ISSN (Online): 2658-4255
RUSSIAN-ARCTIC.INFO
6 / 2019

Russian Arctic

ENVIRONMENTAL MONITORING OF THE ARCTIC ZONE OF THE RUSSIAN FEDERATION (AZRF): SANITARY AND EPIDEMIOLOGICAL WELFARE AND EFFICIENT PRODUCTION

Scientists from the North-Western Scientific Centre of Hygiene and Public Health in St. Petersburg have taken part in preparation of the 6th issue of "The Russian Arctic" journal.

16+

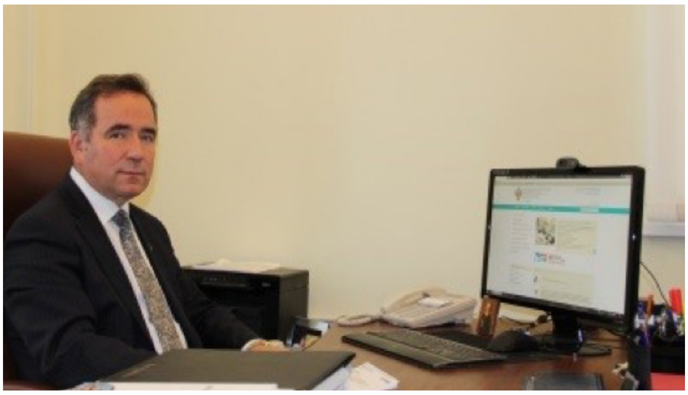
RUSSIAN ARCTIC
SCIENTIFIC PEER-REVIEW JOURNAL

MANUSCRIPT SUBMISSION: info@arctic-centre.com
ADDRESS: 101000, Moscow, Armenian lane, 9/1/1 bld., room 203:
MASS MEDIA registration: ЭЛ №ФС77-72859
FOUNDER AND PUBLISHER: LLC Center for Information and Legal Support for the Development of the Arctic
http://arctic-centre.com

CEO: Yu.V. Belikova
ISSN (online): 2658-4255

TABLE OF CONTENTS

ENVIRONMENTAL MONITORING OF THE ARCTIC ZONE OF THE RUSSIAN FEDERATION (AZRF): SANITARY AND EPIDEMIOLOGICAL WELFARE AND EFFICIENT PRODUCTION



Sergey Gorbanev, Doctor of Medicine, told the readers of “The Russian Arctic” journal about sanitary and epidemiological monitoring of the Arctic regions of the Russian Federation (AZRF) and about modern scientific approaches to achievement of priority objectives in public health

GORBANEV S.A., CEO FOR NORTH-WEST PUBLIC HEALTH RESEARCH CENTER

Mr.Gorbanev, please tell us about the current researches of the Centre aimed at solving actual problems in the AZRF?

For 30 years now, the Centre has been conducting comprehensive environmental and hygienic research in the regions of the Russian Arctic, within the framework of international cooperation as well. It has conducted hygienic and ecotoxicological studies of environmental contamination with long-lived toxic substances. Based on the scientific research, the scientists are developing measures to minimize the negative anthropogenic impact on the Arctic environment.

They conduct hygiene studies of local food safety, drinking water quality, working conditions and many other studies of the environment and public health in the Arctic.

What scientific studies carried out by the Centre’s specialists deserve special attention?

Currently, the Centre’s researchers are implementing several projects; one of the most interesting is creation of geoportal “Sanitary and Epidemiological Welfare of the AZRF Population”.

This is a vast database containing long-term and regularly updated information about demography and health of the population, living conditions, water supply, industrial and economic pollution of the environment, the state of infrastructure, etc.

The geoportal will become an efficient tool for assessment of the impact of adverse living conditions and environmental factors on the population health, for the purpose of an objective assessment and improvement of efficiency of social and hygienic monitoring, and social and economic AZRF development programs.

According to the social and hygienic monitoring data, what are the main problems of sanitary and epidemiological welfare in the AZRF?

According to the social and hygienic monitoring data, the population of the Arctic regions of the Republic of Sakha (Yakutia), Arkhangelsk and Murmansk regions has been steadily decreasing over the last 10 years. Demographic and health indicators in the AZRF show, on the one hand, a decrease both in general mortality (from 10.1 to 9.3 per 1,000 population) and infant mortality (from 10.9 to 6.7 per 1,000 live births), and an increase in life expectancy; on the other hand, these figures show an increase in mortality from malignant tumours (from 1.25 to 1.45 per 1,000 population).

Over the last 11 years, incidence of malignant tumours has a clear upward trend, with the Murmansk and Arctic territories of the Arkhangelsk region being the risk areas.

For the Federal Service for Supervision of Consumer Rights Protection and Human Well-Being (Rospotrebnadzor), the climate change processes, such as warming, which cause the change of permafrost borders, mean problems of assessment of the permafrost thaw risk in the areas of cattle burial sites, domestic and industrial waste deposit, epidemiological risk formation, as the main water supply sources in the Arctic are surface water bodies.

In your opinion, what are the priority tasks for public health maintenance in the AZRF?

Taking into account high rates of the planned development of the Arctic, we consider the following tasks to be the top-priority directions in sanitary and epidemiological welfare in the AZRF:

1. Provide for medical and ecological, and economic assessment of consequences of the adverse risk factors impact on the population health while implementing investment projects for AZRF development.
2. Justify, develop and introduce non-standard management solutions relating to labour and daily life of people in difficult climatic conditions.
3. Introduce medical and biological criteria for professional selection for work in the Arctic, including application of on/off rotation methods.
4. Form and maintain systems of regional registers of infectious and parasitic morbidity, oncopathology, maternal and child health.
5. Justify requirements for adjustment of social and hygienic monitoring programs including indicators representative of the content of highly toxic pollutants and pathogens of hazardous infections and invasions transmitted by the food chain through the traditional industry objects of the population, as well as social and climatic characteristics of the region.

**North-West Public Health Research Center was founded in 1924 as Leningrad Institute of Occupational Disease Studies, being among the first occupational health institutions in Europe.
Over 90 years the staff established an authoritative domestic school of workplace and ecological harmful agents health regulation, of diagnostic techniques, prevention and treatment of most prevalent occupational diseases.*

DOI: 10.24411/2658-4255-2019-10061

GIS PORTAL «SANITARY AND EPIDEMIOLOGICAL WELFARE OF THE POPULATION IN THE RUSSIAN ARCTIC» AS A PROMISING TOOL FOR A COMPREHENSIVE ASSESSMENT OF THE STATE OF ENVIRONMENTAL FACTORS AND THE HEALTH OF THE POPULATION OF THE RUSSIAN ARCTIC

S.A. Gorbanev[1], V.N. Fedorov[1,2] A.A. Kovshov[1, 2]
[1]Northwest Public Health Research Center, St. Petersburg, Russia
[2]North-Western State Medical University named after I.I. Mechnikov, St. Petersburg, Russia
✉ *gorbanev@s-znc.ru, vf1986@mail.ru, kovshov@s-znc.ru*

The Arctic Zone of the Russian Federation (AZRF), being a territory of prospective development and reclamation, requires increased attention to the problems of maintaining the sanitary and epidemiological well-being of the population considering specific climatic and socioeconomic factors. These circumstances force the development and implementation of non-standard managerial decisions in the selection of technological development of territories, the characteristics of the work and life of people in these conditions.

To solve problems in the area of environmental protection and sanitary and epidemiological well-being of the population, various electronic informational and analytical public resources based on geographic information system (GIS) technologies have been developed and are actively used. The advantage of GIS technologies is the convenience of collecting, analyzing and visualizing information directly related to the territory, which is especially important when working with large arrays of information linked to large territories.

That said, when it comes to the AZRF, such resources are either absent or do not address the sanitary and epidemiological well-being of the population.

The authors have developed the concept of a geoportal of the sanitary and epidemiological status of the AZRF based on GIS which could be an extensive electronic database of environmental factors and the population health status and also serve as an effective tool for assessing the sanitary and epidemiological well-being of the population with a spatial analysis function.

A test version to be posted on the Internet has been developed and work on populating it with the up-to-date information on environmental and public health factors is in progress.

Keywords: sanitary and epidemiological well-being, health risks, drinking water, outdoor air, Russian Arctic.

Introduction. The Arctic Zone of the Russian Federation (AZRF) is currently becoming a zone of intensive development involving hundreds of thousands of people into production activities in this region. Implementation of the assigned tasks, including those on the development of industrial, engineering and transport infrastructure, on the creation of jobs, the arrangement of settlements, is inextricably linked with the provision of safe working and living conditions in the territories with significant climatic characteristics affecting first of all the sanitary, hygienic and epidemiological situation, preservation of people's health and life [1]. This circumstance necessitates consideration, discussion and resolution of issues related to ensuring sanitary and epidemiological well-being in the developed territories of the Arctic as a prerequisite for the effective implementation of investment projects planned by the government. This, in turn, makes it necessary to justify, develop and implement non-standard managerial decisions not only in the choice of technological development of territories, but primarily in relation to the work and life of people in these conditions [2].

