institute of Biological Problems of the North Far Eastern Branch of RAS. Direction of scientific researches – adaptation of northern plants to extreme environment, environmental protection, reclamation of disturbed lands. Teaching disciplines: Botany, Flora and vegetation of the North, Ecology of northern plants, Reclamation of disturbed lands. He has conducted research in Canada, the United States, Mexico and Norway. Author of more than 180 scientific publications.
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SEVENTH INTERNATIONAL
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SOME APPROACHES AND RESULTS OF BIOLOGICAL MONITORING OF TOXICITY DURING NEGATIVE IMPACT IN URBAN TERRITORIES

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ABSTRACT

Presently negative impact of different kinds of pollutions sources in condition of urban territories is significantly increasing. Such impact may significantly damage man's health and the state of biosphere components: soil, water, air. Among of the other pollutions, toxicity is one of the most dangerous. The kinds and sources (as industrial as domestic) of toxicity of urban territories are analyzed. For example, lubricating cooling liquids may penetrate into soil and into ground water and cause significant damage to environment and to the man's health. That is why it is necessary to provide high quality monitoring of toxicity of urban territories.

Methods of monitoring are discussed. It is shown that the most convenient to use are biological monitoring methods. Results of monitoring of toxicity of urban territories using biological methods are described on the example of Samara region of Russia. As biological testing objects crawfishes *Daphnia magna* Straus and algae *Chlorella vulgaris* Beijer were used.

Results of investigation of toxicity of waste water of "AVTOVAZ" company as a factor of negative toxic impact to environment on the example of Kuibyshevsky water reservoir are described. Results allow to conclude that the surface waters of Kuibyshevsky water reservoir in the place of emission of waste water of Public Joint Stock Company "AVTOVAZ are toxic, but do not have acute toxicity.

In total results of biological testing are showing that some of often used waste components have high degree of toxicity.

Keywords: urban territory, monitoring, toxicity, biological testing, method, waste

1. INTRODUCTION

Rapid increasing of world population causes significant growth of urban territories [3-6, 8-10, 12, 17]. Urban territories are including cities, towns or conurbations, as well as settlements such as villages and hamlets. Environmental

pollution is a serious problem of urban territories. Impact of different kinds of pollutions may damage the landscapes and cause negative impact to the man and to the environment. The sources of environmental pollutions are differs depending on the kind of territory. Among of the other pollutions, toxicity is one of the most dangerous.

Toxicity is the degree to which a substance can damage a living or non-living organism. Toxicity can refer to the effect on a whole organism, such as an animal, bacterium, or plant, as well as the effect on a substructure of the organism, such as a cell (cytotoxicity) or an organ (organotoxicity), such as the liver (hepatotoxicity). Thus, toxicity is ability of some chemical or other substances to cause negative influence to organisms and to damage it.

Environmental control of toxicity of urban territories is efficient way for gaining the precise information about the degree and danger of toxicity as well as for it forecasting and further reduction.

It should be noted that monitoring of the state of environment is 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.

Analysis of literature sources shows that during the estimation of toxicity of several objects of biological testing the mostly generally studied [1, 2, 7, 11, 16]. It is reasonable to use as a test-objects of green algae Chlorella (*Chlorella vulgaris* Beijer), and of crawfishes *Daphnia magna Straus* [1, 11, 14, 15].

This paper is devoted to environmental control of toxicity of urban territories by using of biological monitoring methods for different sources of pollution on the example of Samara region of Russia.

2. ANALYSIS OF SOURCES OF TOXICITY OF URBAN TERRITORIES AND OF ITS NEGATIVE INFLUENCE

The sources of toxicity of urban territories may be classified by three main types: chemical, biological, and physical.

Chemical toxicants include inorganic substances (e.g. lead, mercury, asbestos, hydrofluoric acid, chlorine gas), organic compounds (lubricating cooling liquids, organic waste, methyl alcohol etc.) and poisons from living things.

Biological toxicants include bacteria and viruses that can induce disease in living organisms. In many cases biological toxicity can be difficult to measure because the "threshold dose" may be a single organism. Theoretically one virus, bacterium or worm can reproduce to cause a serious infection. However, in a host with an intact immune system the inherent toxicity of the organism is balanced by the host's ability to fight back; the effective toxicity is then a combination of both

parts of the relationship. A similar situation is also present with other types of toxic agents.

Physical toxicants are substances like coal dust, asbestos fibers etc. Due to their physical nature, physical toxicants interfere with biological processes.

In general, the most significant sources of toxicity of urban territories are: transport (mainly automobile transport), industry, agriculture. But sometimes influence of domestic sources may be also rather significant.

The sources of toxicity may cause negative influence to the man's health and to environment. It is possible to subdivide negative influence of toxicants to the different scales: large-scale (global) pollution of environment caused by many different sources; regional (territorially restricted), local (e.g. town territory), and single sources influence.

The sequences of toxicants negative influence are widely differ depending on the kind of toxicants, the scale and the time of impact, the object of impact.

Negative influence of toxicity to the man's health may cause different illnesses. Toxicity of a substance can be affected by many different factors, such as the pathway of administration (whether the toxin is applied to the skin, ingested, inhaled, injected), the time of exposure (a brief encounter or long term), the number of exposures (a single dose or multiple doses over time), the physical form of the toxin (solid, liquid, gas), the genetic makeup of an individual, an individual's overall health, and many others. A substance which is a skin sensitizer causes an allergic response from a dermal application. Carcinogens induce cancer, or increase the likelihood of cancer occurring. Reproductively toxic substances cause adverse effects in either sexual function or fertility to either a parent or the offspring. Specific-target organ toxins damage only specific organs. Aspiration hazards are solids or liquids which can cause damage through inhalation.

Environmental impact of toxicants is especially negative due to degradability, bioaccumulation and aquatic toxicity. E.g. penetrating of toxicants into ecosystem leads to it propagation in atmosphere, water, soil, food and for further pollution. Evaporation of toxicants may cause its penetration into large distances. Thus, a significant part of urban territory may be polluted.

3. METHODS AND RESULTS OF MONITORING OF TOXICITY OF URBAN TERRITORIES

Environmental control of toxicity of urban territories is a complex procedure including estimation of sources of toxicity, determination of the most potentially dangerous zones of toxicity of urban territories, selecting of methods of estimation of toxicity, analysis of results of estimation of toxicity, conclusions about the degree of toxicity, and, finally, development and implementation of methods of reduction of negative impact of toxicants.

Toxicity can be measured by its effects on the certain target (e.g. organism, organ, tissue or cell). Because individuals typically have different levels of response to the same dose of a toxin, a population-level measure of toxicity is

often used which relates the probabilities of an outcome for a given individual in a population [2, 3]. One of generally accepted target of such measure is the LD_{50}. When such data does not exist, estimates are made by comparison to known similar toxic things, or to similar exposures in similar organisms.

Assessing all aspects of the toxicity of cancer-causing agents involves additional issues since it is not certain if there is a minimal effective dose for carcinogens, or whether the risk is just too small to see. In addition, it is possible that a single cell transformed into a cancer cell is all it takes to develop the full effect.

It is more difficult to determine the toxicity of chemical mixtures than a pure chemical, because each component displays its own toxicity, and components may interact to produce enhanced or diminished effects. Common mixtures include industrial waste, gasoline, cigarette smoke etc. Even more complex are situations with more than one type of toxic entity, such as the discharge from a malfunctioning sewage treatment plant, with both chemical and biological agents.

Biological monitoring is the kind of environmental monitoring allowing to estimate efficiently the degree of the toxicity of different sources. Presently many scientists have carried out research devoted to using biological indicators as test-objects. For example, it is well known that for estimation of quality of water it is using Woodiviss index. For estimation of degree of the toxicity of water medium green protococcus algae Chlorella (*Chlorella vulgaris* Beijer) and craw fishes *Daphnia magna* Straus are often used as test-objects.

Peculiarity of 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 it point-rating ranging.

The following toxicological characteristics have been taken into consideration:

- irritating impact to eyes;
- skin-resorptive impact;
- sensitizing impact;
- 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 points of distribution during estimation of degree of toxic impact of lubricating cooling liquids to the man and to environment is presented.

Points gradation is distributes as follow: classes of toxicity of substances, singled out during exploitation of lubricating cooling liquids are estimated using 4-point scale, and toxic characteristic of impact to man – using 2-point scale.

Total rating point is determined by summing up of components of points of estimation. Total rating point has 5 gradations, illustrating the degree of negative influence of lubricating cooling liquids to the man and to environment. Additionally with the purpose of improvement of visualization the scale may be ranged by using of different colors.

Table 1

Distribution of balls during estimation of degree of impact of toxicants to the man and to environment (on the example of lubricating cooling liquids)

Name of indicator of estimation	Parameter of estimation	Points
Irritating impact to eyes	Do not cause of impact	0 points
	Causes weak impact	1 point
	Causes irritating impact	2 points
Skin-resorptive impact	Do not cause of impact	0 points
	Causes weak impact	1 point
	Causes irritating impact	2 points
Sensitizing impact	Do not cause of impact	0 points
	Causes weak impact	1 point
	Causes irritating impact	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 to stomach)	LD50 ≤ 5000 mg/kg	2 points
	LD50 > 5000 mg/kg	1 point
	Toxic impact is not determined	0 points

Table 2

Scale of estimation of degree of impact of lubricating cooling liquids to the man and to environment by total rating points

Total rating points	Degree of impact of toxicant	Suggesting for coding
10-12 points	Hyper impact	HI
7-9 points	Strong impact	SI
4-6 points	Moderate impact	MI
1-3 points	Weak impact	WI
0 points	Do not cause impact	NI

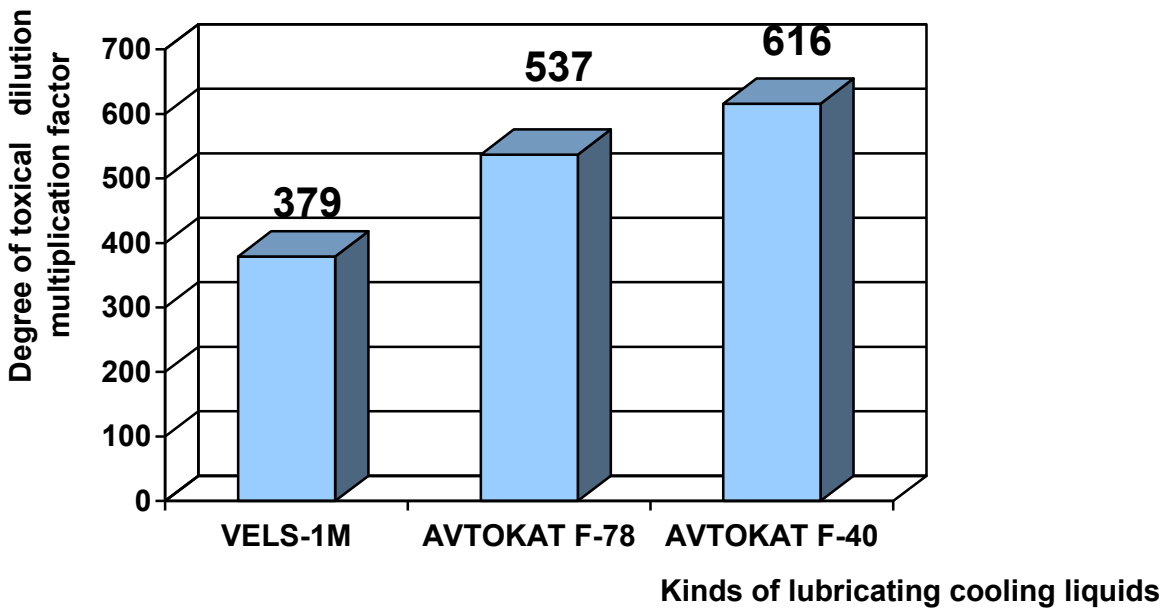

Figure 1 - Degree of impact of different kinds of lubricating cooling liquids to test-object *Chlorella vulgaris* Beijer

Experimental research were carried in Russian State accredited R & D laboratory according to the requirements of accredited methods of determination of acute toxicity of probes of surface fresh, ground, drinkable, sewage waters, water extractions from soil, sewage sediments and wastes in laboratory conditions by variation of optic density of test-culture green protococcus algae Chlorella (*Chlorella vulgaris* Beijer) according to methodic ПНД Ф 14.1:2:3:4:10-04 16:1:2:3:3.7-04 and by determination of mortality of craw fishes Daphnia (*Daphnia magna* Straus) according to methodic ПНД Ф Т 14.1:2:4.12-06, 16.1:2:3:3.9-06.

As experimental samples 1 dm^3 probes of wastes of the most widely used marks of lubricating cooling liquids used in "AVTOVAZ" Enterprise were investigated: VELS-1, Avtokat F -78, Avtokat F-40 etc.

For achieving of water extraction the mixture of water and of lubricating cooling liquids in proportions (1:27 and 1:243) was agitated during 1 hour and stored during 24 hours. Than resulting suspension have been centrifugated during 10 minutes under rotation number 5 000 rotations per minute and supernatant liquid have been used for biological testing.

Results of biological testing are presented in fig. 1 and 2. Toxicity of different marks of waste lubricating cooling liquids have been determined. It is shown that a number of the most widely used marks of lubricating cooling liquids have hyper toxicity and strong toxicity.

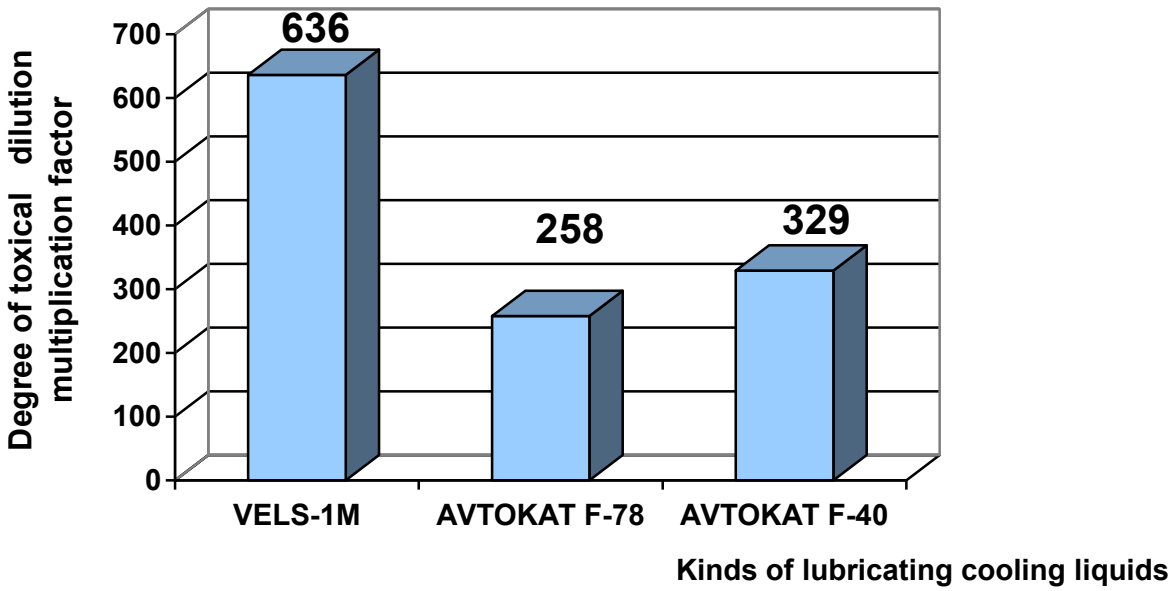

Figure 2 - Degree of impact of different kinds of lubricating cooling liquids to test-object *Daphnia magna* Straus

As the next object of toxicity investigation the territory of former industrial plant "Phosphorus" was selected. The problem is that when the plant was closed the toxic wastes on the territory of the plant were remained, at its presence causes significant potential negative impact to environment.