Among the high-priority national and investment projects in the development of the Arctic which require a comprehensive sanitary and epidemiological expertise, the following should be listed:

- Creation of 8 pivot zones for the development of the Arctic [3, 4];
- Establishment of a single operator of the Northern Sea Route [5];
- Digitalization of the Arctic: telemedicine, telecom and communication;
- Construction of the railway «Northern Latitudinal Railway»;
- Implementation of the federal target project “Pure Water”: providing the population with pathogen-free drinking water; creation of an Interactive Map for Drinking Water Quality Control in the Russian Federation;
- Implementation of the federal target project “Clean Air”: reduction of atmospheric air pollution in large industrial centers; reduction of pollutant emissions into the air; creation of an effective system for monitoring and control of air quality;
- Solving the problems of municipal waste and production waste and their disposal.

To solve the above listed problems, it is necessary to create a system for the effective assessment and management of the sanitary and epidemiological situation in the Arctic considering special attention to maintaining public health, reducing mortality and increasing life expectancy of the population, as well as developing measures to prevent morbidity. An important factor determining the effectiveness of these measures is the completeness, reliability and quality of the source information that directly affects the nature of decisions to be made [6].

Presently a fair amount of electronic information and analytical public resources based on geographic information system (GIS) technologies have been developed for solution of various problems in the field of environmental protection and sanitary and epidemiological well-being of the population, and they are actively used both in Russia and in other countries [7, 8, 9].

The main advantage of GIS technologies in these areas is the convenience of collecting, analyzing and visualizing of various information directly related to the territory ("map-linked") [10, 11].

The Government of the Russian Federation has adopted the Concept of creation and development of spatial data infrastructure (SDI) of the Russian Federation. Regional and departmental SDIs are also being formed, providing for the creation of specialized, industry-specific and thematic geoportals. Various regional electronic resources based on GIS technologies (regional geoportals of the constituent entities of Russia) have been created and are actively used, however, none of them covers the problems and tasks of ensuring sanitary and epidemiological well-being, especially in the Arctic Zone [11].

Targets and goals. In consideration of the foregoing, for the purpose of collecting and analyzing information on the sanitary and epidemiological well-being status, there was set a task to create and develop a geoinformation portal (Geoportal) "Sanitary and epidemiological well-being of the population in the Arctic Zone of the Russian Federation".

The Geoportal concept is based on a geographic information system (GIS), a database server and an array of information about environmental factors, public health, socio-economic and medical-demographic indicators using information and analytical tools and spatial data processing methods [12].

The Geoportal is created as a multi-level system for collecting, storing and analyzing data which is implemented on a cartographic basis and includes:

- the actual cartographic part (the "atlas" in the traditional sense);
- various features associated with the map;
- a set of analytical and calculation methods;
- managerial and expert decisions based on data analysis.

The concept of the Geoportal is schematically shown in Figure 1.

ArcGis GIS in the server version of ArcGis Server v.10.7 Advanced Enterprise is used as a software environment for implementing the technical capabilities of the Geoportal and for visualizing information on a cartographic basis. For storage and loading of databases (DB) in the GIS, the SQL series of the database management system (DBMS) is used.

The visual representation of the Geoportal is implemented as a website accessible on the Internet with access through a web browser window with customizable multilevel access rights.

The following layers (presentation levels) of data are implemented in the Geoportal:

- AZRF as a whole;
- Territorial subjects of the AZRF;
- Areas of the subjects;
- Settlements;
- Separate objects: infrastructural, point and areal (polygonal) objects.

Currently, the Geoportal is in the mode of technical debugging and populating it with data. Given the software, hardware and technical capabilities, it is planned to populate the Geoportal with the following volume and list of data:

- Demographic indicators – 19 indicators;
- Health status of the population – over 2100 indicators;
- The state of the population living environment – over 1200 indicators;
- Socio-economic indicators of the territories – more than 20 indicators;
- Food quality – over 60 indicators;
- Natural climatic data and territorial geographical indicators;
- Infrastructure and economic indicators of the development of the territories.

An example of the database structure is shown in Figure 2.

To perform analytical tasks, the Geoportal is equipped with a wide range of functionality and various tools, in particular:

- Statistical analysis of sample arrays of spatially related data;
- Spatial analysis of the distribution and correlation of indicators, its visualization;
- Retrospective correlation analysis to identify causal relationships.

The following sources of information are used as the main data sources for populating the Geoportal with information:

- Forms of federal and sectoral statistical monitoring of the state of public health and the environment;
- Templates of the Federal Information Fund SGM (FIF SGM);
- Data from Earth's remote (satellite) sensing (ERS);
- Reports of the Federal State Statistics Service (Rosstat);
- Information and analytical system of Rospotrebnadzor.

In view of the actual and predicted sanitary and epidemiological situation, the capabilities of the Geoportal will allow the following:

1. Development of general schemes for the development of the AZRF territories;
2. Planning of investment projects;
3. Development of measures to prevent and reduce the morbidity of the population, including occupational morbidity;
4. Development of targeted social programs for various groups of the population considering various specifics;
5. Creation of programs for comprehensive improvement of territories and ensuring hygienic and environmental safety of the population
6. Improving the SGM system;
7. The ability to quickly access the list of medical-

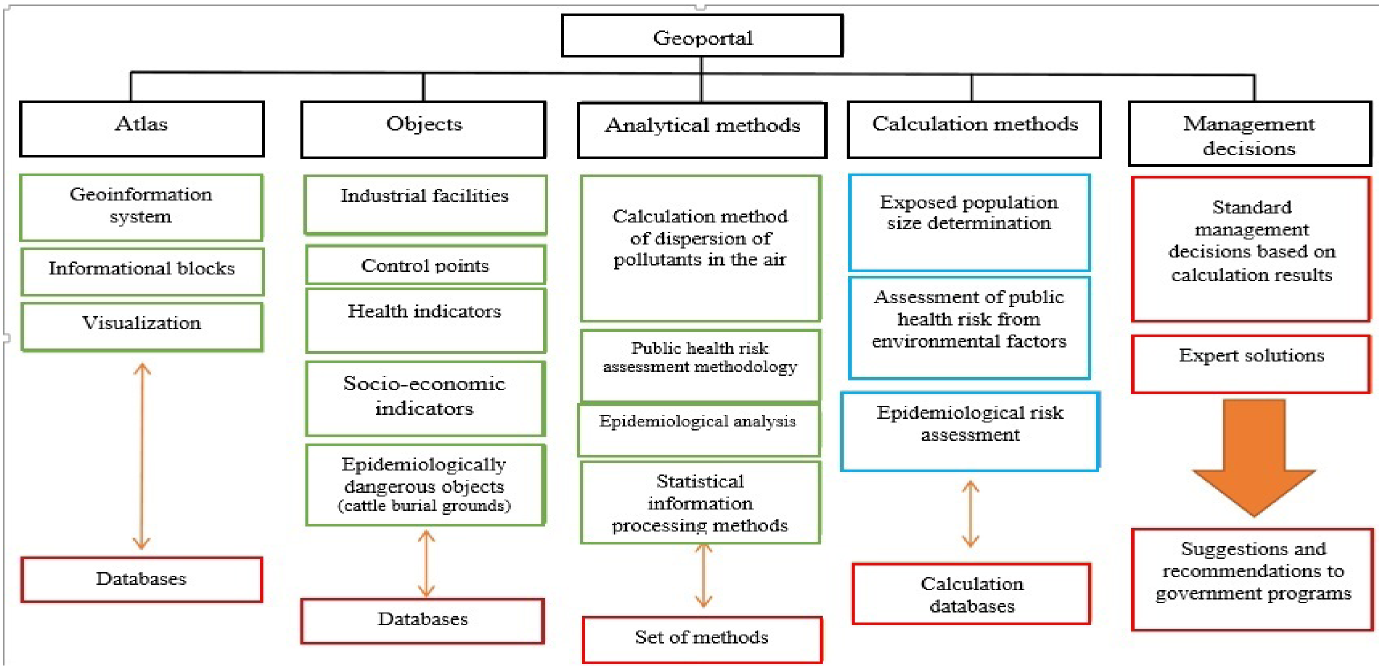


Fig. 1. Concept of the Geoportal

demographic and socio-economic information online via the Internet portal for a wide range of authorized organizations (authorities, medical institutions, Rospotrebnadzor, etc.).

With the help of spatial analysis tools, it is possible to graphically visualize and rank territories of various levels (subject, district, settlement) by number, population density, intensity of morbidity indicators (both general and by individual nosologies) or the severity of indicators of environmental factors.

The statistical analysis tools allow to select certain areas of interest and compare the indicator of interest in the dynamics for a specific period.

Similarly, it is possible to visualize the location of monitoring points for the quality of drinking water and atmospheric air, estimate their amount and territorial distribution in different regions (subjects, settlements) and make a correlation between density and population and the number of monitoring posts.