More than 30 probes of organic wastes of former industrial plant "Phosphorus" were analyzed. Results of analysis are showing that the most of wastes are hyper-toxic. For example, the results of biological testing of wastes in cisterns located in railways on the territory of former industrial plant "Phosphorus" are showing that waste probe causes hyper-toxic impact to text-object *Daphnia magna* Straus. The impact of waste was tested in range of concentrations 0,011%-1,0. Death rate of test-object was 100% during the several minutes. The same results were achieved for to test-object *Chlorella vulgaris* Beijer: hyper-toxic impact to text-object was observed even for maximal dilution proportion.

Thus, the most widely-distributed toxicants of urban territories may have hyper-toxicity and cause significant negative influence to man's health and to environment.

Let us describe also the results of investigation of toxicity of waste water of "AVTOVAZ" company as a factor of negative impact to environment on the example of Kuibyshevsky water reservoir. The place of emission of "AVTOVAZ" company waste water into Kuibyshevsky water reservoir is shown on the figure 3.

Figure 3 - The place of emission of "AVTOVAZ" company waste water into Kuibyshevsky water reservoir

Biological testing of probes of surface waters of Kuibyshevsky water reservoir has been provided in laboratory conditions according to the requirements of accredited methods for determination of acute toxicity of probes of surface fresh, ground, drinkable, sewage waters, water extractions from soil, sewage sediments and wastes in laboratory conditions by variation of optic density of test-culture green protococcus algae Chlorella (*Chlorella vulgaris* Beijer) according to the method PND F 14.1:2:3:4:10-04 16:1:2:3:3.7-04 and by determination of mortality of craw fishes Daphnia (*Daphnia magna* Straus) according to the method PND F T 14.1:2:4.12-06, 16.1:2:3:3.9-06 [14].

Results of biological testing of some probes are submitted below.

Probe 1

1. Investigated probe does not cause toxic effect on the test-object *Daphnia magna* Straus. 100% survival rate of test-object has been observed during the initial toxic dilution multiplication factor for all the time of exposure (48 hours).

2. Investigated probe causes toxic effect on the test-object *Chlorella vulgaris* Beijer. Toxic dilution multiplication factor is 9 times, which corresponds to toxic medium.

Probe 2

1. Investigated probe does not cause toxic effect on the test-object *Daphnia magna* Straus. 100% survival rate of test-object has been observed during the initial toxic dilution multiplication factor for all the time of exposure (48 hours).

2. Investigated probe causes toxic effect on the test-object *Chlorella vulgaris* Beijer. Toxic dilution multiplication factor is 3 times, which corresponds to feebly toxic medium.

Probe 3

1. Investigated probe does not cause toxic effect on the test-object *Daphnia magna* Straus. 100% survival rate of test-object has been observed during the initial toxic dilution multiplication factor for all the time of exposure (48 hours).

2. Investigated probe causes toxic effect on the test-object *Chlorella vulgaris* Beijer. Toxic dilution multiplication factor is 3 times, which corresponds to feebly toxic medium.

Results of experiments allow making the following general conclusions. According to the results of biological testing of probes of surface waters of Kuibyshevsky water reservoir in the place of emission of waste water of Public Joint Stock Company "AVTOVAZ" into Kuibyshevsky water reservoir, it is determined that the investigated probe does not cause toxic effect on the test-object *Daphnia magna* Straus. However, the investigated probe causes toxic effect on the test-object *Chlorella vulgaris* Beijer. Toxic dilution multiplication factor differs from 3 to 9 times, which corresponds to toxic medium. Thus, the surface waters of Kuibyshevsky water reservoir in the place of emission of waste water of Public Joint Stock Company "AVTOVAZ" into Kuibyshevsky water reservoir are toxic, but do not cause acute toxicity.

It should be noted that even feebly toxic medium may cause significant negative influence on water reservoir biota. Therefore it is necessary to develop efficient methods and means of further minimization of negative impact of toxicity of waste water of Public Joint Stock Company "AVTOVAZ" on Kuibyshevsky water reservoir.

4. CONCLUSIONS

Toxicity is one of the most dangerous sources of pollutions of urban territories. Analysis of kinds and sources of toxicity of urban territories shows that the main of them are different waste components, as industrial as domestic. For example, lubricating cooling liquids may penetrate into soil and into ground water and cause significant damage to environment and to the man's health.

Provision of high quality environmental control of toxicity of urban territories is very important not only for receiving the precise information about the degree and danger of toxicity for the health of inhabitant of urban territory and ecological safety, but also for toxicants forecasting and further reduction of it negative impact.

It is shown that for environmental control of toxicity of urban territories the most convenient to use are biological monitoring methods. It is described using of green protococcus algae Chlorella (*Chlorella vulgaris* Beijer) and craw fishes *Daphnia magna* Straus as test-objects for estimation of degree of the toxicity of urban territories toxicants.

New method in comparison with existing methods is complex consideration of the main toxicological values of lubricating cooling liquids on the basis of it point-rating ranging. The following toxicological characteristics have been taken into consideration: irritating impact to eyes; skin-resorptive impact; sensitizing impact; toxic particles assignable under exploitation of toxicants (number of singled out toxicants and it class of danger); toxicity during inside-stomach injection.

The results of experimental research of toxicity of different sources of pollution are showing that the most widely-distributed toxicants of urban territories may have hyper-toxicity and cause significant negative influence to man's health and to environment.

According to the results of biological testing of probes of surface waters of Kuibyshevsky water reservoir in the place of emission of waste water of Public Joint Stock Company "AVTOVAZ" into Kuibyshevsky water reservoir, it is determined that the surface waters of Kuibyshevsky water reservoir in the place of emission of waste water of Public Joint Stock Company "AVTOVAZ" into Kuibyshevsky water reservoir are toxic, but do not cause acute toxicity.

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DEVELOPMENT OF BIOACTIVE COMPOSITION FOR EFFECTIVE BIOREMEDIATION OF OIL-CONTAMINATED SOIL

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ABSTRACT

The authors of the article on the basis of theoretical analysis of existing technologies of detoxification and restoration of oil-contaminated lands developed biological sorption complexes and technological approaches of their application. The article presents the technological solutions developed by the authors for the use of Biosorption Active Composition (BAC) for biological remediation of oil-contaminated lands and substantiates the methods of application of the developed BAC at the stage of biological land reclamation. The results of researches and the developed set of biological methods can be recommended for using for the effective treatment and restoration of lands contaminated with oil and oil products.

Keywords: bioremediation, pollution sources, soil, biological sorption, bioremediation, composition

Soil quality is concerned with more than the soil's constituents and composition, but how it functions in a specific environment. The major functions of a soil are generally recognized to include the ability to protect water and air quality, the ability to sustain plant and animal productivity, and the ability to promote human health [1, 11, 12, 15, 34].

The release of contaminants into the environment by human activities has increased enormously over the past several decades. In fact, although a few decades ago, man's greatest challenge resided in speeding up the industrialization process, today man attempts to find ways to deal with the growing industrialization and the associated problems. The relatively sudden introduction of pollutants into the recipient ecosystems has clearly overwhelmed their self-cleaning capacity and, as a consequence, resulted in the accumulation of pollutants.

The utilization of organisms, primarily microbes, to clean up contaminated soils, aquifers, sludges, residues, and air, known as "bioremediation", is a rapidly changing and expanding area of environmental biotechnology, that offers a potentially more effective and economical clean-up technique than conventional physicochemical methods [16, 21].

Soil pollution has recently been attracting considerable public attention since the magnitude of the problem in our soils calls for immediate action [1, 13]. The large-scale production of a variety of chemical compounds, such as organic solvents, fuels and fuel additives, pesticides, plasticizers, pigments, dyes, plastics and chemical feedstocks, has caused global deterioration of environmental quality [1-10, 14, 21, 23-33, 35-37]. Contaminated soils are a common environmental problem all over the world. The various countries confronted with contaminated soil differ considerably in awareness of the problem and in the policies and the technologies to tackle it. Nonetheless, intensive exchange of experiences gained with the management and remediation of polluted soils is taking place among the various countries. As a matter of fact, increasingly widespread pollution has caused vast areas of land to become non-arable and hazardous for both wildlife and human populations. Contaminated lands generally result from past industrial activities when awareness of the health and environmental effects connected with the production, use, and disposal of hazardous substances were less well recognized than today. Unfortunately, the enormous costs associated with the removal of pollutants from soils by means of traditional physicochemical methods have been encouraging companies to ignore the problem [21].

In addition to minimizing the impact of future incidents by means of controlling soil pollution input (developing a long-term perspective of pollution amelioration measures that focus on slowing the rate of pollution increase), it is imperative to deploy innovative technologies which could economically remediate toxic wastes adversely impacting our environment, thereby reducing the threat to human health and the environment.

In the last few years, disquiet among ordinary people has grown and the public is now strongly demanding clean-up measures to be urgently introduced. In this context, governmental recognition of the accumulating hazards has resulted in legislative restrictions on uncontrolled discharges of wastes and actions mandating environmental restoration of hazardous waste sites. This recent environmental awareness has highlighted the need for new technologies for the treatment of these wastes.

Traditional physicochemical processes for remediation of soil polluted sites are expensive and often do not permanently alleviate the pollution hazard. The most common conventional techniques used for remediation are excavation and disposal to a landfill, and to cap and contain the contaminated areas of a site. Apart from the fact that it is very difficult and increasingly expensive to find new landfill sites for the final disposal of the material, the first method simply moves the contamination elsewhere (with the possibility of creating risks during the excavation, handling, and transport of hazardous material), while the second is only an interim solution since the contamination remains on site, requiring monitoring and maintenance of the isolation barriers. Other methods such as incineration lack public acceptance since they can increase the exposure to contaminants of both the workers at the site and nearby residents. Some other techniques that are in various stages of development are the following: extraction

of pollutants with organic solvents or CO_2, oxidation of organic pollutants under subcritical or supercritical conditions, vitrification, electroreclamation, dehalogenation of chlorinated organic compounds using an alkali polyethylene glycol, chemical reduction or oxidation of contaminants, steam stripping, plasma torch techniques, microwave heating, solidification/stabilisation, and so on.

A theoretical analysis of existing methods and technologies for cleaning and restoring contaminated soils has shown that bioremediation (biological recovery) is currently considered the most effective, environmentally friendly and economical method for cleaning the environment. The main methods of bioremediation are based on enhancing the activity of indigenous microflora by introducing various stimulating additives or introductions into contaminated ecosystem of active microorganisms-destructors [15].

Bioremediation is a general concept that includes all those processes and actions that take place in order to biotransform an environment, already altered by contaminants, to its original status. Bioremediation uses primarily microorganisms or microbial processes to degrade and transform environmental contaminants into harmless or less toxic forms.

The participation of microorganisms in the mineralization of organic compounds is due to their widespread presence in the environment and a high potential to catabolize organic compounds in the soil. Available data indicate that most natural and artificial materials can undergo biological transformation using natural microorganisms [12].

The key to biotransformation (biodegradation) of contaminants is the metabolic activity of microorganisms. Biodegradation of pollutants ends with complete mineralization or partial decomposition in both aerobic and anaerobic conditions. However, for the course of biotransformation at a noticeable speed, optimal conditions for the vital activity of microorganisms are necessary.

At present, a large amount of information has accumulated on the implementation of technologies for cleaning and reclamation of contaminated soils based on introduction into the soil or stimulation of native microflora by introducing a complex of mineral fertilizers, sorbents, surfactants, and a number of agrotechnical measures [3, 9, 18, 23].

To effectively manage and regulate the process of biotransformation of pollution in soils, we summarized the experience of researchers in this direction, identified key mechanisms of this process, identified the conditions of biotransformation, considered factors that affect the speed of the process and the characteristics of biotransformation depending on the type and degree of pollution. Such an analysis is necessary for the development of methodological foundations and technological approaches for successful and scientifically sound regulation of the process of biotransformation of pollution during soil bioremediation.

An analysis of the literature showed that bioremediation includes two main approaches:

1. Biostimulation - activation of degrading ability native microflora by the introduction of nutrients, oxygen, various substrates;

2. Bio-supplementation - the introduction of natural and genetically engineered strains-destructors of foreign compounds.

Biostimulation in vitro (biostimulation at the site of contamination). This approach is based on stimulating the growth of natural microorganisms living in contaminated soil, and their potential ability to utilize the pollutant. In this case, during laboratory tests using samples of contaminated soil, it is determined which components and in what quantities should be added to the contaminated object in order to stimulate the growth of microorganisms capable of utilizing the pollutant [4] .

Biostimulation ex vitro. The difference of this approach is that the biostimulation of samples of the natural microflora of contaminated soil is carried out first in laboratory or industrial conditions (in bioreactors or fermenters). This ensures the preferential and selective growth of those microorganisms that are able to utilize this pollutant most effectively. The "activated" microflora is introduced into the contaminated object simultaneously with the necessary additives that increase the efficiency of the disposal of the pollutant.

The existing two ways of intensifying the biodegradation of xenobiotics in the environment - the stimulation of natural microflora and the introduction of active strains, not only do not contradict, but also complement each other [10].

The main factors influencing the biodegradation of organic pollutants are their chemical nature (which determines the possible paths of biotransformation), concentration and interaction with other pollutants (at the level of their direct interaction or mutual influence on transformation).

For the technological restoration of oil-contaminated lands, an understanding of the general laws of oil transformation in soil is necessary. Oil, as a multicomponent system consisting of various hydrocarbons and other toxic substances, degrades very slowly in the soil, the oxidation processes of some structures are inhibited by other structures, the transformation of individual compounds proceeds along the path of acquiring forms that are difficult to oxidize in the future.

In an aerated environment on the earth's surface, oil oxidizes much faster. The main mechanism for the oxidation of hydrocarbons (HC) of different classes in an aerobic environment is as follows: the incorporation of oxygen into a molecule, the replacement of bonds with a low rupture energy (OC, C-H) with high-energy bonds, therefore, the process proceeds spontaneously. The main abiotic transformation factor is ultraviolet radiation. Photochemical processes can decompose even the most persistent polycyclic hydrocarbons in a few hours.