The results of long-term monitoring that are linked to a specific territory can be compared in dynamics by a combination of factors or by a separate indicator which makes it possible to quickly visualize successful or unsuccessful territories by applying spatial analysis tools.

Examples of visualization of spatial data on the sanitary-epidemiological situation in the Geoportal are presented in Figure 3 and Figure 4.

In the process of the Geoportal development, the capacity of work with local data, with their subsequent refinement, for example, to the level of a separate industrial enterprise (or even a separate source) was implemented. In this case, in the process of sanitary-epidemiological assessment or examination, specialists can use verified and up-to-date information about the parameters of the enterprise's impact on the population's environment, the levels of the population exposure for a given period of time including the assessment of the risk to the residents' health.

The organization of data on the Geoportal is indicative of the spatial relationship of the industrial site and the habitable area, the potential impact zone of the enterprise, the sources of pollutant emissions and other components of the assessment of the sanitary and epidemiological situation in a convenient visual and digital form.

Calculations in the system can be performed for any point of the estimated space which allows operating with verified quantitative indicators of the exposure load.

Given the described capabilities of the Geoportal, the following points appear to be promising and feasible:

- Implementation of the Geoportal as an analytical tool into the practice of the authorities and institutions of the Rospotrebnadzor, as well as the executive bodies of the AZRF constituent entities.
- Ensuring automatic updating and uploading of relevant data on environmental factors and the population health status from various existing information and analytical systems – both Rospotrebnadzor and within interdepartmental interaction and integration (Roshydromet, Rosprirodnadzor, Ministry of Health, etc.);
- Use of the Geoportal results in the development and implementation of state, investment and regional projects and development programs of the AZRF.

Conclusion. Given the significant amount of data planned for placement, storage and visualization, these activities are planned as long-term work aimed at the systematic collection of new information, analysis of existing data and expanding the list of indicators, which, according to the authors, should allow to identify causal relationships and correlations between various factors (groups of factors) and the public health

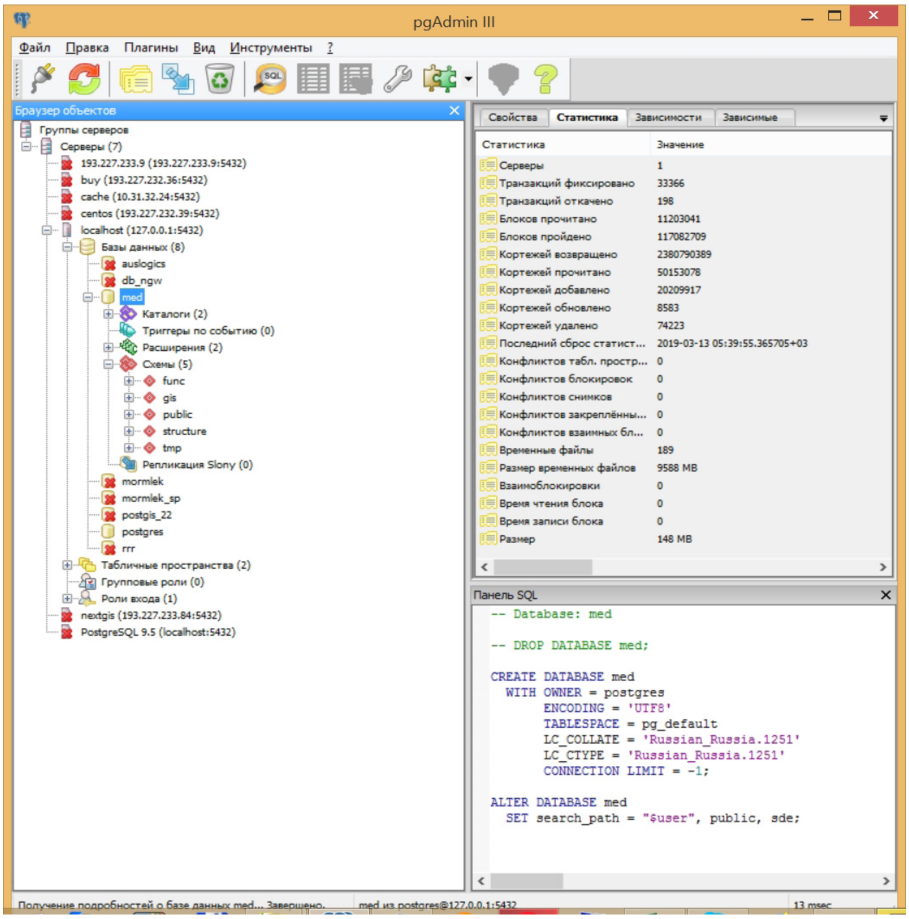


Fig. 2. Example of Geoportal database structure

status.

Thus, the created Geoportal should become, on the one hand, an information-analytical system with an extensive database of environmental factors and the public health status, and, on the other hand, an effective tool for assessing the sanitary and epidemiological well-being of the population of the Russian Arctic in general and in individual territories with a wide list of spatial analysis functions which together will serve as a tool for substantiating the managerial decisions.

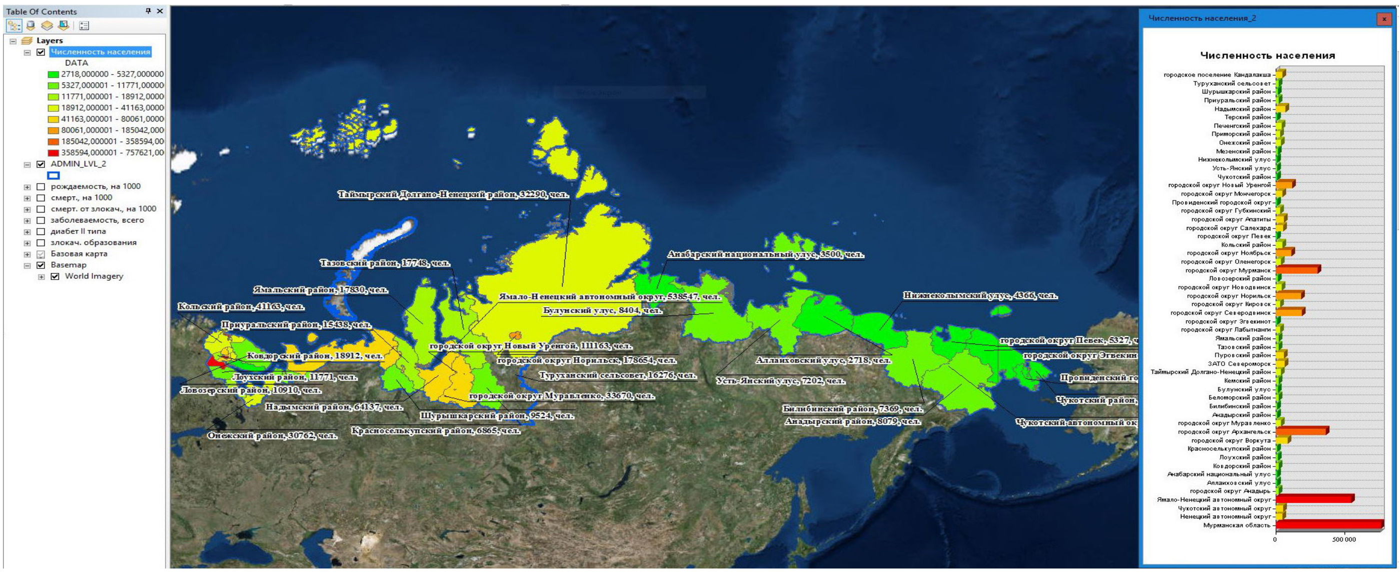


Fig. 3. Example of ranking the AZRF territories by demographic indicators.