The final products of oil metabolism in the soil are: carbon dioxide, which can bind to carbonates, oxygen compounds (alcohols, acids, aldehydes, ketones), which partially enter the soil humus, partially dissolve in water and are removed from the soil profile. Solid insoluble metabolic products are the result of further compaction of high molecular weight products or their binding to organic-mineral complexes [16].

There are several stages of oil conversion in natural systems. The first stage is physicochemical destruction, degassing, weathering, leaching and ultraviolet destruction [12]. Microbiological processes at the initial stage are suppressed. But gradually the number and activity of microorganisms increase. Depending on the soil and climatic conditions and oil composition, this period lasts from several months to 1.5 years. The second stage is biodegradation of petroleum hydrocarbons, where the leading role is played by bacteria of the genera Pseudomonas, Bacillus, Candida yeast, microscopic Aspergillus fungi, etc. Carbon bonds are destroyed, and the concentrations of the most stable high molecular weight compounds increase. The duration of the stage is 3-4 years, and it increases with an increase in the amount of spilled oil [12]. The third stage corresponds to the degradation of polyarenes. During this period, despite the general decrease in the concentration of toxicants per unit volume of the contaminated soil body, the environmental hazard of residual oil concentrations remains high. The final products arising from the destruction of oil are oxykerites and huminocerites.

Thus, the natural degradation of petroleum hydrocarbons under natural conditions involves the sequential decomposition of components and occurs over a sufficiently long period of time.

According to different authors, the rate of oil decomposition varies five or more times, the restoration of the initial land productivity during active restoration took place in some cases during the year, in others it stretched from several years to 12 or more.

During the recent two decades it has been established that virtually all types of hydrocarbons are susceptible to microbial degradation, and hence the relevance of biotechnological approach using the microbial capability for bioremediation of the hazardous waste is justified. Bioremediation has emerged as one of the most promising options for treatment of oil contamination in terms of affordability, ecologically approachable and efficient in treating the contamination of hydrocarbon polluted soils [14, 22]. Bioremediation is a process that uses naturally occurring microorganisms to transform harmful substances to nontoxic compounds.

The success of bioremediation depends on having the appropriate microorganisms in place under suitable environmental conditions and composition of the contaminant. Although extensive laboratory research has been conducted on oil bioremediation, only limited numbers of pilot-scale and field trials with a small quantity of oily sludge, which may provide the most convincing demonstrations of this technology, have been carried out in Russia and abroad [14, 22, 30 et al].

In the present investigation, in situ and ex situ bioremediation of waste oily sludge and oil contaminated soil / land was carried out on a large scale in the fields at various ONGC installations located at different climatic zones in India. In situ bioremediation was carried out for oil contaminated land, effluent pits and oily sludge pits; whereas ex situ bioremediation was carried out in case of the waste oily sludge generated from tank cleaning and ETP operation and oil contaminated

soil generated due to accidental oil spill. Some of the large effluent pits were restored for ecological development after bioremediation.

For bioremediation studies at all ONGC installations an indigenously developed microbial consortium was applied (Mandal et al, 2007, 2007a, 2009, 2009a, 2011, 2012). Successful laboratory feasibility study was carried out for bioremediation of oily waste (from ONGC) using the said microbial consortium prior the field application.

The priority way to clean soil from oil products is to use biological destructors. Their effectiveness is ensured by the activity of microorganisms in relation to hydrocarbons under conditions of good soil aeration, favorable water, temperature (5-30 ° C) and nutrient regime of soils. Thanks to the action of such preparations, the content of petroleum products in the soil in 10 days may decrease by 30%.

In the processes of transformation of oil hydrocarbons in nature, an important role is played by many groups of microorganisms with the ability to use oil and oil products as the sole source of carbon nutrition. Identification of the most active and promising isolates using classical microbiological methods showed that the studied isolates belong to the genera Micrococcus, Mycobacte¬rium, Corynebacterium, Rhodococcus, Bacillus, Acinetobacter, Pseudomonas [7, 10].

Biotechnological methods of soil restoration are the most common due to the relatively low cost of their implementation [7, 12, 24].

The soil is a system in which there are several indigenous (local) biodegradable hydrocarbons [37], which are activated as soon as the proper conditions (oxygen, vegetation) appear.

A number of experiments have investigated the possibility of increasing the rate of biodegradation [28]. All methods of optimizing the bioremediation process (bioreactor, increasing temperature and forced aeration, adding active mushrooms, additional vegetation) positively affected the rate of degradation of the rapidly degrading and most bioavailable hydrocarbon fraction. Other methods for increasing the rate of degradation of the first rapidly decomposing fraction are the use of agriculture and tillage [33], the addition of sewage sludge [25], the use of agricultural waste [27] and the use of Mycobacterium gilvum destructive bacteria [36].

Joop Harmsen, Ren_e P.J.J. Rietra studied the biodegradation of PAHs and petroleum hydrocarbons for 25 years and noted that after an initial rapid degradation of hydrocarbons and PAHs, continuous very slow degradation of PAHs is observed. It is known that OU hydrocarbons, including PAHs (polyaromatic hydrocarbons), are biodegradable [35]. Several types of microorganisms capable of biodegrading OH and PAH have been identified [30, 31]. Ghosal et al [26] have identified and described a large number of oil-degrading microorganisms in combination with the appropriate conditions necessary for the degradation of oil pollution, including regulation of oxygen concentration, pH, temperature, nutrient availability and improved bioavailability.

In a number of experiments, it was found that the simultaneous use of all microorganisms and appropriate conditions can lead to increased biodegradation of petroleum hydrocarbons [37].

Over the past decades, numerous studies have been carried out related to biotransformation, biodegradation and bioremediation of petroleum hydrocarbons (HC), and the use of oil-degrading organisms to clean the environment.

The results of scientific work in this area have led to various developments in oil bioremediation, including active oil destructor strains and their consortiums, on the basis of which commercial biological products are produced in Russia and abroad to eliminate hydrocarbon pollution. These are Putidoyl, and Devoroil, Bamil, Petro Trit, Soyleks, Firezine, etc. In addition to viable microbial cells, they contain various additives in all kinds of combinations.

Research centers engaged in the development of such biological products currently work in four areas:

1) Isolation of active biodestructive strains from the native microflora of oil-bearing regions, combining several strains in one composition to expand the conditions of use, proving the non-pathogenicity of such preparations - work is ongoing in Russia, Ukraine, and some EU countries (for example, the Czech Republic and Great Britain);

2) The creation of drugs based on genetically modified microorganisms, which allows us to expand the range and, again, to unequivocally talk about the safety of use, are pioneers in this area of the USA and Japan;

3) Use instead of living cultures of oil destructors of their active enzyme systems, and / or treatment of contaminants with nutrients (prebiotics, biosurfactants) that activate the native microflora;

4) Development of methods for the complex biological effect on oil pollution, when the oil-containing waste is first subjected to treatment with various biologically active substances, simplifying and accelerating the second stage, the effect of a biological product, which significantly reduces the overall waste disposal time.

The most effective and affordable method of rapid oil recovery during accidental spills is sorption. Sorbents form agglomerates upon contact with oil. The collection and removal of oil and oil products from the soil surface using sorbents is carried out in several ways: by simple spreading method (like “wet cake”), by applying molded or dispersed sorbents, and also by means of special rolls with application to the sorbent’s working surface material. Various raw materials are used for the production of sorbents. Russia has its own technologies for the production of oil sorbents from local raw materials and waste.

Both single-component sorbents and multicomponent sorbents are produced in the world, consisting of natural raw materials (peat or its mixture with sapropel) and modifiers (salts of divalent metals of humic acids). A special group is made up of biosorbents [6]. Recently, natural sorbents are widely used. Use as components of biosorption mixtures of natural sorbents and ameliorants of the soil (dolomite flour, mineral components), as well as material carriers of biodestructors - straw,

pine sawdust to localize pollution and prepare the soil for cleaning. The advantages of the proposed sorbents is that they are an organic part of existing ecosystems and are most consistent with environmental requirements.

Natural sorbents contribute to the creation of favorable conditions for achieving the required soil condition in economically rational ways. Dolomite improves the physical, physico-chemical and biological properties of the soil. Increases the amount of assimilable forms of nitrogen, phosphorus, potassium, molybdenum, increases the efficiency of the use of organic and mineral fertilizers, improves the nutritional conditions of plants. It enriches the soil with calcium, which promotes plant growth, improves the condition of the root system. It enriches the soil with magnesium, which is part of chlorophyll and is involved in photosynthesis.Their wide distribution in nature, low cost and simple application technology along with high sorption properties make them promising for the purification of land from oil products.

Biodegradation of hydrocarbons is a leading factor in the transformation of ecosystem polluting substances. Biochemical methods for eliminating hydrocarbon pollution are as follows: the creation of multicomponent compositions: microorganisms immobilized on a sorbent + numerous prebiotic additives.

The objective difficulties associated with the use of microbial biodestructive preparations are caused, first of all, by the conditions of growth and vital activity of microorganisms that make up their composition. The optimum moisture content of hydrocarbon biodegradation processes in the soil is 60-65%, and, as a rule, regular watering is required to stimulate natural self-cleaning processes.

The quantity and type of biological products for HC disposal is determined by the nature of the pollution, its concentration, the chemical composition of related substances and the conditions of the work. Based on the results of laboratory and field studies, a change in the degree of biodegradability of various pollution components was confirmed in accordance with the following regularity (in descending order): vegetable oils> edible fats> paraffins> diesel fuel, kerosene, gasoline, gas condensate> oil> fuel oil> crude oil. Thus, the approximate ratio of biological product / pollutants is expressed by the following data:

- crude oil, fuel oil, condensed aromatic hydrocarbons - 1:10;
- engine and motor oils, petroleum jelly, heavy fractions of paraffins - 1: 100;
- gas condensate, diesel fuel, gasoline, kerosene, aviation fuel, cycloalkanes - 1: 1000;
- n-alkanes, vegetable oils and animal fats - 1: 10000.

Due to the uneven chemical and mineralogical composition of the soils of different regions, in practice, the number of biological products is determined by the results of a chemical analysis of the object being cleaned. It is assumed that the disposal of 1 ton of crude oil requires at least 5 kg of biological product. Naturally, under natural conditions with inconsistent climatic and physico-chemical parameters, as well as the presence of factors that inhibit the growth of microorganisms, the duration of disposal increases significantly and requires not

only an increase in starting quantities, but also additional introductions of biological products and mineral fertilizers.

Biological products show the greatest activity at an oil concentration of 0.05 to 10.0%. When the degree of contamination is above 5%, repeated application of nutrients is recommended to stimulate the process of oil destruction.

As you can see, cleaning with the use of microbial preparations of oil destructors per se is a very complex and ambiguous process for its effectiveness. Therefore, the utilization of oil sludge and oil-contaminated soils requires the development of integrated technologies, including the module for the use of biological products as an integral part of successful waste processing. Such techniques allow you to receive the least hazardous waste (5th hazard class).

In the search for new effective solutions for the bioremediation of oil-contaminated soils, we developed and experimentally tested new Biosorption Active Composition (BAC) [4, 5, 6]. Experimental studies of their effectiveness have shown that there is an effect of effective soil cleansing and reduction of its toxicity even on soils of medium and high oil pollution. This is probably due to the complex effect of the mixture on the biodegradation of oil - an increase in the catalase activity of the microbial community and TMP (total microbial number) was observed. In addition, the sorbents included in the mixtures of the biological product absorbed oil from the soil, which led to a decrease in the toxic load on the microorganisms of the destructors, and mineral additives stimulated the processes of biotransformation of oil pollution and improved soil composition.

In the search for new effective solutions for the bioremediation of oil-contaminated soils, we developed and experimentally tested new Biosorption Active Composition (BAC) [4, 5, 6].

When conducting research, they used “Oil 3.2.1.2 GOST R51858 - 2002” (high-sulfur medium density, fertile soil.

Oil in a mass concentration of 30 g / kg was added to the soil distributed in 11 containers, which corresponds to an average degree of soil pollution with oil and 50 g / kg, which corresponds to a high degree of soil pollution with oil, as during accidental oil spills (Figure 5). Control - soil contaminated in the same mass ratio without making BSS.

The approximate composition of the mixtures:

BAC - 1 (experiment 1.1 (50 g / kg of oil) and 1.2 (30g / kg of oil)) - sorbent + vermiculite without adding an EM preparation;

BAC - 2 (experiment 2.1 (50 g / kg of oil) and 2.2 (30g / kg of oil)) - sorbent + vermiculite with the addition of an EM preparation in a 50/50 dilution;

BAC - 3 (experiment 3.1 (50 g / kg of oil) and 3.2 (30g / kg of oil)) - sorbent + vermiculite with the addition of an EM preparation in a ratio of 1/3;

BAC - 4 (experiment 4.1 (50 g / kg of oil) and 4.2 (30g / kg of oil)) - sorbent + vermiculite with the addition of EM preparation in the ratio 1/3 + compost accelerator;

Control with contaminated soil without making BAC - (experience 5.1 (50g / kg of oil) and 5.2 (30g / kg of oil).

Control without oil pollution and without making FSU (experiment 6)

Biological testing of soil samples was carried out by the method of seedlings, determining their phytotoxicity. The method is based on the reaction of the test object to the presence of contaminants in the soil. Allows you to identify the toxic effects of certain substances (oil pollution). In the course of the experiment, germination, the length of the aerial and root systems were monitored.

The use of the biotesting method for watercress seedlings made it possible to compare the phytotoxicity of oil pollution at different stages of the experiment. The results of phytotoxicity experiments carried out after 1 month, 7 months, 10 months and 15 months after contamination of soil samples with oil are presented in Fig. 1.