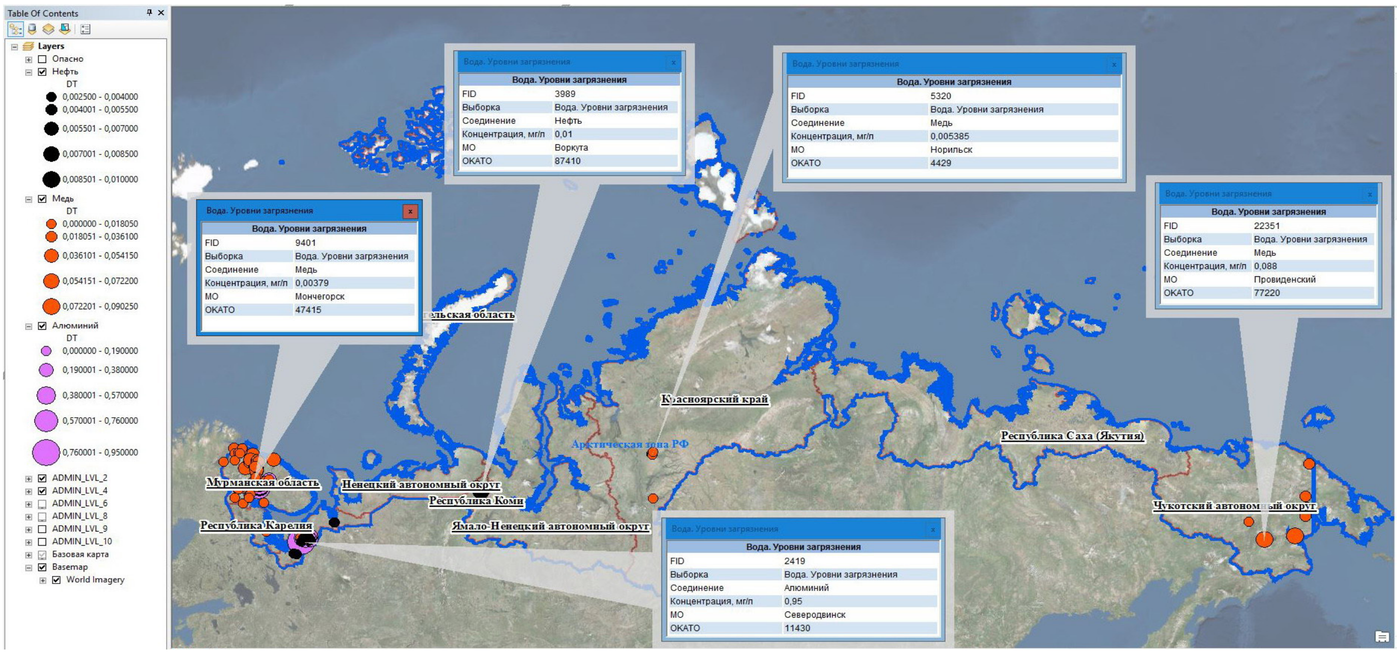


Fig. 4. Example of visualization of water pollution levels of centralized drinking water supply in the AZRF

References:

1. Scientific and technical problems of Arctic exploration. Report of the Minister of Natural Resources and Ecology of the Russian Federation S.E. Donskoy. M .: Nauka, 2015.490 s.
2. S.A. Gorbanev. Main directions and tasks of scientific research of the North-West Scientific Center of Hygiene and Public Health of the North-West Scientific Center for Sanitary and Epidemiological Wellbeing in the Arctic Zone of the Russian Federation. // «Problems of Preservation of Health and Ensuring the Sanitary and Epidemiological Well-Being of the Population in the Arctic». Materials of the scientific-practical conference with international participation. 2017 - Publisher: OOO «IPK» Kosta». Pp. 8-13.
3. Voronina E.P. The formation of supporting zones for the development of the Arctic zone of the Russian Federation and ensuring their functioning: the use of Gap-analysis // Regional Studies. 2017.V. 4. No. 6. P. 60-69. DOI: 10.14530 / reg.2017.6
4. Andreeva E.N. Support zones in the Arctic: new trends in solving old problems // IVF. 2017. No. 9. C. 26-41.
5. Federal Law «On the State Atomic Energy Corporation» Rosatom» dated 01.12.2007 N 317-ФЗ (latest revision).
6. Yu.A. Novikova Interregional social hygienic monitoring – topical trend to provide sanitary-epidemiological wellbeing // Russian hygiene - developing traditions, rushing into the future. Materials of the XII All-Russian Congress of Hygienists and Sanitary Physicians. 2017. Moscow. - P. 140-143.
7. S.M. Tokarchuk, O. V. Tokarchuk, E.V. Trofimchuk Methodological basis for the creation of regional electronic ecologo-geographical atlases. Pskov Regional Journal. 2015 No.22//URL:https://cyberleninka.ru/article/n/metodicheskie-osnovy-sozdaniya-regionalnyh-elektronnyh-ekologo-geograficheskih-atlasov
8. D.V. Yakovlev Geoportal of the Voronezh region - a tool for increasing the efficiency of circulation of regional spatial data // Vestnik Voronezh State University. 2012 T. 8 No. 1. P. 41-45.
9. A.P. Dexter, D.R. Strukov. Geoportal «Geoinformation system of St. Petersburg healthcare» in the Internet as an example of a system for managing the health territory. // Doctor and information technology. 2012 № 3 S. 58-63.
10. N.A. Chepikov Perfection of the system of socio-hygienic monitoring of the region using geoinformation technologies. // URL: https://cyberleninka.ru/article/n/sovershenstvovanie-sistemy-sotsialno-gigienicheskogo-monitoringa-regiona-s-ispolzovaniem-geoinformatsionnyh-tehnologiy (26.08.2018).
11. Fedorov V.N., Novikova Yu.A., Kovshov A.A. Actual issues of the practical application of GIS technologies in the activities of bodies and institutions of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare // Collection of scientific papers of the All-Russian Scientific and Practical Conference with international participation «Preventive Medicine-2017» . T. 3.P. 225-230.
12. Gorbanev S.A., Kulichenko A.N., Fedorov V.N., Dubyansky V.M., Novikova Yu.A., Kovshov A.A., Tikhonova N.A., Shayahmetov O.H. Organization of an interregional monitoring system using gis technologies by the example of Russian Federation Arctic Zone. Hygiene and sanitation. 2018. Vol. 97. No. 12. S.1133-1140.

DOI: 10.24411/2658-4255-2019-10062

ON IMPROVEMENT OF SOCIAL AND HYGIENIC MONITORING IN THE ARCTIC ZONE OF THE RUSSIAN FEDERATION

K.B. Fridman, Yu.A. Novikova, N.A. Tikhonova
Northwest Public health Research Centre, St. Petersburg, Russia
kirill.fridman@yandex.ru, novikova@s-znc.ru, tihonova@s-znc.ru

During the period of work of the social and hygienic monitoring system, the main formation stages of the indicators showing the sanitary and epidemiological situation were completed, as well as information on the population health condition and the environment state was collected. At the moment, there is a need for an upgrade and development of social and hygienic monitoring, change of methodological approaches to the information collection and assessment of the environment and public health quality. When conducting social and hygienic monitoring in the AZRF, there are certain difficulties: the search for indicators that are adequate to the purposes and objectives of monitoring and showing the impact of environmental factors on public health. Methodological approaches to selection of control points and creation of programs for laboratory studies of environmental samples have not been sufficiently developed. There are limited opportunities to exchange information on natural and climatic factors as well as on environmental and health factors due to the difficulties of interdepartmental interaction. The article suggests possible ways to improve efficiency of the social and hygienic monitoring in the AZRF.

Keywords: social and hygienic monitoring; sanitary and epidemiological welfare; geoinformation systems; population health; habitat factors; Arctic Zone of the Russian Federation.

Since 1994, the Federal Service for Supervision of Consumer Rights Protection and Human Well-Being has been carrying out social and hygienic monitoring, which is based on the principles of constancy, continuity, adequacy of tasks of protection and promotion of health, automation of accounting, mathematical processing and observational analysis, unification of collection methodology, information processing and analysis, etc.

Information collected within the social and hygienic monitoring:

- is unique (lack of similar information in other monitoring systems);
- is diverse: public health and habitat factors: biological, chemical, physical, social, natural-and-climatic;
- is in demand for use in territorial automated information systems, in implementation of investment projects, etc.

Over the period of work of the social and hygienic monitoring system, the main formation stages of indicators, objects and factors characterizing the sanitary and epidemiological situation were completed, as well as information on the state of the population health and human environment was collected, formed in the federal, regional and local information files of the social and hygienic monitoring data. Regulatory legal acts and reference materials in analysis, forecasting and determination of cause-and-effect relations between the state of the population health and the impact of environmental factors have been developed [1].

The results of the social and hygienic monitoring are used to inform about the sanitary and epidemiological state of the regions of the Russian Federation, for preparation and implementation of management decisions aimed at improvement of the habitat, prevention of mass noncommunicable diseases due to the impact of habitat factors by Rospotrebnadzor, public authorities and local governments.

Further development of the social and hygienic monitoring system is constrained by a number of legislative, organizational, technological and financial and economic problems: mainly the territorial principle of social and hygienic monitoring management without regard to inter-regional aspects; insufficient development of the methodology for social and economic efficiency assessment of social and hygienic monitoring; insufficient human resourcing level of social and hygienic monitoring; outdated information platforms for collection and storage of social and hygienic monitoring data, which do not meet modern requirements and ensure interdepartment cooperation [2, 3].