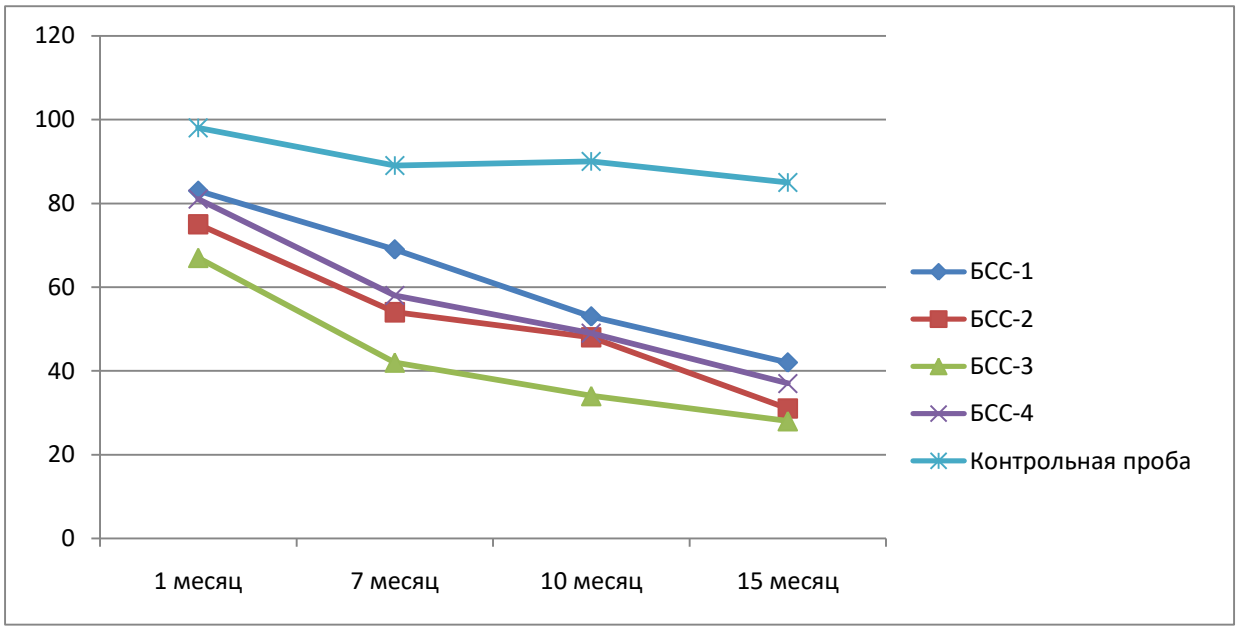

Figure 1 - Comparative phytotoxicity of prototypes for watercress seedlings with a high degree of contamination of 50g / kg

An analysis of the phytotoxicity of soil contaminated with oil with and without BSS at different time periods showed that the addition of BSS to experimental, oil-contaminated soil samples affected the reduction of soil toxicity compared to experimental control contaminated soil samples without applying BAC (Biosorption Active Composition).

Determination of catalase activity of pilot samples of oil-contaminated soils. This method for determining the activity of soil by catalase is based on taking into account the amount of unreacted portion of hydrogen peroxide introduced into the soil.

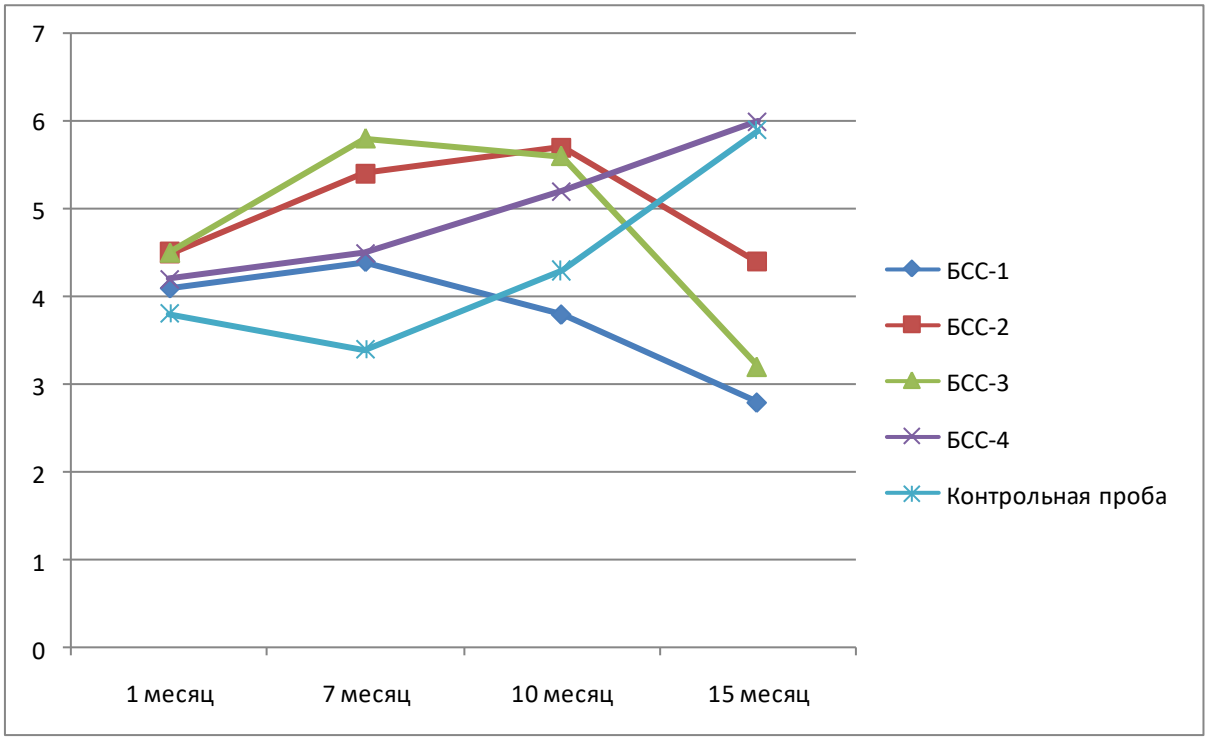

Figure 2 - Comparative diagram of the catalase activity of soil samples with the addition of (Biosorption Active Composition) BAC and a control sample without the introduction of BAC of an average degree of pollution of 30g / kg

The difference between the amounts of peroxide introduced into the reaction medium and detected after interaction with soil enzymes is equal to the amount of split peroxide and characterizes the activity of the catalase action of soil microorganisms. Catalase activity was expressed in milliliters of 0.1 N. $KMnO_4$ per 1 g of dry soil in 20 min.

An analysis of the changes in the catalase activity of prototypes of soils contaminated with oil (30 g / kg and 50 g / kg) over different periods of time from laying the experiment (only 15 months) showed that when applying mixtures BAC -3, BAC -4 and BAC - %, the highest rates of catalase activity were observed after 7 and 10 months, and in the control samples, on the contrary, there was a decrease in the catalase activity of soil microorganisms, which is probably due to toxic inhibition of petroleum hydrocarbons of microorganisms of the control soil samples without application of BAC (biosorb ion mixture) (Figure 2).

The results of studies on the determination of catalase activity showed that the introduction of BAC leads to an increase in enzymatic activity, which reflects the activation of biodestructive activity of microorganisms of oil destructors of the soil.

The results of studies of TMN (total microbial number) of experimental samples of soil contaminated with oil (30 g / kg and 50 g / kg) showed that 6 months after the laying of the experiments, the greatest increase in TMN was observed - 17 · 105 CFU / g (sample 2.1 contaminated 50g / kg of oil with BAC - 2), TMN – 18,5 · 105 CFU / g (sample 3.2 contaminated 30g / kg of oil with BAC

- 3), TMN - 18.5 · 105 CFU / g (sample 4.1 contaminated 50g / kg of oil with BAC - 4) and TMN – 16,7 · 105 CFU / g (sample 4.2 contaminated with 30g / kg of oil with BAC - 4) compared to the control without making BAC mixtures, where chalis lowest indicators TMN – 7,4 · 105 CFU / g (sample 5.2 contaminated 50g / kg oil) and TMN - 9 · 105 CFU / g (sample 5.2 contaminated 30g / kg oil without making FSU).

The introduction of biosorption mixtures stimulated the activity of microorganisms of oil destructors of contaminated soils, which was expressed in a comparative increase compared with the control of the catalase activity of microorganisms – 6,2 ml $KMnO_4$ / g / 20 min (experiment 3.1 application of BAC -3)), 5,8 ml $KMnO_4$ / g / 20 min (experiment 3.2, application of BAC - 3) (after 7 months) compared with the control - 3.7 ml $KMnO_4$ / g / 20 min (experiment 5.1 without introduction of BAC), 3,4 ml $KMnO_4$/g/20min (experiment 5.2 without introduction of BAC). In experiments with the use of biosorption mixtures, the number of destructive microorganisms - OMC - increased, which indicates the stimulating effect of mixtures with sorbents and biological product Baikal-EM1 - BAC -2, BAC -3, BAC -4 on the activity of microorganisms of oil biodestructors and their effectiveness in bioremediation of oil-contaminated soil.

As a result of experiments, it was found that the biosorption complex mixtures BAC - 2; BAC -3 and BAC -4 were the most effective for cleaning the soil. This allows us to recommend their introduction at the stage of biological reclamation of soil contaminated with oil products or during the liquidation of emergency oil spills.

At a further stage of research, technological solutions for the use of biosorption mixtures for the biological reclamation of oil-contaminated lands, waste disposal were developed and the methods for introducing the developed BSS at the stage of biological reclamation of land were substantiated.

Based on the analysis of works by domestic and foreign authors, biosorption mixtures were developed and experimental studies of their effectiveness in the bioremediation of oil-contaminated soils were carried out. The results of these studies and the developed biosorption mixtures can be recommended for use for the effective cleaning and restoration of lands contaminated with oil and oil products.

Experimental studies using the test object of watercress made it possible to identify changes in soil toxicity in the sample with the addition of the Bioactivator complex. Comparative studies have shown that as a result of the application of the developed bio-complex “Bioactivator”, the destruction of oil products was more efficient. The studied complex "Bioactivator" was the most effective in reducing soil toxicity and cleaning it from oil products. In the samples with the introduced Bioactivator complex, the lowest soil toxicity was noted in comparison with other samples. The use of the Bioactivator complex will reduce the toxicity of the soil, accelerate the process of biodegradation of oil pollution, and activate the processes of soil self-cleaning (Fig. 3). The mixture consists of inexpensive and readily available natural materials, environmentally friendly and economical [3, 4, 5].

As a result, technological solutions for the use of biosorption mixtures for the biological reclamation of oil-contaminated lands, waste neutralization were developed, and the methods for introducing the developed BAC at the stage of biological reclamation of lands during the elimination of emergency oil spills are justified.

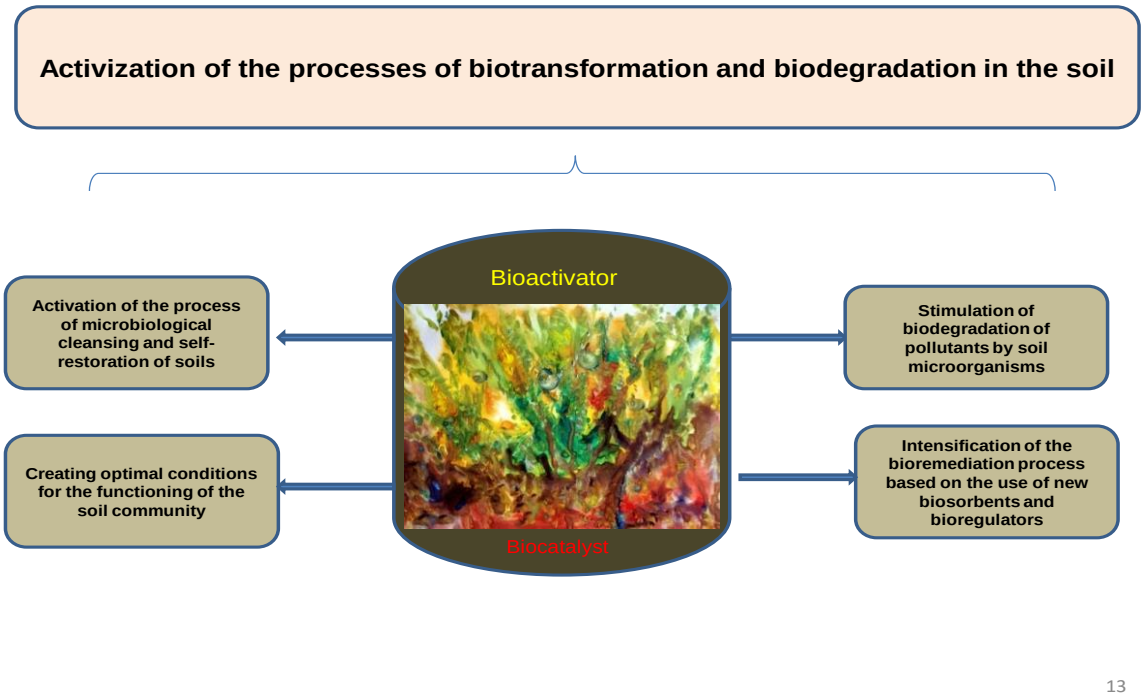

Figure 3 - The mechanism of action of the bioactive composition in capsule packaging on the process of bioremediation of oil-contaminated soils

The main idea of the development and application of FSU is to create the necessary conditions for the soil micro-community to restore and actively clean the soil. The multicomponent biosorption mixture is introduced into the place of contamination with oil and oil products and helps to stimulate the process of biodegradation of oil and the rapid and effective cleaning of soils from toxic pollutants.

The problem of finding the most effective, optimal and affordable technologies for cleaning and reclamation of soils contaminated with oil products in the specific conditions of the region is important and relevant at present due to the rapid development of the oil fields and the oil industry and extensive environmental pollution by oil and oil products.

Based on a comparative and experimental study of methods and technologies, a complex of effective and optimal measures for biological treatment

(biodegradation of pollution) and the restoration of soils contaminated with oil products has been developed.

In the process, the properties of oil and oil products and the features of their transformation in the soil, changes in the properties of the soil in the process of its pollution and restoration as a result of reclamation were studied. Experiments have been developed and conducted on the influence of various biological methods (biodegradation, phytoremediation, biosorption, augmentation) on the efficiency of cleaning and restoration of soils contaminated with oil products.

Based on experimental data and a comparative analysis of the methods, the authors have developed a set of measures for biodegradation of oil pollution of the soil and proposed an effective technological model for the biological treatment and remediation of soils contaminated with oil products in the Samara region.

The results of these researches and the set of biological methods can be recommended for using for the effective treatment and restoration of lands contaminated with oil and oil products.

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RESEARCH PROGRAM OF "ECO-EXPRESS-SERVICE" LLC "THE MACROPHYTE THICKET ECOSYSTEMS IN THE EASTERN GULF OF FINLAND"

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ABSTRACT

The latest brief report on the implementation progress of a comprehensive research program about macrophyte thicket ecosystems in the Neva Bay and the Eastern Gulf of Finland in the context of the impact and aftereffect of hydraulic works is given. Some preliminary results of phytocenological, ichthyological, ornithological program aspects are presented. In general, according to preliminary results of the program, thickets, which have appeared during the Saint Petersburg flood prevention facility complex construction, are not behind the older thickets in the most important environmental properties and, in some cases, they even prevail. The environmental role of younger thickets that formed after the completion of the Saint Petersburg flood prevention facility complex is still less significant, but they have a good potential.

Keywords: ecosystem, macrophyte thicket, impact, hydraulic works, research

The macrophyte thicket ecosystems in the Neva Bay (NB) and Eastern Gulf of Finland (EGoF) form special ecosystems, the so-called Reed bed. They are known for their high biodiversity and multifaceted role in the ecosystem: it strengthens the shore, purifies water, forms special living conditions, providing food and shelter to aquatic organisms. They favorable conditions for breeding, spawning and fattening of different fish species [1, 3].

The macrophyte thicket ecosystems serve as habitats, nesting grounds and migratory stopovers for aquatic and semi-aquatic birds. The Neva Bay of the Gulf of Finland is one of the most important places of aquatic and semi-aquatic birds accumulation in the North-West of Russia both during their nesting period (May-June) and during seasonal migrations (primarily in spring). The Neva Bay and St. Petersburg city are located on the White Sea-Baltic Sea migration route, which main branches pass along the coast of the Gulf of Finland. Therefore, shallow water areas at the coast of EGoF are so important for the protection of migratory birds, primarily aquatic and semi-aquatic ones. The importance of parking in our macrophyte thicket ecosystems for them in spring is vital. They are given the last opportunity to stop and relax in comfortable conditions of Baltic soft marine climate exactly here, before making a difficult throw to the north and north-west of the European part of Russia. It is no coincidence that so many coastal special protected natural areas adjoin the macrophyte thicket ecosystems of EGoF, which main task is the protection of migratory birds.

In the last decades, hydraulic works in EGoF are actively carried out: the Saint Petersburg Flood Prevention Facility Complex (FPFC) has been constructed, new port complexes have been created or are under construction, a set of the artificial land plots has arisen, approach channels have been built. Besides, both old, and new navigation canals should be deepened regularly so that they are not covered by soil.

All these hydraulic works more or less often have a strong negative impact on the marine environment generally and macrophyte thicket ecosystems specifically [4,5,6]. There is a considerable violation of a seabed and a temporary increase of water turbidity that leads to death or inhibition of life-sustaining activity both of aquatic vegetation, and its diverse population. As a result, macrophyte thicket ecosystems in hydraulic works impact zone lose their most important functions: silted spawning areas lose their productivity, the fish food potential suffers, local conditions become unfavorable for migratory stopovers and bird nesting, and the mechanism of self-cleaning of water bodies is disrupted. However some hydraulic works lead to proliferation of new communities of water macrophytes creating favorable substrates and water conditions.

The largest hydraulic structure with a striking example of “side” positive environmental effects for macrophyte thicket ecosystems is Saint Petersburg Flood Prevention Facility Complex (FPFC). FPFC dams form a huge artificial reef with a large area of new solid substrates occupied with pleasure by various aquatic organisms [2]. Such artificial underwater structures often form special ecosystems distinguishing by the richness and diversity of life forms. So-called artificial reefs of various designs, made from different solid materials, are created in coastal waters of many countries specifically to increase the fish food supply and give a considerable commercial effect. Artificial reefs for fishery purposes in the water area of the Neva Bay cannot be created: it is interfered by current legislation and the significant cost of such works. So-called "artificial reef effect" also concerns macrophyte thicket ecosystems. Active formation of new macrophyte thicket

ecosystems is observed near FPFC dams from both the eastern and western sides, almost from the very beginning of its construction [1, 7]. Besides, the FPFC had a significant impact on the distribution of aquatic and semi-aquatic birds in EGoF and facilitated their seasonal migrations through the Neva Bay, giving the possibility of intermediate rest when crossing the water area.

But also indirect influence of FPFC on macrophyte thicket ecosystems of the Neva Bay is not less important: a decrease of flowage already mentioned and shallowing processes at some areas. It also contributes to the growth of macrophyte thicket ecosystems, and not only near the dams, but almost throughout the Neva Bay and even to the west of FPFC. Moreover, in contrast to the temporary negative impact of hydroconstruction, this effect is permanent. Therefore, it turns out that the stimulating indirect influence of FPFC on macrophyte thicket ecosystems expansion is even more important than the direct one.

Thus, the system of hydraulic structures under construction and operating in the Neva Bay and the surrounding marine area influences on macrophyte thicket ecosystems ambiguously. The effect of anthropogenic macrophyte thicket ecosystems overgrowth compensates their decrease due to hydraulic works to some extent. But the overall balance of increases/decreases in projective cover of macrophyte thickets on the water surface is still unknown. Therefore, it is extremely important to estimate the quality of St. Petersburg macrophyte thicket ecosystems resources and its resistance to impact, to range them accordingly (to identify the most valuable and less important areas) and to consider the results obtained when planning the sustainable complex management of the St. Petersburg coastline.

The comprehensive research program "The macrophyte thicket ecosystems in the Eastern Gulf of Finland" was developed and is currently under implementation by environmental design company “Eco-Express-Service” with the participation of experts from leading scientific organizations of St. Petersburg in order to clarify regularities of qualitative and quantitative changes of macrophyte thicket ecosystems in the system of hydraulic structures under construction and operating in the Neva Bay and the surrounding marine area. The objectives of this program are:

– identification of the most significant and productive breeding sites and spawning areas of phytophilous fish species location (such mapping has not been carried out so far);

– identification of main migratory stopovers and breeding places for aquatic and semi-aquatic birds in St. Petersburg macrophyte thicket ecosystems (currently these data are fragmentary and too general);

– studying of comparative value and resistance to the impact of macrophyte thicket ecosystems adjacent to the coastal special protected natural areas in St. Petersburg;

– hydrological, hydrochemical and hydrobiological regime assessment of diverse St. Petersburg macrophyte thicket ecosystems for their role assessment in regulation of coastal waters quality;

– studying the role of diverse macrophyte thicket ecosystems in strengthening of the coastline;

– identification and description of main regularities of different age macrophyte thicket ecosystems' response to anthropogenic effect;

– studying and description of quantitative regularities of FPFC influence on St. Petersburg macrophyte thicket ecosystems system;

– environmental value and impacts resistance ranking of macrophyte thicket ecosystems.

Further purposes are: balance assessment of macrophyte thicket ecosystems dynamics in this area; determination of restoration measures necessity and composition; proposals on improvement of technical and methodological environmental documents.

Certainly, it is impossible at present to carry out a detailed survey of all thickets at the entire sea coast of St. Petersburg. Therefore, model parcels of macrophyte thicket ecosystems with the main combinations of the following factors were selected and studied:

- thickets age,
- impact degree of hydraulic works,
- position relative to FPFC.

A system of model parcels of macrophyte thicket ecosystems indicates different combinations of thicket age gradations, gradations of hydraulic works' impact level and position relative to FPFC. Three thicket age gradations were studied: "aged macrophyte thicket ecosystems" – that have been existing before the construction of the FPFC; "middle-aged" – have appeared during FPFC construction (1979-2011); "new" – formed after the completion of FPFC. Impact level of hydraulic works and their consequences on thicket ecosystems is also divided into three gradations: "strong" impact is in the zone of direct works or their recent consequences impact; "moderate" (indirect) and "background".

Observations were started in August, 2016 at model parcel which area is about 1 km^2. It reflects all real combinations of thicket age and hydraulic works impact level gradations. Such combinations are distinguished in two variants: far from FPFC and near it. Two additional (non-system) plots in macrophyte thickets with the highest biodiversity are also considered. Total is 16 model parcels (fig. 1).

Comprehensive environmental monitoring at selected model parcels is carried out according to integrated program (including all key characteristics of macrophyte thicket ecosystems, determining their value degree: hydrological and hydrochemical, phytocenological, ornithological, ichthyological, hydrobiological, etc.) 3 times a year.

Figure 1 - Model parcels of macrophyte thicket ecosystems observed according to the program

At the same time, quantitative count of different age and structure macrophyte thicket ecosystems is also carried out using a quadcopter, occupied area is determined, its seasonal changes are monitored (at areas of more than 35 km^2). Figure 2 shows an example of such plan for thickets of the Neva Bay southern coast in August 2017. It is so-called orthophotomap – here the results of aerial survey are combined with the map.

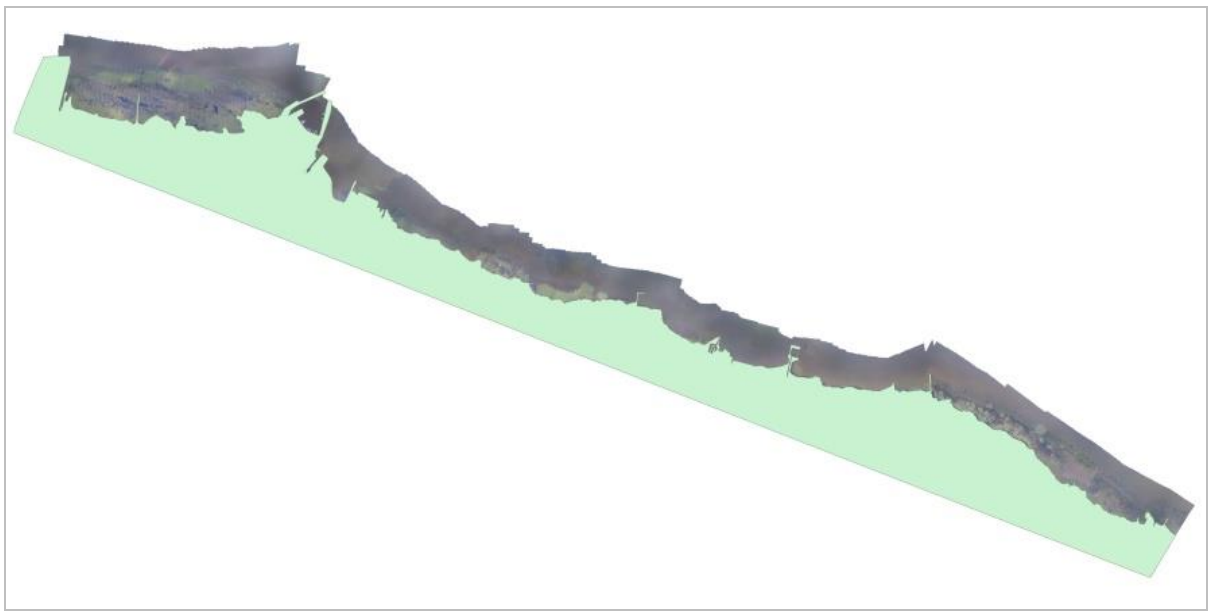

Figure 2 - The orthophotomap of macrophyte thicket ecosystems at the Neva Bay southern coast

At this moment, the majority of the collected materials undergo various stages of processing. Some preliminary results are as follows. Basically, "old" macrophyte thickets have the most difficult structure. These thickets are the densest with the highest value of projective cover degree of the water and ground surface. They are stable as they have already occupied all suitable biotope. The projective cover degree of the water surface by vegetation in "old" thickets far from FPFC is 39-41%, near FPFC it reaches 66%. Besides, submerged vegetation covers a considerable additional part of the bottom (far from FPFC is 3-11%, near FPFC – up to 23%). "Middle-aged" macrophyte thickets are simpler and more dynamic. They are less dense and intersperse with gaps. They continue to gradually expand and thicken. Its projective cover degree of the water surface is less: far from FPFC is 14-35%, near FPFC up to 40%. Submerged vegetation here also covers less additional part of the bottom: far from FPFC is 2-7%, near FPFC – locally up to 43%. "New" macrophyte thickets are simple, form only 1-layer groups. They occupied a small percent of the biotopes and actively expand. Accordingly, the projective cover degree of the water surface is minimum: far from FPFC it varies from 2 to 12%, near FPFC – up to 20%. Additional cover degree of the bottom by submerged vegetation is also not too bid: far from FPFC is 0-10%, however, near FPFC in some places it reaches 23%. Thus, the projective cover degree of the water and ground surface by vegetation is quite directly related to the thickets age and the proximity to FPFC.

Main spawning areas of phytophilous fish species were revealed, mapped and studied. "Old" and "middle-aged" thickets were found to be the most attractive for the spawning of phytophilous fishes. In this case, only its external zone is used more actively for spawning in denser "old" thickets. "Middle-aged" thickets, that are less dense, are used for spawning throughout its area (more effectively than

"old" one). "New" thickets are not very suitable for spawning now, they are mostly used for breeding of juveniles. Results of studying the dependence of spawning indicators on soil types and macrophyte thickets' characteristics are being processed now.

Significant clusters of aquatic and semi-aquatic birds were observed at all model parcels in "old" and "middle-aged" thickets at spring migrations. The "old" and "middle-aged" thickets during the nesting period also have the highest "ornithological value". "Middle-aged" thickets are even more preferable according to some indicators. They are less dense and have an open space which allow birds to freely maneuver and feed. A species convergence of model parcels at "old" and "middle-aged" thickets is quite high during spring migration, but they differ markedly from "new" thickets. "New" thickets are minimum used by birds. Autumn stopovers of wetland birds seemed to be expressed much worse than spring. According to model parcels studied, the total number of birds in the Neva Bay during the autumn migration 2016-2017 is massively less than during spring migration.

Hydraulic works and hydraulic structures operation can have a significant local impact on the thickets use for bird migration sites: it can significantly disturb the spatial and temporal dynamics of migration sites formation and reduce its number by 2-3 times. However, FPFC doesn't have a negative impact on the birds' distribution. Moreover, it provides new biotopes for migratory and nesting sites to birds.

According to results of the benthos studying component of the program, 212 individuals of lower identified taxa have been found in macrozoobenthos communities of studied model parcels so far. A composition and structure of macrophyte thicket ecosystems, which depend on thicket age and its location concerning FPFC, play a significant role in a macrozoobenthos communities' formation. Species abundance and macrozoobenthos diversity in macrophyte thicket ecosystems was expected to be in a high positive correlation with thicket age and in negative correlation with hydraulic works impact level. However, the truthful overview turned out to be more complicated. Main trends of macrozoobenthos communities' response in different-aged thickets on hydraulic works impact are tabulated (table 1).

Values of macrozoobenthos species abundance and biodiversity in macrophyte thicket ecosystems, which have been formed during the FPFC construction, turn out to be not less, but often higher, than in the older thickets, which has been existed before the FPFC construction. Macrozoobenthos of younger thickets, which have been formed in the last 10 years, has still small values of species abundance and biodiversity. The "moderate" impact of hydraulic works considerably "erases" spatial boundaries and natural differences of macrozoobenthos in different macrophyte thicket ecosystems that have been formed before or during the FPFC construction, and forms more homogeneous macrozoobenthos communities with a depleted species composition, relatively low biodiversity and, sometimes, higher abundance values.