Currently, there is an urgent need for update and development of social and hygienic monitoring, changes in methodological approaches to information collection and assessment of the environment and public health quality [4]. First of all, these are the requirements of today:

1. social utility, adequacy of information to the set purposes and objectives.
2. prompt delivery of the collected information, timeliness of obtaining information on the state of habitat factors and population health, necessary for the quickest adoption of measures to improve the sanitary and epidemiological situation.
3. sufficiency is a balance between the necessary information to assess the impact of habitat factors on the population health and redundant information, which overloads databases and makes it difficult to carry out the analysis, as well as requires considerable effort.
4. the information collected on habitat

factors should allow assessing the impact on population health.
5. possibility of automated information collection, data conversion (import) into already developed programs or programs under development should be fulfilled.
6. availability of specialists able to collect, evaluate and analyse the collected information.
For an objective analysis of the sanitary and epidemiological situation, assessment of the public health risk in the Arctic zone of the Russian Federation (AZRF) and development of measures to prevent morbidity it is necessary to have complete, reliable and qualitative information in environment and human health.
However, despite the set state objectives and the efforts made to implement social and investment programs, the key features and problems of the Arctic are taken into account and solved insufficiently effectively, which is related to:

- extreme natural and climatic conditions;
- local character of industrial and economic development of the territories and low population density;
- significant reduction of population in the macro-region;
- •outflow of skilled personnel and inflow of low-skilled, socially unadapted manpower;
- •high resource intensity and dependence of economic activities and life support of the population on the supply of fuel, food and essential goods from other regions of Russia;
- •underdeveloped infrastructure, especially energy and transport infrastructure;
- •environmental tension in the Arctic territories, low sustainability of environmental systems and their dependence on even minor anthropogenic impacts;
- •low social and economic protection of the indigenous population [5].
- For Rospotrebnadzor, this means the need to form scientifically based management decisions to ensure the sanitary and epidemiological welfare of both indigenous and newly arrived population, not adapted to the Northern conditions [6].
- When conducting social and hygienic monitoring in the AZRF, there are certain difficulties: the search for indicators that are adequate to the purposes and objectives of the monitoring system, and indicating the impact of habitat factors on the population health. Methodological approaches to selection of control points and formation of programs for laboratory studies of environmental samples have not been sufficiently developed. There are limited opportunities to exchange information on natural and climatic as well as on environmental and health factors due to the difficulties of interdepartmental interaction.

Table 1
Number of social and hygienic monitoring points by the AZRF constituent territories

Constituent territory	Number of the monitoring points		
	ambient air	soil	drinking water
Arkhangelsk	7	52	18
the Republic of Karelia	-	3	8
the Republic of Komi	2	3	7
Krasnoyarsk Krai	24	2	18
The Murmansk region	14	41	154
The Nenets Autonomous Okrug	-	6	11
The Chukotka Autonomous Okrug	2	82	81
the Republic of Sakha (Yakutia)	-	-	2
The Yamalo-Nenets Autonomous Okrug	9	54	45
Totally	58	243	342

In 2018, the habitat factors in the AZRF were monitored in 643 points (Table 1).

The Nenets Autonomous Okrug, the Arctic territories of the Republic of Sakha (Yakutia) and the Republic of Karelia do not have ambient air monitoring. The list of the controlled indicators differs upon the AZRF constituent territories. When selecting the indicators controlled in the air, one should keep in mind the temperature limitations during the research. For example, the minimum temperature of ambient air at which samples of dioxide nitrogen and dioxide sulphur are taken is 0°C, samples of suspended solids and oxide carbon are taken at minus 10°C.

Within the framework of the social and hygienic monitoring, soil is studied at 243 monitoring points in the Arctic settlements. In the Arctic territories of the Republic of Sakha (Yakutia), the Norilsk city district and the Taimyr district of the Krasnoyarsk Krai the soil is not studied (Table 1). In order to assess the impact of the soil quality on health in the populated areas, each monitoring point should have at least 6 studies per year on chemical, bacteriological, parasitological indicators and cover all seasons of the year, which is difficult to achieve in the Arctic conditions. Despite the significant number of monitoring points in the Chukotka Autonomous Okrug the soil is studied only for parasitological indicators, in the Nenets Autonomous Okrug - for bacteriological and parasitological indicators.

While assessing availability of public centralized water supply, it should be noted that, considering the vast areas of the Chukotka, Nenets Autonomous Okrugs and the Republic of Sakha (Yakutia), arrangement of a properly centralized water supply is a complex technical and technological task, including in permafrost [7].

In 2018, the quality of drinking water of the centralized utility and drinking water supply systems was controlled in 46 Arctic districts in 342 control points (tab. 1). Neither social nor social and hygienic monitoring research was conducted in the Shuryshkarsky District of the Yamal-Nenets Autonomous Okrug and 12 uluses (districts) of the Republic of Sakha (Yakutia): Abyiskiy, Allaikhovskiy, Anabarskiy, Verkhnekolymskiy, Verkhoyanskiy, Zhiganskiy, Momskiy, Nizhnekolymskiy, Olenekskiy, Srednekolymskiy, Ust-Yanskiy, Eveno-Bytantaiskiy. In the Arctic zone, the lists of the controlled indicators differ significantly (Table 2).

Table 2

List of the drinking water indicators under control upon the Arctic constituent territories

Constituent territory	List of the controlled indicators
Arkhangelsk	alkyl benzene sulphonates, aluminium, hydroxybenzene, iron, cadmi-um, manganese, copper, arsenic, oil, nickel, nitrates, mercury, lead, strontium, sulphates, formaldehyde, fluorine, chlorides, chloroform, chromium, zinc
the Republic of Karelia	Ammonia and ammonium ion, iron, cadmium, copper, nitrates, nitrites, lead, chlorides, zinc
the Republic of Komi	Ammonia and ammonium ion, iron, manganese, nitrates, nitrites, sul-fates, chlorides
Krasnoyarsk Krai	DDT, 1,2,3,3,4,5,6-hexachlorocyclohexane, aluminum, ammonia and ammonium-ion, barium, beryllium, boron, iron, cadmium, cobalt, man-ganese, copper, molybdenum, arsenic, nickel, nitrates, nitrites, mercury, lead, selenium, strontium, sulfates, tetrachloromethane, tetrachloroeth-ylene, trichloroethylene, fluorine, chlorides, chloroform, chromium, cyanides, zinc
The Murmansk region	aluminium, ammonia and ammonium ion, bromodichloromethane, hy-droxybenzene, dibromchloromethane, iron, manganese, copper, nickel, nitrates, nitrites, lead, tetrachloromethane, chlorides, chloroform, zinc
The Nenets Autono-mous Okrug	ammonia and ammonium ion, iron, manganese, copper, nitrates, ni-trites, sulphates, chlorides
the Republic of Sakha (Yakutia)	ammonia and ammonium ion, iron, magnesium, sodium, nitrites, sul-phates, chlorides
The Chukotka Auton-omous Okrug	aluminium, ammonia and ammonium-ion, iron, cadmium, calcium phosphate, magnesium, manganese, copper, molybdenum, arsenic, ni-trates, nitrites, mercury, lead, sulphates, fluorine, chlorides, zinc
The Yamalo-Nenets Autonomous Okrug	ammonia and ammonium ion, iron, silicon, manganese, nitrates, ni-trites, sulphates, chlorides

One of the possible ways to solve the problems of data collection on the state of the population health and habitat factors under current conditions is the use of geoinformation systems.

In order to collect and analyse information about the state of sanitary and epidemiological welfare, the North-Western Scientific Centre of Hygiene and Public Health conducts research work on creation of the geoportal “Sanitary and Epidemiological Welfare of the AZRF Population”.

Within the framework of the “Pure Water” federal project within “Ecology” national project, the Rospotrebnadzor project office is creating an interactive map of drinking water quality control of centralized water supply systems, the purpose of which is to inform the population, state and executive authorities of the Russian Federation, local governments and water supply organizations on the quality and safety of water of centralized drinking water supply systems. Qualitative drinking water supply to the population will be assessed, in 2024 it should be 90.8%, and for the urban population it should be 99.0%.

In-depth analysis shows that the favourable situation with quality drinking water in the AZRF is due to the cities and urban-type settlements, where a significant part of the AZRF population lives. At the same time, the situation in rural settlements is not so favourable.

The specific gravity of water samples from the centralized drinking water supply distribution network exceeding hygienic standards of the sanitary and chemical indicators in the AZRF is almost twice as high as the Russian average, and in the settlements of the Chukotka Autonomous Okrug and the Arctic regions of Krasnoyarsk Krai and the Republic of Sakha (Yakutia) more than 30.0% of drinking water samples did not meet the hygienic standards.

The specific gravity of water samples from the centralized drinking water supply distribution network exceeding the hygienic standards of the microbiological indicators in the AZRF is at the level of the average Russian indicator. However, in the Arctic regions of the Republic of Sakha (Yakutia), the proportion of samples exceeding the hygienic standards in 2017 was 22.4%.

Except for keeping the population informed, the performance capabilities of the Interactive Map will also include:

1. prompt hygienic assessment of the areas according to the quality of drinking water supplied to the population;
2. prompt assessment of the number of population supplied with quality water, in case of emergencies as well;
3. development of targeted programs to improve the quality of drinking water;
4. identification of cause-and-effect relations between water quality and population morbidity at runtime;
5. proposals on improvement of water quality control system.

One of the methods of timely identification of deviations of quality indicators from standard values is to control water quality of centralized water supply systems with the use of devices that allow carrying out automated quality control throughout the water supply system. The most universal is the on-line analysis, which imply creation of a continuous sampling line with installation of a permanently functioning analyser or a system of analysers.