Table 1

Main trends of macrozoobenthos communities' response in different-aged thickets on hydraulic works impact

<table>
<tr><th rowspan="2">Thicket age</th><th colspan="3">Hydraulic works impact level</th></tr>
<tr><th>Background</th><th>Moderate (indirect) impact</th><th>Strong (direct) impact</th></tr>
<tr><td>"Old"</td><td>● Species abundance and biodiversity are usually high.
● There are relatively many stenobiont species.</td><td rowspan="2">● Species abundance and biodiversity reduce due to species loss and reduction of most stenobiont species abundance value.
● An increase of eurybiontic abundance value, that are indicators of oligo-β-mesosaprobity:
- mussels fam. Euglesidae (Pisidium amnicum Műll., species of gen. Euglesa and Henslowiana),
- oligochaete fam. Tubificidae (Spirosperma velutinus Eisen, species of gen. Limnodrilus, Tubifex),
- chironomids larvae (Endochironomus dispar Meigen, E. stackelbergi Goetghebuer, Lipiniella arenicola Shilova, Sergentia coracina Zetterstedt etc.).
● Due to eurybiontic species:
- effect of benthos biomass stimulation in "middle-aged" thickets;
- increasing of species similarity values in spatially separated benthos communities of these categories.</td><td rowspan="2">● Further reduction of species abundance and biodiversity.
● The effect of benthos biomass stimulation in "middle-aged" thickets disappears: eurybiontic species are repressed as well generally.</td></tr>
<tr><td>"Middle-aged"</td><td>● Species abundance and biodiversity are usually high, often the maximum.
● There are relatively many stenobiont species.</td></tr>
<tr><td>"New"</td><td>● Species abundance and biodiversity are usually comparably low (but sometimes they are high too).
● There are no stenobiont species or in small quantity.</td><td colspan="2">● Impact response is relatively weak and not normalized.
● The effect of benthos biomass stimulation by moderate impact does not appear or is weakly expressed.</td></tr>
</table>

It is caused by both the limitation of stenobiont species, specific for exact biotopes, and by the wider distribution of eurybiontic species.

The “strong” direct impact of hydraulic works significantly inhibits macrozoobenthos be every indicator.

In general, according to preliminary results of the program, thickets, which have appeared during FPFC construction, are not behind the older thickets in the most important environmental properties and, in some cases, they even prevail. The environmental role of younger thickets, that formed after the completion of FPFC, is still less significant, but they have a good potential.

The results of the comprehensive research program are expected in the following three areas:

1) Scientific results: knowledge of important regularities in macrophyte thicket ecosystems’ dynamics and its system ecology, as well as the foundation of relevant environmental data comprehensive bank.

2) Environmental monitoring of macrophyte thicket ecosystems: creation and correction of an established system of long-term macrophyte thicket ecosystems environmental monitoring, that consider all their main environmental functions and features, as well as this monitoring maintaining and effective use of its results.

3) Improvement of regulatory and methodological environmental framework, including:

– creation and improvement of methods for hydraulic works and structures impact assessment on macrophyte thicket ecosystems;

– development of engineering activities for protection of macrophyte thicket ecosystems from harmful effects;

– recommendations preparing for restoration of most valuable thickets at coastal areas affected by industrial impacts.

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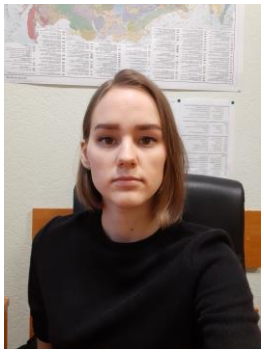

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SUSTAINABLE SHORE USE AND COASTAL ZONE MANAGEMENT OF THE GULF OF FINLAND

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ABSTRACT

The project “GET READY” has been approved as part of South-East Finland – Russia CBC Programme 2014-2020. Its purpose is capacity development in the region in the field of sustainable shore use and coastal zones management using the best practices accumulated by the Russian and Finnish parties. The success of the project is provided by a combination of “science-innovation-education/training-business”. As a result of the project, conditions for the implementation of the developed innovative solutions on infrastructure optimization of the near-port environment will be created. The education and professional training system in the field of sustainable shore use will be further developed. A plan of safe using the coastal zone of the Gulf of Finland and creation the Russian-Finnish center for advanced training in the field of sustainable shore use will be the final result of collaboration.

Keywords: project, capacity development, shore use, coastal zones, management

"Water is the driving force for sustainable development, including the environmental integrity and poverty and hunger eradication, and it is absolutely essential for ensuring human health and well-being. Priority attention to water issues is an urgent global requirement" (from the International Summit report "The Environment and Sustainable Development: Agenda 21").

Aquatic ecosystems around the world undergo a crisis, and many rivers, seas and lakes are already polluted or severely degraded as a result of natural ecosystems areas reduction, including forests and watershed areas. Coastal zones with the most productive ecosystems on Earth are in especially vulnerable condition and it threatens a people and animals’ life and existence of entire

ecosystems [6]. Coastal territories represent a zone of all Earth's Spheres integration: a hydrosphere, a lithosphere, an atmosphere and a biosphere. There is a formation and functioning of specific coastal ecosystems within this contact zone under the influence of a various environmental conditions and factors. Approximately the two-fifths of the world's population live in a radius of 100 km from the coast [6].

The coastal zone is one of the most important components of the natural environment. The natural resources of the coastal zone are used and protected in the Russian Federation in accordance with the Constitution of the Russian Federation [2] as the basis for the population well-being, the existence of fauna and flora living within the coastal zone [7]. The coastal area is an object of active practical and economic use, starting from the seafood and minerals extraction, the hydraulic structures construction for various purposes, industrial development and ending with the recreational areas development. These activities have a significant impact on natural-ecological and socio-economic factors, and through them on progress of natural coastal ecological processes [1].

Coastal zones are extremely important for the ecology and human life, that is why reliable protection and sustainable management are required [4]. Currently, there are many international documents, activities and acts focused on protecting and preserving of coastal territories, for example, the Ramsar Convention, the Helsinki Commission HELCOM, the Global Environment Facility (GEF), the International Union for the Conservation of Nature and Natural Resources (IUCN), etc. Assessment of the current state and the forecast of the coastal zone dynamics is one of the key issues in a range of questions related to a strategy development of coastal territories' sustainable development. The decisions of the United Nations International Conference on Environmental Protection and Sustainable Development, that took place in Rio de Janeiro in 1992 [5], determine it necessary to create an effective system of integrated processes management of coastal territories in countries and regions with sea shore [3]. The basic requirement for sustainable coastal zone management is a compliance with four principles of sustainable development:

1. principle of justice;
2. principle of environment protection;
3. principle of holistic thinking;
4. principle "Think globally, act locally".

The first principle (the principle of justice) is associated with the necessity of preserving the environment for future generations and a high life quality providing for people. This principle is closely related to the second one (the principle of environment protection), which is not to destroy the natural balance or the ability of the biosphere and coastal zone to self-regeneration, in particular. The third (the principle of holistic thinking) and the fourth ("Think globally, act locally") principles allow to consider the diversity and specificity of local disturbances in the coastal zone and general trends in human and natural complexes "interaction". Environmental measures should be carried out taking into

account local specifics, but at the same time considering the experience and consequences of similar problems solving in other parts of the biosphere. Activities, necessary to maintain aquatic, coastal and semi-aquatic ecosystems in an environment purity, require considerable efforts and means. And the management of estuarine ecosystems has to be based on a comprehensive study of the ecological situation, its monitoring, and a use of biomanipulation and biorehabilitation methods. At the same time, as world experience shows, the use of only these methods is not enough for coastal ecosystems management. It is necessary to attract general public, non-governmental organizations, in collaboration with which experts in the field of ecology, economy, agriculture, etc., as well as employees of local government are capable to create and implement a programme for coastal zone sustainable development.

A network of new ports, aimed to traffic flows expansion and sustainable development of coastal infrastructure, has been created in the coastal zone of the Eastern Gulf of Finland (EGoF) from both the Russian and Finnish sides. This network is a framework of a "coastal technosphere" in EGoF region. The functioning of the network provides the exchange of goods, raw materials and intelligent information between the countries of the Eastern and Western Baltic, which is a supposition for the sustainable development of the Baltic region in general.

At the same time, the EGoF coastal zone is recognized as a valuable natural object, that is very sensitive to anthropogenic impact and consequences of global warming. It is characterized by a diversity of biotopes and biological communities and plays a key and complex role in many environmental (reproduction of aquatic biological resources, formation of migration channels for birds and fishes, self-cleaning of aquatic ecosystems, etc.) and economic (this region is strategically important for the Russian Federation) processes.

The development of the "coastal technosphere" is accompanied by significant environmental risks in the EGoF coastal zone arising at the cross-border level. The appearance (or expansion) of each new object in the "coastal technosphere" leads to an increase of the anthropogenic impact level on the environment.

Having regard to the above, the task to ensuring an environmental safety and preserving the biological diversity of coast at the Gulf of Finland becomes the problem number one at present against the background of intensive development of coastal infrastructure. And in this regard, one more vital task is increasing of a cross-border region readiness to existing and expected problems by introducing best practices from Russian and Finnish parties and applying innovative solutions in the field of sustainable shore use. Obviously, the achievement of this purpose is possible only thanks to highly qualified specialists' efforts which have necessary knowledge and professional competences.

The project "Getting Ready for the Cross-Border Challenges: Capacity Building in Sustainable Shore Use, GET READY" was approved as part of South-East Finland – Russia Cross-border cooperation Programme 2014-2020 with

funding from the European Union, the Russian Federation and Finland. The purpose of the project is to carrying out researches and development of technologies and innovations in the region in the field of sustainable shore use and coastal zones management with a clear priority "Education, researches, technological development and innovations support in the cross-border region". The tasks of this project is capacity building in the field of sustainable shore use by:

(1) raising professional level of coastal zone managers and related specialists, training of the workforce to serve both objects of the technosphere and specially protected natural areas;

(2) developing and implementing professional educational programs and training courses (including those focused on distance learning) for a wide range of specialists, youth and students, stakeholders and decision makers;

(3) developing infrastructure (including distance learning capacities) for continuous education and professional development;

(4) introducing highly professional, scientific approach to shore use and coastal management in the EGoF;

(5) contribution to the safe technosphere in the ports region based on innovative and environmentally friendly solutions.

It is supposed to use the accumulated experience, the best practices and innovations of shore use in Russian and Finnish Ports for the project implementation. The success of the project is provided by a combination of “science-innovation-education/training-business”. The project foreseen strenghtening Public-Private-People Partnership in the cross-border region having appropriate represetatives on board.

During the GET READY project development, the following strategic guidelines were taken into account:

• Concepts of cross-border cooperation of the Russian Federation

• Adopted in 2010, the strategy of the European Union "Europe 2020" in the field of economic growth and employment in terms of ensuring environmental protection, reducing emissions and preventing loss of biodiversity

• The EU Maritime Strategy Directive which imposes an obligation on the EU member states to improve the environmental state of the marine environment.

The project GET READY covers 4 work packages (WPs):

WP1: Science (improving scientific base for sustainable coastal management to support decision making and implementation innovations / evaluation of environmental status of the project area);

WP2: Business and innovations (implementation of innovations in the field of coastal management and sustainable shore use);

WP3: Education, training (skills development) and raising awareness (capacity building in professional competencies via education and training of young and elderly people, professionals and students; raising an ecological awareness in the field of sustainable coastal management);

WP4: Network of professional expertise (establishing of an expert cooperation network for sustainable shore use and coastal management).

The project partners are Institute of Earth Sciences of St. Petersburg State University (department of environmental safety and sustainable development of regions), State Hydrological Institute, Finnish Environmental Institute, University of Turku, South-Eastern University of Applied Sciences (XAMK) and Kotka Maritime Research Association. The lead partner is "Eco-Express-Service" LLC.

Beneficiaries in the end of the GET READY project implementation should become:

1) specialists in the field of coastal zone management – firstly in municipal area of St. Petersburg, within which there is a Bronka port;

2) residents and shore users of the Bronka and Hamina-Kotka ports region;

3) employers sending their staff to professional development;

4) specialists in the field of providing educational services.

The main steps of the GET READY project implementation are:

- establishing of the Russian-Finnish center for education, research and innovations in the field of sustainable shore use and coastal zone management based on "Eco-Express-Service" LLC;
- development of pilot educational curricula and training programs, and multimedia courses in the field of sustainable shore use and coastal management;
- formation of an international cohort of highly educated specialists and experts of high competency in sustainable shore use and coastal management;
- implementation of regional strategies on climate change mitigation in training curricula;
- development of proposals on a legal framework for interaction of ports with adjoining natural protected areas and strategy for environmentally friendly port for inclusion in the training and educational programmes;
- development and publishing of methodological materials for wide professional community which includes guide on implementation of scientific and technological innovations (including resilence to climate change issues);
- contribution to creation innovative port environment, with adopted technological and engineering innovations.

As a result of the project, conditions for the implementation of the developed innovative solutions on infrastructure optimization of the near-port environment will be created. The education and professional training system in the field of sustainable shore use will be further developed. A plan of safe using the coastal zone of the Gulf of Finland and creation the Russian-Finnish center for advanced training in the field of sustainable shore use will be the final result of collaboration.

The realization of the project will assist Russia to reach some main targets stated in the “Strategy of innovative development of the Russian Federation until 2020” such as improving public perception of innovations; development of human resources in science, education, technology, innovations spheres; adaptation of the educational system of innovations. Besides, the GET READY project aims to

achieve the following Sustainable Development Goals (SDGs) on the agenda until 2030, adopted by all United Nations Member States in September 2015:

№ 9 – Innovation and Infrastructure;

№ 13 – Climate Action;

№ 14 – Life Below Water;

№ 15 – Life on land and

№ 17 – Partnerships for the goals.

Promotion and support of research and innovation within the framework of the project will facilitate Russia in modernization and in innovative development of the key-industries of the Northwestern Federal district according to the "Strategy of social and economic development of the Northwestern Federal district till 2020".

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MODELING OF FUGITIVE EMISSIONS OF DUST AND GASES INTO THE ATMOSPHERE IN OPEN PITS MINING AND PROCESSING PLANTS, AND IMPROVING MEASURES TO IMPROVE WORKING CONDITIONS

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ABSTRACT

The questions of influence of harmful emissions from technological processes and productions in career of mining and processing combine are considered. The analysis of quantitative and qualitative composition of dust and gas emissions released during blasting at a specific object of the techno sphere. The simulation of unorganized emissions of substances into the atmosphere with the determination of the main parameters of emissions from explosions. Based on the analysis of calculations, it was revealed that the concentrations of harmful substances in emissions repeatedly exceed the MPC, which creates a critical situation in the working areas of the plant. A comparative analysis of the project of maximum permissible emissions into the atmosphere and actual emissions at «Lebedinsky GOK». Measures have been developed to reduce dust and gas emissions, taking into account the analysis of existing measures to suppress dust and gas emissions from mass explosions at the quarry of the mining and processing plant of «Lebedinsky GOK». The effect of surfactants on the wettability of dust particles was studied. Measurements of physical and chemical parameters (surface tension coefficient and wetting angle) for water solutions used for irrigation of saw pits, recommended concentration of sodium lauryl sulfate triethanolamine salt ~ 4-5 wt. % , while the hydrophilic characteristics of the liquid-solid (dust) system are increased ~2-3 times. The proposed engineering solution is proposed to be used to ensure environmental safety and improve working conditions in industries with high dust content by increasing the efficiency of dust collection.

Keywords: Modeling, pollution sources, dust and gas emissions, maximum permissible concentration, surface tension, wetting angle, surfactants, wettability

1. INTRODUCTION

A significant amount of work has been devoted to the issues of reducing dust emissions at the quarries of mining processing plants [1-5].

Lebedinsky mining and processing plant Gubkin Belgorod region is a leader in the production of raw materials for the metallurgical industry in the domestic and global consumer market. The Deposits of natural resources exploited by Lebedinsky GOK (mining and processing plant) are located in the largest sphere of mining and processing production-at the Kursk magnetic anomaly, where magnetite ores are enriched with iron and have an average amount of 34-39 %.

2. ASSESSMENT OF CHARACTERISTICS OF DUST AND GAS EMISSIONS

It is difficult to calculate the dispersion of polluting components entering the air during an explosion because of the cost of suspended solids per explosion. Due to this, it is established, according to [6], the cost of suspended solids per explosion to fix 30 tons, and the cloud consisting of dust and gases, symbolically split into 40 identical sources. Modeling of the cloud consisting of dust and gases is based on the following aspects: the highest formation and a clear outline. The following methods were applied [7-9].

1. The dust and gas cloud parameter (V_0) is fixed by the formula:

$$V_0 = 44000 \cdot A^{1,08}, m^3 \tag{1}$$

where A - the value of suspended solids, $A = 30$ т.

$$V_0 = 44000 \cdot 30^{1,08} = 1732781,1 \ m^3 \tag{2}$$

4. The level of dust and gas cloud rise (H_0) is fixed by the formula:

$$H_0 = b \cdot (164 + 0,258 \cdot A) \ , m \tag{3}$$

wre b - the factor without dimension, providing depth of wells, b = 0,8.

$$H_0 = 0,8 \cdot (164 + 0,258 \cdot 1200) = 378,9 м \tag{4}$$

5. The temperature of gases in the cloud (T_0) is fixed by the formula:
6.

$$T_0 = T_B + T \ ,°C \tag{5}$$

where T_B -ambient air temperature, °C ; T - temperature rise clouds containing dust and gases, relative to the ambient air temperature, T =4,8 °C.

$$T_0 = 22{,}9 + 4{,}8 = 27{,}7 \ °C \tag{6}$$

3. CALCULATION OF THE CONCENTRATION OF COMPONENTS IN THE DUST AND GAS EMISSION

The content of the polluting component in the cloud containing dust and gases *(C)* is fixed by the formula:

$$C = \frac{10^9 \cdot q \cdot A}{V_0} \cdot \left(1 - \frac{r}{100}\right), mg/m^3 \ , \tag{7}$$

where r - the profitability of the applicable ways to minimize the negative impact produced during blasting dust and gas, *%; r = 0;*

q - specific factor of a pollutant component in the explosion of 1 suspended solids, m/m; in the operation of granulate and packaging and labelling according to the reference data for dust $q = 0{,}148$. For gases contained in the dust-gas cloud, the specific factor depends on the type of suspended solids. In the operation of granulate $q = 0{,}044$ *no CO;* $q = 0{,}0015$ *no* NO_X. When operating packaging and labelling $q = 0{,}025$ *no CO;* $q = 0{,}0026$ *no* NO_X*:*

$$C_{SS} = \frac{10^9 \cdot 0{,}148 \cdot 30}{1732781{,}1} = 2562{,}4 \ mg/m^3; \tag{8}$$

in the operation of granulate specific factor for CO is fixed by the formula:

$$C_{CO} = \frac{10^9 \cdot 0{,}044 \cdot 30}{1732781{,}1} = 761{,}78 \ mg/m^3; \tag{9}$$

during the operation of grammonite the specific factor of CO is fixed by the formula:

$$C_{CO} = \frac{10^9 \cdot 0{,}025 \cdot 30}{1732781{,}1} = 432{,}83 \ mg/m^3; \tag{10}$$

in the operation of granulate specific factor for NO_X is fixed according to the formula:

$$C_{NO_X} = \frac{10^9 \cdot 0{,}0015 \cdot 30}{1732781{,}1} = 25{,}97 \ mg/m^3; \tag{11}$$

during the operation of grammonite the specific NOx factor is fixed by the formula:

$$C_{NO_X} = \frac{10^9 \cdot 0{,}0026 \cdot 30}{1732781{,}1} = 45 \ mg/m^3. \quad (12)$$

The volume of the gas-air connection is calculated by the formula (provided the duration of the explosion is 3 min. (180 s)):

$$1732781{,}1 \ м^3 \div 180 \ c = 9626{,}56 \ m^3/s \quad (13)$$

Thus, the maximum one-time emissions of polluting components from the cloud containing dust and gases are fixed according to the formulas (14), (15), (16), which calculation is made on average values from 5 measurements:

$$G_{SS} = 2562{,}4 \cdot 9626{,}56 \cdot 10^{-3} \cdot \frac{3 \cdot 60}{30 \cdot 60} = 2466{,}71 \ g/s \quad (14)$$

$$G_{CO} = (761{,}78 \cdot 0{,}4 + 432{,}83 \cdot 0{,}6) \cdot 9626{,}56 \cdot 10^{-3} \cdot \frac{3 \cdot 60}{30 \cdot 60} = 543 \ g/s; \quad (15)$$

$$G_{NO_X} = (25{,}97 \cdot 0{,}4 + 45 \cdot 0{,}6) \cdot 9626{,}56 \cdot 10^{-3} \cdot \frac{3 \cdot 60}{30 \cdot 60} = 36 \ g/s; \quad (16)$$

Multipliers of 0,4 and 0,6 take into account the relative size of the operation suspended solids: granulate and packaging and labelling.

The results of model calculations showed that the total maximum single emissions from the cloud containing dust and gases are equal to: suspended solids (dust) - *98668,4 g/s; CO - 21720 g/s;* NO_x *- 1440 g/s.*

4. QUANTITATIVE ASSESSMENT OF THE GROSS EMISSIONS TO THE AIR A CAREER

1. The annual emission of dust into the air of the quarry is fixed by the formula:

$$Mss = V_0 \cdot C_{ss} = 3{,}011 \cdot 10^9 m^3/year \cdot 2562{,}4 \cdot 10^{-9} m/m^3 = 7715{,}4 \ m/year \quad (17)$$

2. The annual emission of gases in the explosion at the quarry is fixed by the formula:

$$M_{CO} = 3{,}011 \cdot 10^9 \cdot (761{,}78 \cdot 0{,}4 + 432{,}83 \cdot 0{,}6) \cdot 10^{-9} = 1699{,}4 \ m/year \quad (18)$$

$$M_{NO_X} = 3{,}011 \cdot 10^9 \cdot (25{,}97 \cdot 0{,}4 + 45 \cdot 0{,}6) \cdot 10^{-9} = 112{,}58 \ m/year \quad (19)$$

Integral part dust 100% of the explosion; gas – 70% of blast in the cloud containing dust and gases, and in the rock formations of gases - 30% from explosion.

So, the gross emissions from the cloud containing dust and gases are fixed by the formula:

$$M_{SS} = 7715{,}4 \ \ m / year; \tag{20}$$

$$M_{CO} = 1699{,}4 \cdot 0{,}7 = 1189{,}58 \ \ m / year; \tag{21}$$

$$M_{NO_X} = 112{,}58 \cdot 0{,}7 = 78{,}01 \ \ m / year; \tag{22}$$

Gross emissions from the rock mass are recorded by the formula:

$$M_{CO} = 1699{,}4 \cdot 0{,}3 = 509{,}82 \ \ m / year; \tag{23}$$

$$M_{NO_X} = 112{,}58 \cdot 0{,}3 = 33{,}77 \ \ m / year; \tag{24}$$

The final result of modeling of unorganized emissions of dust and gases into the atmosphere during blasting operations at the quarries of mining and processing plants is shown in table 1.

Table 1

Selection of contaminants for blasting in quarries

Component	Concentration of components in the cloud containing dust and gases, mg / m^3	Maximum permissible concentrations (MPC), mg / m^3	Annual emission of substances, t / year
Suspended solids	2562,4	0,15-0,5	7715
CO	564,41	30	1699,4
NO_X	37,4	5	112,58

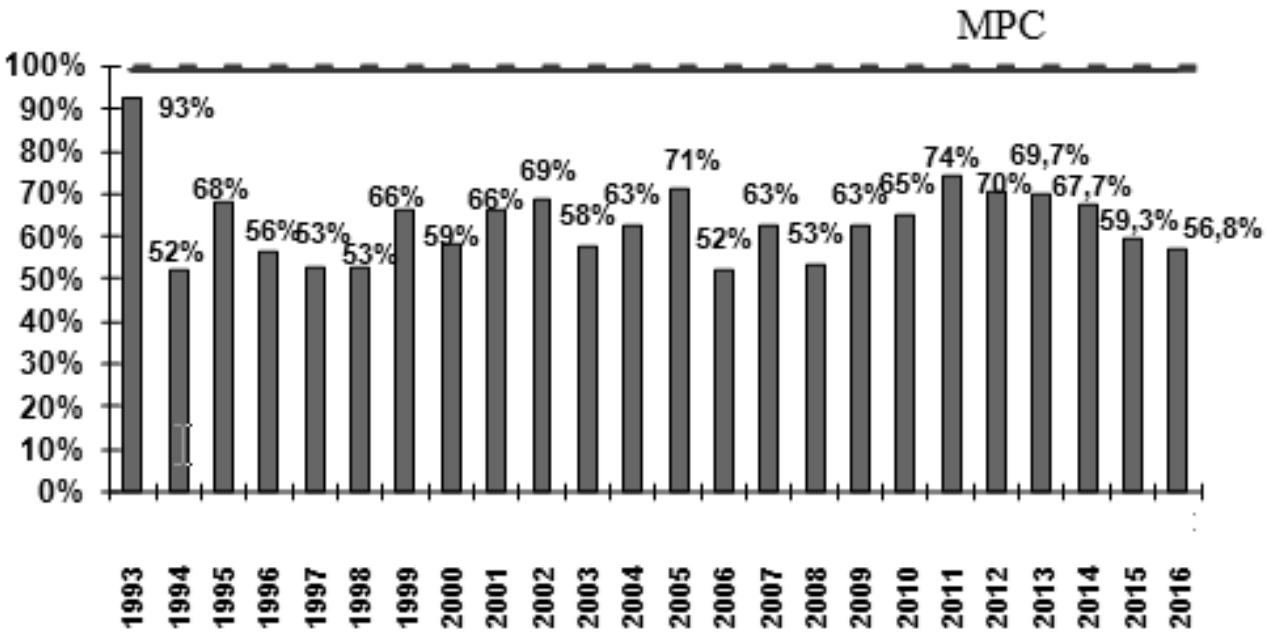

Figure 1 - Dynamics of maximum permissible emission standards

Data analysis (table 1) indicates that the content of CO and NO_X, without considering the background concentration, in the air of the quarry and the residential area located next to the landfill during blasting exceed the MPC by 19 and 7.5 times. The main pollutant of the environment is the dust in the implementation of blasting operations at landfills. At the maximum consumption of suspended solids, the release of dust from explosions into the air of landfills exceeds the MPC by 5125 times. This leads to a critical environmental situation for pollution of the working area of landfills of mining and processing plants, in particular «Lebedinsky GOK».

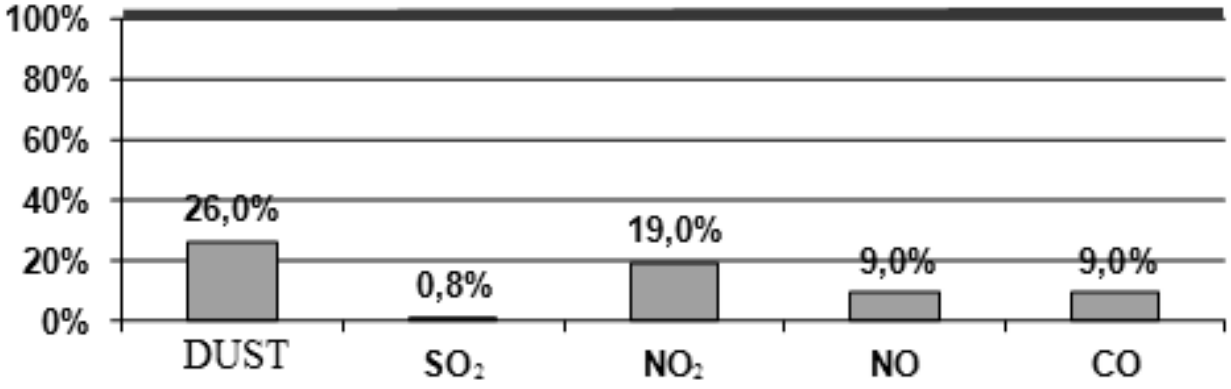

Figure 2 - Annual values of the content of polluting components at the boundary of «Lebedinsky GOK»

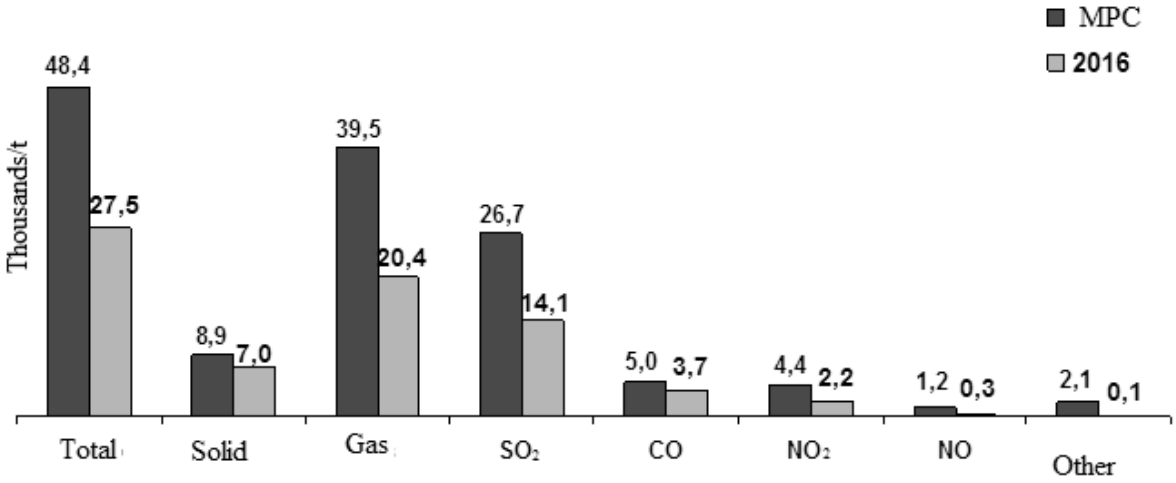

Figure 3 - Air Emissions of «Lebedinsky GOK»

The atmosphere of the industrial site and sanitary protection zone of the plant and the atmospheric air in normal situations and during mass explosions in the quarry were controlled by a mobile environmental post. Measurements of air quality are performed daily, in accordance with the approved schedule of air quality control. As a result, it was revealed:

1. First-the actual emissions of «Lebedinsky GOK» into the atmosphere amounted to 56.8 % of the permitted emissions, Fig. 1 shows the ratio of total actual emissions to the project maximum permissible (MPC). Total emissions consist of solid, gaseous (SO_2, CO, NO_2, NO).