Conclusion.

1. To increase the social and hygienic monitoring efficiency in the AZRF it would make sense:
2. To develop normative and legal documents on arrangement of social and hygienic monitoring.
3. To develop a regulatory and methodology framework for arrangement and conduct of inter-regional social and hygienic monitoring, the purpose of which will be to improve the quality of expert and analytical processing of data having an interregional features, with regard to the factors affecting the population health.
4. To include health risk assessment indicators (the risk of mandatory requirements violation) as target indicators of implementation of state (regional) target programs and municipal development programs.
5. To create a modern online resource in order to generate an information file of the social and hygienic monitoring data with access to other departments for the purpose of a joint management of the information file and analytical processing.

References:

1. Risk analysis of a healthy lifestyle in the strategy of state socio-economic development: monograph / G.G. Onishchenko, N.V. Zaitseva, I.V. May [et al.]; under the general. ed. G.G. Onishchenko, N.V. Zaitseva. - M .; Perm: Publishing house Perm. nat. researched Polytechnic University, 2014 .-- 738 s
2. Zaitseva N.V., May I.V., Kir'yanov D.A., Goryaev D.V., Klein S.V. Current social-hygienic monitoring: present state and development outlook with respect to risk-based supervision. Health Risk Analysis [Analiz riska zdorov'yu], 2016, 4. Available at: http://journal.fcrisk.ru/sites/journal.fcrisk.ru/files/upload/article/197/health-risk-analysis-2016-4-1.pdf (in Russian)
3. Nechukhaeva EM, Maslov DV, Afanasyeva S.I. Actual tasks of socio-hygienic monitoring at the regional level // Health. Medical ecology. The science. - 2010. - T. 41–42, No. 1–2. - S. 39–40.
4. Fridman K.B., Novikova Yu.A., Ovchinnikova E.L. Tasks of socio-hygienic monitoring in the new legal conditions // Health is the basis of human potential: problems and solutions: proceedings of the XIII All-Russian Scientific and Practical Conference with international participation. St. Petersburg, 2018.V.13, part 2.P. 939-949
5. Chashchin V.P., Gudkov A.B., Popova O.N., Odland Yu.O., Kovshov A.A. Description of the main risk factors for health disorders of the population living in the territories of active nature management in the Arctic // Human Ecology. - 2014. - No. 1. - S. 3–12.
6. Popova A.Yu. Hygienic aspects of ensuring human health safety during the development and development of the Arctic zone of the Russian Federation // Problems of maintaining health and ensuring sanitary and epidemiological well-being of the population in the Arctic: materials of scientific and practical. conf. from the international participation. - SPb .: IPK "Costa", 2017. - S. 5–7.
7. Tovanova A.A., Meltzer A.V., Erastova N.V., Chashchin V.P., Bazilevskaya E.M. To the question of the formation of programs for socio-hygienic monitoring in terms of laboratory quality control of drinking water // Preventive medicine-2017: Materials of the All-Russian scientific and practical conference with international participation. - 2017 .-- S. 183-188.

DOI: 10.24411/2658-4255-2019-10063

ADULT INCIDENCE IN THE RUSSIAN EUROPEAN ARCTIC WITH DEVELOPED MINING AND METALLURGICAL INDUSTRY

A. N. Nikanov, V.M. Dorofeev, L.V. Talykova, N.V. Sturlis, I.V. Gushin
Kola Research Laboratory for Occupational Health, Kirovsk, Murmansk region, Russia
krl_s-znc@mail.ru

The purpose of the research. The research aims to assess the adult incidence within the mining complex in the Murmansk Region (the Russian Arctic). Materials and methods. The analysis of the adult incidence change in 1989-1990, 1999-2000, 2009-2010 and 2014-2015 was carried out. To assess the population health status, the incidence data was used in this work. The research covers the territory of the municipal formations with the city-forming mining and metallurgical complex (MMC) enterprises in the Murmansk Region. Main results and conclusions. It has been established that between 1989 and 2015 the adult incidence in the MMC territories, as well as in the Murmansk Region at large, clearly tends to increase (the coefficient of determination R2>0,7) for the following disease categories: neoplasms; endocrine diseases; diseases of the blood and blood-forming organs; diseases of the nervous system and sense organs; diseases of the circulatory system; diseases of the genitourinary system; diseases of the musculoskeletal system and connective tissue; congenital malformations. There is no doubt that a set of climatic, geographical and production factors, along with the pollution of the natural environment within the MMC territories in the Murmansk Region, has a negative impact on the health status of the adult population, including working individuals.

Key words: Arctic, adult incidence, mining and metallurgical industry

The Russian Arctic zone is an area with diverse environmental conditions that extends from its western border on the Kola Peninsula to Cape Dezhnev on the Chukchi Peninsula in the east of the country. The Russian European Arctic includes 5 federal subjects, of which the Murmansk Region is the most economically significant. Favorable geographical location and ice-free waters of the seaport provide the region's considerable advantages over the other northern regions of Russia. The region's economy is based on an industry with high export potential. The largest sources of critical mineral raw materials are located on the territory of the Kola Peninsula. An industrial complex supplying most of the country's requirements for phosphate ores, nickel, copper, cobalt, rare-earth metals, brazilite, nepheline and ceramic raw materials has been created here [2, 8].

More than 90% of the Murmansk Region's population resides in the towns that serve as sources of labor supply for the city-forming enterprises. The health status of the working-age population is characterized by the following medical demographic indicators: incidence, prevalence, disability and physical development. The incidence rates in the Murmansk Region are higher than in other regions of the Russian Federation. A significant increase of the working-age male mortality rate for the diseases that are conceivably connected with harmful industrial factors is also characteristic of this area [3, 5, 9, 12].

To assess the adult population health status in the Murmansk Region, the incidence data for the period between 1989 and 2015 was used. The research covers the territories of the municipal formations with the city-forming mining and metallurgical complex (MMC) enterprises in the region. The list of the municipal formations of this type includes the towns of Apatity and Kirovsk («Apatit» JSC), the town of Monchegorsk and Pechengsky District («Kola Mining and Metallurgical Company» JSC), Olenegorsk («Olenegorsk Ore Mining and Processing Enterprise» JSC), Kovdorsky District («Kovdor Ore Mining and Processing Enterprise») and Lovozersky District («Lovozero Ore Mining and Processing Enterprise» CJSC) [6].

Under the changing demographics, significant «qualitative» changes in the population's state of health are occurring in the Kola North. The results of many scientific teams' researches suggest that the primary factor impeding the health maintenance of the Far Northern population is the influence of the extreme climatic and geographical conditions in high latitudes which weaken the human organism making it more sensitive to social and economic collisions. The fact that the Murmansk Region is located north of the Polar circle determines certain physical and geographical factors creating difficulties in setting the population's working and living conditions that would correspond to the physiological conditions of the environment. A high meteorological activity adversely affects the functioning of all organs and systems of the human body; an unusual night-and-day periodicity causes a variety of physiological breakdowns; the peculiar geochemical soil and water composition can't fail to have impact on a human being as well. A high migration level results in a substantial proportion of the population's being in the process of acclimatizing and adapting, while the significant seasonal migration contributes to the spread of reacclimatization processes. Poor management of social and economic changes in the northern regions has considerably increased the incidence and mortality rates, primarily via the increasing amount of stress affecting the population. Chronic diseases arise among the non-indigenous Arctic inhabitants 8-10 years earlier than average; their

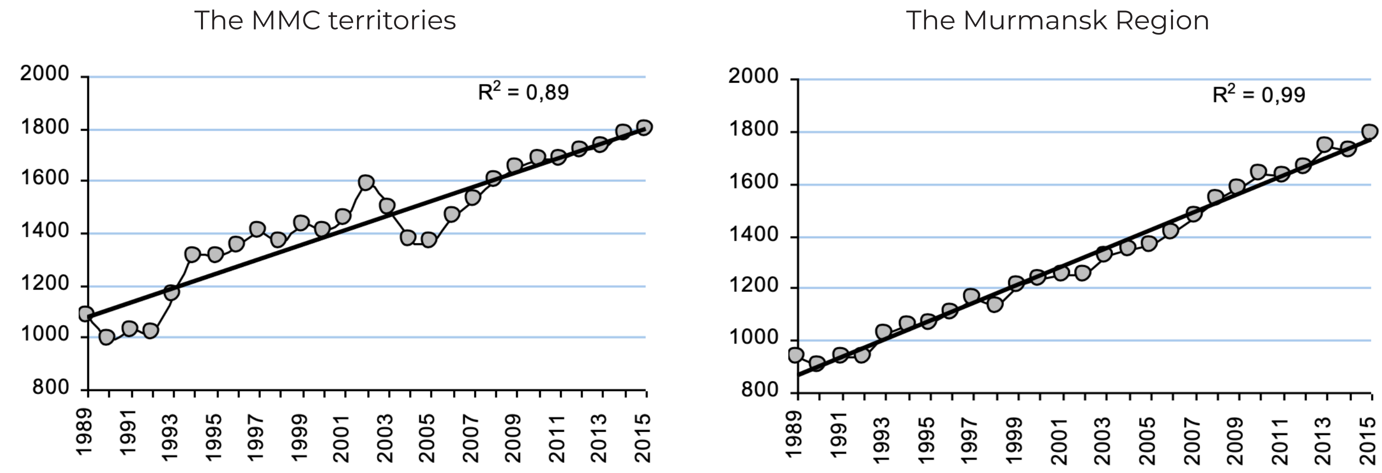


Figure 1. The adult incidence dynamics in the MMC territories and the Murmansk Region in 1989-2015.

life expectancy is reduced by 10-15 years; premature aging is observed. Furthermore, after having lived in the North for more than 15-20 years, the non-indigenous inhabitants obtain negative health characteristics that constrict the adaptability of their organisms and in some cases do not allow them to migrate back to more comfortable geographical zones unproblematically [1, 4, 7, 11, 12].

To characterize the disease incidence and spread rate among the population, the Federal statistical observation form No.12 «Report on the Number of Diseases Registered in Patients Living in the Service Area of the Medical Institution» was used.

It has been established that between 1989 and 2015 the adult incidence in the MMC territories, as well as in the Murmansk Region at large, clearly tends to increase (see Figure 1):

11 out of 14 disease categories reflect an incidence increase among the adult population in the MMC territories. Infectious and parasitic diseases reveal no changes in the incidence dynamics. For the categories «Mental and behavioral disorders» and «Diseases of the respiratory system» the adult incidence in the MMC territories for the period of 1989-2015 tends to decrease. Similar trends are observed in the Murmansk Region at large.

The adult incidence in the MMC territories has a clear tendency to increase during the period under consideration (the coefficient of determination R2>0,7) for the following disease categories: neoplasms; endocrine diseases; diseases of the blood and blood-forming organs; diseases of the nervous system and sense organs; diseases of the circulatory system; diseases of the genitourinary system; diseases of the musculoskeletal system and connective tissue; congenital malformations. Diseases of the skin and subcutaneous tissue show a moderate tendency to increase (0,3<R2>0,7). A minor increase tendency (R2<0,3) is characteristic of diseases of the digestive system, injuries and poisonings.

Among particular groups and nosological forms of diseases comparable for the period of 1989-2015, the adult incidence increase tendency in the MMC territories is shown by diabetes mellitus (R2=0,85), obesity (R2=0,51), anemias (R2=0,56), epilepsy (R2=0,90), hypertensive diseases (R2=0,92), ischemic heart diseases (R2=0,96), including angina pectoris (R2=0,87) and acute myocardial infarction (R2=0,63); cerebrovascular diseases (R2=0,89), asthma (R2=0,99), diseases of pancreas (R2=0,89) and urolithiasis (R2=0,61).

At the same time, a clear tendency to incidence decrease was registered for particular groups and

Table 1

The incidence dynamics among adults in the MMC territories and the Murmansk Region in 1989–2015.

Territories	1989-1990	1999-2000	2009-2010	2014-2015	The increase rate from 1989-90 to 2014-15
The Murmansk Region	923,1 + 0,2	1225,4 + 0,5	1608,7 + 1,1	1760,4 + 1,3	+90,7%
Apatity	834,3 + 1,1	1347,2 + 2,6	1892,4 + 5,3	1939,7 + 5,6	+2,3 раза
Kirovsk	1268,2 + 2,6	1466,0 + 4,2	1696,0 + 6,1	1831,8 + 7,2	+44,4%
Monchegorsk	1233,9 + 2,0	1698,5 + 4,3	1721,4 + 5,0	1754,1 + 5,3	+42,2%
Olenegorsk	1065,1 + 1,2	1288,3 + 3,1	1408,8 + 4,3	1640,5 + 6,0	+54,0%
Kovdorsky District	1129,0 + 2,0	1360,3 + 4,2	1721,5 + 7,6	1956,1 + 9,8	+73,3%
Lovozersky District	1305,3 + 4,7	1171,1 + 3,8	1892,5 + 11,6	2472,6 + 18,2	+89,4%
Pechengsky District	817,8 + 1,6	1335,0 + 3,1	1362,7 + 3,4	1419,7 + 4,0	+73,6%
Total in the MMC territories	1039,1 + 0,3	1420,6 + 1,4	1668,2 + 2,1	1792,6 + 2,5	+72,5%

nosological forms of diseases for the period of 1989-2015: chronic otitis (R2=0,89), chronic rheumatic heart diseases (R2=0,95), chronic bronchitis (R2=0,78).

Given the fluctuations of the incidence levels in particular years, the time-series smoothing method by means of consolidation of the time periods being compared was used to estimate the incidence increase rate. The analysis of the adult incidence dynamics for the periods of 1989-1990, 1999-2000, 2009-2010 and 2014-2015 was carried out.

It has been established that between 1989-1990 and 2014-2015 the adult incidence in the MMC territories increased by 72,5%. The greatest incidence increase was observed in the 10-year period from 1989-1990 to 1999-2000 (+37%). In the next 10 years (from 1999-2000 to 2009-2010) the incidence increased by 17%; in the period from 2009-2010 to 2014-2015 the increase was 7,5%. In most of the MMC territories, the highest incidence increase was also observed in the first decade, from 1989-1990 to 1999-2000. The exceptions were Kovdorsky and Lovozersky Districts where the highest increase was registered from 1999-2000 to 2009-2010. In the town of Kirovsk the common adult incidence increase had the same level during the first and the second decade of the time period under study. The general adult incidence increase rate in the Murmansk Region remained at approximately the same level during the first two decades of the time period considered: +32,7% from 1989-1990 to 1999-2000; +31,3% from 1999-2000 to 2009-2010. In the next 5 years, from 2009-2010 to 2014-2015, the increase amounted to +9,4% (see Table 1).

In most of the MMC territories, the incidence exceeds the average rates both in the Murmansk Region and in the Russian Federation at large. The only MMC territories with lower incidence levels in 2014-2015 were the town of Olenegorsk (the incidence was lower than the average rate in the Murmansk Region) and Pechengsky District (the incidence was lower than the average rates both in the Murmansk Region and in the Russian Federation).

The incidence of certain infectious and parasitic diseases was 18% higher than the average rate of these diseases in the Russian Federation, but 10% lower than their incidence in the Murmansk Region at large. The highest incidence in 2014-2015 was registered in Monchegorsk and Apatity; it exceeded the average incidence level in the MMC territories by 70% and 20%, respectively.

The incidence of neoplasms in the adult population of the MMC territories in 2014-2015 was 36% higher than the average rate in the Russian Federation and 20% lower than the average rate in the Murmansk Region. The significant difference between the incidence levels in the MMC territories and in the region at large is caused by a usual high incidence of neoplasms in Murmansk, which was 35% higher than the average rate in the region in 2014-2015 because of the established system of registration of malignant neoplasms in the Murmansk Region. The highest incidence levels of neoplasms soundly exceeding the average rate in the MMC territories were registered in Kovdorsky District (+29%), Lovozersky District (+28%), the towns of Monchegorsk (+22%) and Apatity (+17%).

The adult incidence of endocrine, nutritional and metabolic diseases in the MMC territories was 23% higher than the average rate in the Russian Federation, but 16% lower than the average rate in the Murmansk Region. The authentic exceeding of the average incidence levels in the MMC territories in 2014-2015 was registered in Lovozersky District (+56%), the towns of Olenegorsk (+17%) and Monchegorsk (+11%).

The incidence of thyrotoxicosis in the adult population of the MMC territories was 24% higher than the average rate in the Russian Federation, but 11% lower than the average rate in the Murmansk Region. In 2014-2015 the highest incidence levels of this disease were registered in Lovozersky District (52% higher than the average rate among the MMC territories), the towns of Monchegorsk (44% higher) and Kirovsk (24% higher).

The incidence of diabetes mellitus in the MMC territories in 2014-2015 was 8,5% higher than the average rate in the Russian Federation and 8% lower than in the Murmansk Region. The exceeding of the average Russian rate is achieved through a higher incidence of type 2 diabetes (11% higher), while the incidence rate of type 1 diabetes is 27% lower. The highest incidence of diabetes mellitus soundly exceeding the average rate in all the MMC territories was registered in the towns of Monchegorsk (+25%) and Olenegorsk (+13%), as well as in Lovozersky (+9%) and Kovdorsky (+9%) Districts.

The prevalence of obesity in the adult population of the MMC territories in 2014-2015 was 19% lower than the average rate in the Russian Federation and 20% lower than the average rate in the Murmansk Region. The exceeding of the average rate among particular MMC territories was observed in Apatity (+24%), Monchegorsk (+17%) and Kirovsk (+14%).