2. Secondly, the average content of contaminants at the boundary of the sanitary protection zone did not exceed 26% of the upper point of the protective index, Fig. 2.

State and protection of atmospheric air. According to the «Resolution No. 233 on the emissions of harmful (polluting) substances in atmospheric air» for 2016 year», «Resolution No. 124 for the emission of harmful substances (pollutants) in atmospheric air during the construction of production facilities to 2016-2017 year from stationary sources of pollutant emissions into the atmosphere» 356,8 amounted to 48 tons, including solid substances – 8 901,5 tons.; volatiles - 39 455,3 tons. Actual emissions at the plant, for example, for 2016 year, has made 27 of 480,2 tons, including: solids - 7 047,3 tons; gaseous substances - 20 432,9 tons (Fig. 3).

Next, we consider the complex of environmental protection measures at the quarry of the mining and processing plant of JSC Lebedinsky GOK. The plant has developed: measures to reduce emissions of harmful substances into the atmosphere; to protect against physical influences; a number of security measures.

In 2018, the following work was carried out:

- continuous monitoring of the current state and changeable dynamics of the natural complex on the Yamskaya Steppe site, located in the Belogorye reserve,

carried out in order to obtain data on the influence of the Lebedinsky mining and processing plant as a whole on the state of the ecosystem in the reserve:

- to carry out laboratory research and instrumental testing of soil samples as part of production control;
- on the implementation of physico- chemical studies of water samples according to indicators: titanium, barium, lithium, total organic carbon;
- to carry out laboratory tests for legionellosis of water systems (pools, cooling towers, water supply systems);
- biotesting of production wastes;
- to conduct a toxicological study of industrial waste to determine the degree of toxicity;
- the implementation of sanitary - parasitological studies of swimming pool water and sewage sludge;
- conducting a sanitary-epidemiological examination of water intake for drinking and drinking purposes at workshop No. 2 «Lebedinsky» and issuing an expert opinion;
- step by step treatment of ponds for tertiary treatment of mine water with the aim of restoring the biological balance and self-cleaning with the biological product Mikrozim (tm) «POND TRIT».

Thus, the activities of «Lebedinsky», taking into account the envisaged environmental protection measures, may have a slight negative impact on the environment.

5. DEVELOPMENT OF MEASURES TO REDUCE DUST AND GAS EMISSIONS BY SUPPRESSING THEM IN THE SOURCE OF FORMATION, USING THE METHOD OF WETTING AND STICKING OF DUST PARTICLES

Consideration of projects and literary sources to minimize the negative impact of dust and its suppression in the domestic and foreign sphere indicates that the best results are observed in technological processes associated with the use of aqueous solutions of surface-active substances. This method of dust removal guarantees efficiency and high productivity in vast quarry areas while reducing the volume of water consumed by ~ 50-70% compared to similar technologies practiced for dust suppression based on the use of dispersed water. The profitability of dust suppression with water cannons is ~ 90% [10].

One of the methods of dust suppression is to improve the wettability and stickiness of dust particles. The dust of open pit mines of mining and processing plants is hydrophobic with respect to water; therefore, when dust suppression water is used, the surface tension of which is 72 mJ / m^2 [11], limited dust humidification takes place and it can again appear in the open pit air.

Based on a study of existing measures, it was proposed to reduce dust and gas emissions by suppressing it at the source of formation using the method of wetting and sticking of dust particles [11] on the career of a mining and processing

plant for suppressing dust and gas emissions during mass explosions. In the works [12, 13] P. Rebinder set the rules for equalizing polarities. Based on this rule, the adsorption of substances at the interface is predicted, as well as the orientation of the molecules in the adsorption monolayers. Starting from these works, it is customary to scientifically substantiate the use of surfactants in order to control wetting. As surfactants that improve the wettability of a solid surface, organic compounds consisting of diphilic molecules that simultaneously have a hydrophobic hydrocarbon radical and hydrophilic or polar groups are most often used [11].

In a polar medium - water, surfactant adsorption leads to hydrophilization and a decrease in surface tension is observed at the “liquid – solid particle” interface, which leads to a decrease in the wetting angle, and, accordingly, an acceleration of the wetting process and an increase in dust particle aggregation.

The effect of surfactant concentration on the reduction of surface tension and the wettability of the surface of dust particles should be emphasized. A decrease in surface tension and an improvement in wetting is observed only at a certain surfactant concentration in the solution; therefore, it is necessary to determine the optimal surfactant concentration that has the maximum effect.

In order to increase the efficiency of dust collection, a study was made of the effect of surface-active substances on the dust wettability. Currently, there is a huge variety of surfactants. The study of the mechanism of surfactant adsorption on the solid phase (dust particles) is an independent task, which was not put in this paper. The main goal of the work was to determine the fundamental possibility of using anionic surfactants based on triethanolamine salts of alkyl sulphates [14], which contain diphilic molecules and have a greater potential to improve the wettability of solid materials (dust) in contrast to non ionic and cationic surfactants. Specifically, the triethanolamine salt of sodium lauryl sulphate, an anionic surfactant, was used in the work [40].

The determination of the above characteristics was carried out on surfactant solutions prepared using distilled and tap water in the city of Gubkin. The concentration of surfactants in water (by weight) ranged from 0.1 to 6%. The surface tension measurements (mJ / m^2) are given in table. 1 and in fig. 1. Experimental procedure: the surface tension coefficient (σ) is determined on a TD1 / LAUDA tensiometer at the interface between the liquid-air phase and the Wilhelmy plate. The device allows you to immediately determine the value of the surface tension force in mJ / m^2. The measurements were carried out in a thermostatically controlled chamber at a constant temperature of 25 ° C [15].

From the above data it is seen that with an increase in the concentration of the triethanolamine salt of sodium lauryl sulphate from 0.5 to 6 wt. % in the water used for pit irrigation, a decrease in surface tension is observed from 71 to 18 mJ / m^2, and this favors the wetting of dust. When a surfactant, a triethanolamine salt of sodium lauryl sulfate, is introduced into water, σ decreases by a factor of ~ 2 for distilled water at a surfactant concentration of ~ 4 wt. %, and for tap water used for irrigation pit - at a concentration of ~ 2 wt. % The data table. 2 and fig. 4 show that

the increase in the concentration of surfactants over 5 wt. % in distilled and tap water does not contribute to a further significant decrease in surface tension. This phenomenon indicates the complete saturation of the adsorption layer when the maximum orientation of the surfactant molecules at the liquid – solid particle interface is reached, according to the data [12, 13].

First, with the help of foam can be achieved directly isolate the source of dust.

Secondly, due to the longer interaction of the foam layer with dust, the wetting properties of surfactant solutions are used in full scale compared to irrigation. This is due to the fact that the formation of the adsorption layer of surfactant molecules on the interface requires at least 0.5 s, and the droplets of surfactant solution from the nozzles reach the interaction zone with dust during 0.1 - 0.2 s [16].

Thirdly, the adhesion force of dust particles with foam bubbles is always greater than with the surface of the corresponding surfactant solution. Therefore, dust particles, especially in loose solid material, intensively pass into the liquid phase, easily stick together.

Processing with surfactant solutions in open pit mines of MPP can be carried out by irrigation of a source of dust formation or dust. In addition, it is possible to process in foam mode (foam can be obtained using a foam generator from aqueous solutions of blowing agents). This method is more effective and has a number of advantages [12].

Table 2

The relationship between the surface tension coefficient (mJ/m^2) and concentration in solutions (wt. %)

Water sample *	The value of the surface tension coefficient (mJ / m^2) at surfactant concentrations in aqueous solutions (wt. %)									
	0	0,1	0,25	0,5	1	2	3	4	5	6
1	72	70	66	61	53	42	37	35	33	28
2	71	67	61	51	41	33	28	24	21	18

*1 – distilled; 2 – water, water sampling was carried out in the city of Gubkin

The results of measuring the values of the contact angles of dust wetting Ɵ (degrees) or the angle of contact with water solutions in the presence of a surfactant — the triethanolamine salt of sodium lauryl sulphate at various concentrations are given in table 2 and in fig. 2.

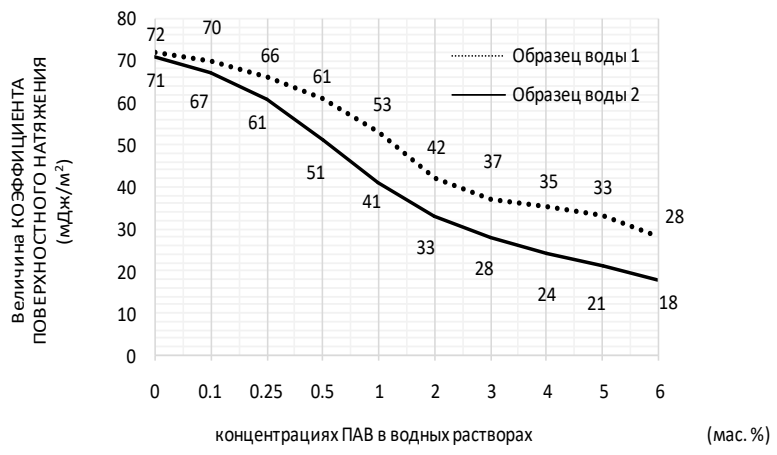

Figure 4 - The relationship between the surface tension coefficient and the concentration of triethanolamine salt of sodium lauryl sulfate in solutions prepared using: 1 - distilled water; 2 - tap water

It is believed that if the value of the contact angle is less than <90 °, then the liquid will be wetted by the solid surface, and the surface itself is called lyophilic (in our case, liquid water is hydrophilic). If the contact angle is greater than> 90 °, then the solid surface is not wetted by the liquid and is lyophobic (hydrophobic). With full or absolute wetting (spreading), the edge angle is zero, with full or absolute non-wetting it is 180 ° according to [12, 14]. The cosine of the contact angle determines the wettability of the solid surface of the dust by a liquid. It was determined by the drop projection method [15]. For distilled water without surfactant, the value is ~ 68 deg., And for tap water ~ 62 deg.

The equilibrium contact angle is calculated according to Young's law:

$$\cos\Theta = \sigma_{23} - \sigma_{13}/\sigma_{12}, \qquad (25)$$

where σ_{23}, σ_{13}, σ_{12} - surface energies respectively, and at the interface the solid is gas, the liquid is solid and the liquid is gas.

Table 3

The relationship between the value of the contact angle Θ (deg.) and the concentration of surfactants in solutions (wt. %)

Water sample*	The value of the contact angle Θ (deg.) at surfactant concentrations in aqueous solutions (wt. %)									
	0	0,1	0,25	0,5	1	2	3	4	5	6
1	68	65	62	60	58	55	50	47	44	43
2	62	59	56	53	47	39	34	30	27	25

*1 – distilled; 2 – water, water sampling was carried out in the city of Gubkin

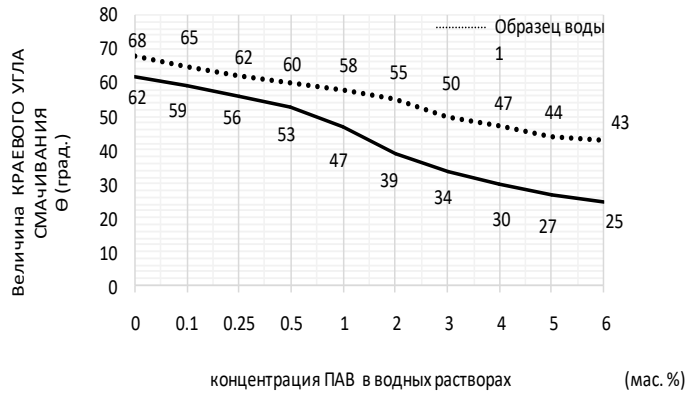

Figure 5 - The relationship between the contact angle and the concentration of the triethanolamine salt of sodium lauryl sulphate in solutions prepared using: 1 - distilled water; 2 - tap water

Analyzing the results, we can conclude the following, with an increase in the concentration of triethanolamine salt of sodium lauryl sulphate from 0.5 to 6 wt. % in distilled water and water used for pit irrigation, the value decreases, which indicates an improvement in the wetting of the surface of dust particles. The largest decrease to 25 degrees is typical for solutions of tap water with a surfactant concentration of 6 wt. % in contrast to solutions based on distilled water is 43 degrees at the same surfactant concentration. The optimal concentration of surfactants for solutions prepared with distilled water to improve the wettability of the surface of dust particles is ~ 4 wt. % For solutions prepared on the basis of tap water, the optimal concentration of surfactant is ~ 5 wt. % A further increase in the concentration of surfactants, the triethanolamine salt of sodium lauryl sulphate, is not advisable, since there is no significant decrease.

So, as a result of measuring the physic-chemical parameters (surface tension coefficient and contact angle) for water solutions used to irrigate quarries with surfactants, a concentration of triethanolamine salt of sodium lauryl sulphate of ~ 4-5 wt. %, since the hydrophilic characteristics of the liquid - solid system (dust) increase ~ 2-3 times.

The results obtained indicate an improvement in the wetting and sticking together of dust particles, therefore, the use of surfactants is rational and effective for solving problems with dust in open pit mines of MPPs, and specifically at JSC Lebedinsky MPP of the Belgorod Region, as well as for other industrial facilities in order to optimize the environmental situation and conditions labor on the objects of the technosphere, by analogy with the problems considered in [4, 5,17] using information technology [18].

6. CONCLUSIONS

1. The model calculation of the content of polluting components during the explosions at the quarries makes it possible to summarize: the content of CO, NO_X, dust in the air of the quarry developments of GOK exceed the MPC. Therefore, «Lebedinsky» requires the use of cost-effective, productive means to minimize the content, primarily dust, in open-pit mining, due to the fact that the technologies used are not sufficiently unprofitable.

2. Based on a study of the enterprise's activities to suppress dust and gas emissions during mass explosions at a quarry of a mining and processing plant, it was proposed to reduce dust and gas emissions by suppressing it at the source of formation using the method of wetting and sticking of dust particles.

3. Conducted studies of surface-active substances on the wettability of bulk materials showed that improving wettability and adhesion helps to reduce dust formation, therefore, the use of foaming agents is appropriate for dust control.

4. Based on the results of measuring the physic-chemical parameters (surface tension coefficient and contact angle) for solutions of water used for irrigation of quarries with surfactants, a concentration of triethanolamine salt of sodium lauryl sulphate ~ 4-5 wt. %, since the hydrophilic characteristics of the liquid-solid system (dust) increase ~ 2-3 times.

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