The adult incidence of diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism in the MMC territories in 2014-2015 was 44% higher than the average rate in the Russian Federation and authentically not dissimilar to the average rate in the Murmansk Region. More than 80% of diseases of this category are represented by anemias, which incidence in the MMC territories in 2014-2015 was 45% higher than in the Russian Federation and 11% higher than in the Murmansk Region. The adult prevalence rates of diseases of the blood exceeding the average rate in the MMC territories were registered in Kovdorsky (2,3 times higher) and Lovozersky (74% higher) Districts.

The incidence of diseases of the nervous system in the adult population of the MMC territories was 9,4% lower than the average rate in the Russian Federation, but 5% higher than the average rate in the Murmansk Region. The incidence level of diseases of the nervous system exceeded the average level in the MMC territories in 2014-2015 in Lovozersky (+54%) and Pechengsky (+46%) Districts, the town of Kirovsk (+19%) and Kovdorsky District (+15%). The exceeding of the average Russian adult incidence level of epilepsy and status epilepticus is notable in the MMC territories (2,1 times higher) and in the Murmansk Region at large (2,2 times higher).

The adult incidence of diseases of the eye and adnexa in the MMC territories in 2014-2015 was 59% higher than the average rate in the Russian Federation and 24% higher than in the Murmansk Region. The prevalence of myopia in the adult population of the MMC territories was 2,6 times higher than the average rate in the Russian Federation and 38% higher than in the Murmansk Region. The adult incidence of cataract in the MMC territories was 54% higher than the average rate in the Russian Federation and 38% higher than in the Murmansk Region. The highest levels of the common incidence of diseases of the eye were registered in Lovozersky District (2,0 times higher than the average level in the MMC territories), the towns of Apatity (+48%) and Kirovsk (+16%).

The incidence of diseases of the ear and mastoid process in the adult population of the MMC territories in 2014-2015 was 12,4% higher than the average rate in the Russian Federation and authentically not dissimilar to the average regional rate. The incidence level of diseases of this category exceeded the average level in the MMC territories in Apatity (+27%), Monchegorsk (+17%) and Kirovsk (+7%). At the same time, the adult prevalence of chronic otitis in the MMC territories was 21% lower than the average rate in the Russian Federation, but statistically not dissimilar to the average rate in the Murmansk Region..

The incidence of mental and behavioral disorders in the adult population of the MMC territories was 16% and 45% higher than the average rates in the Russian Federation and in the Murmansk Region, respectively. At that, the incidence rates of mental disorders exceeding the average level in the MMC territories were observed in Kovdorsky District (+57%), Monchegorsk (+43%), Olenegorsk (26%) and Kirovsk (+10%).

The adult incidence of diseases of the circulatory system in the MMC territories in 2014-2015 was 10% higher than the average rate in the Russian Federation and 4% higher than in the Murmansk Region. Among the particular nosological groups of diseases of the circulatory system, the common incidence rates of hypertensive diseases were 17% higher than the average levels in the Russian Federation and 11% higher than the average rate in the Murmansk Region. Ischemic heart diseases were registered among adult inhabitants of the MMC territories 4% more often than in the Russian Federation and in the Murmansk Region as a whole; at that the common incidence of acute myocardial infarction was 50% higher than the average rates in the Russian Federation and 24% higher than in the Murmansk Region, while the incidence of recurrent myocardial infarction was 7% higher than the average levels in Russia and 6% higher than the rates in the Murmansk Region. At the same time, the adult prevalence of angina pectoris in the MMC territories was 12% lower than in the Russian Federation, but 16% higher than in the Murmansk Region. The incidence of chronic rheumatic heart diseases in the MMC territories was 22% and 8% lower than the average rates in the Russian Federation and in the Murmansk Region, respectively; the incidence of cerebrovascular diseases was 13% lower than the average rate in Russia, but 9% higher than the average level in the Murmansk Region.

The average incidence level of diseases of the circulatory system in the MMC territories in 2014-2015 was exceeded in Lovozersky District (58% higher) and the town of Kirovsk (23% higher). The incidence of chronic rheumatic heart diseases in Lovozersky District was 86% higher than the average level in the MMC territories; in Olenegorsk it was 50% higher. Hypertensive diseases were most frequently registered in Lovozersky District (68% more often), the town of Kirovsk (24% more often) and Kovdorsky District (11% more often). Ischemic heart diseases (IHD) were observed more frequently than in the MMC territories on average in Kirovsk (+53%), Lovozersky District (+25%) and Apatity (+9%). Among IHD exceeding the average incidence level, the common incidence of angina pectoris was 2,2 times higher in Olenegorsk and 2,1 times higher in Lovozersky District; the incidence of acute myocardial infarction was higher in the towns of Monchegorsk (+31%), Apatity (26%) and Kirovsk (+13%); the incidence of recurrent myocardial infarction was 2,2 times higher in Apatity and 52% higher in Kirovsk. Cerebrovascular diseases were authentically most often registered among the adult population of Lovozersky District (38% more often than in the MMC territories on average), Kirovsk (25% more often), Monchegorsk (7% more often) and Olenegorsk (5% more often). The common incidence of endarteritis and thromboangiitis obliterans was higher than average in the following MMC territories: the town of Kirovsk (+35%), the town of Monchegorsk (+18%) and Kovdorsky District (+11%).

The adult incidence of diseases of the respiratory system in the MMC territories in 2014-2015 was 6% higher than the average rate in the Russian Federation and 16% higher than the average rate in the Murmansk Region. Among them, pneumonias were registered 9% more often than in the Russian Federation and 17% more often than in the Murmansk Region; asthma was recorded 66% more often than in Russia and 17% more often than in the Murmansk Region. At the same time, the prevalence of chronic diseases of tonsils and adenoids in the adult population of the MMC territories was 33% lower than in the Russian Federation, and authentically not dissimilar to the average rate in the Murmansk Region. The incidence of chronic bronchitis was 45% lower than the average rate in the Russian Federation and, again, authentically not dissimilar to the average regional rate.

Among the individual administrative MMC territories, the incidence levels soundly exceeding the average rate in the MMC territories in 2014-2015 were registered:

- in the category of diseases of the respiratory system in total – in the towns of Apatity (+11%), Monchegorsk (+8%) and in Lovozersky District (+5%);
- chronic diseases of tonsils and adenoids – in Monchegorsk (+70%) and Apatity (+15%);
- pneumonias – in Kovdorsky District (+75%), the towns of Monchegorsk (+17%) and Apatity (+9%);
- chronic bronchitis – in Lovozersky (+2,4 times) and Pechengsky (+2,0 times) Districts;
- asthma – in Monchegorsk (+81%);
- other chronic obstructive pulmonary disease and bronchiectasis – in the town of Monchegorsk (+80%), Lovozersky District (+39%) and the town of Apatity (+7%).

The incidence of diseases of the digestive system in the adult population of the MMC territories in 2014-2015 was authentically not dissimilar to the rate in the Russian Federation and 16% lower than the average rate in the Murmansk Region. Yet, the incidence levels of certain diseases from this category were higher in this area: gastritis and duodenitis (26% higher compared with the Russian Federation and 22% higher than in the Murmansk Region); peptic ulcer disease (37% higher than in the Russian Federation and 10% higher than in the region); noninfective enteritis and colitis (68% higher than the average rate in the Russian Federation and 6% higher than the average rate in the region); diseases of pancreas (31% higher than in Russia, but 12% lower than in the Murmansk Region). The incidence of diseases of liver in the MMC territories was 9% lower than in the Russian Federation, but 6% higher than the average rate in the Murmansk Region.

The exceeding of the average incidence level of diseases of the digestive system in the MMC territories in 2014-2015 was registered in Lovozersky (+29%) and Kovdorsky (+21%) Districts and in the town of Apatity (+17%). Among particular groups and nosological forms of diseases, the incidence in the MMC territories is authentically higher than the average rate for:

- gastritis and duodenitis – in Lovozersky District (+17%) and the town of Monchegorsk (+8%);
- peptic ulcer disease – in the town of Apatity (+33%) and Lovozersky District (+29%);
- noninfective enteritis and colitis – in the towns of Apatity (+2,1 times) and Kirovsk (+96%);
- diseases of liver – in the town of Apatity (+83%) and Lovozersky District (+57%);
- diseases of pancreas – in the town of Monchegorsk (+61%).

The incidence of diseases of the genitourinary system in the adult population of the MMC territories in 2014-2015 exceeded the average rate in the Russian Federation by 19%, but it was 18% lower than the average rate in the Murmansk Region. Renal glomerular and tubulointerstitial diseases were registered in the MMC territories 43% more often than among the adult population of the Russian Federation and 13% less often than in the Murmansk Region on average. Urolithiasis was recorded in the MMC territories 40% more often than in the Russian Federation, without any sound distinction from the average incidence rate in the Murmansk Region. The highest incidence levels soundly exceeding the average rate in the MMC territories were registered for the category of diseases of the genitourinary system as a whole: in Lovozersky (+96%) and Kovdorsky (+34%) Districts, and in the town of Olenegorsk (+38%); for renal glomerular and tubulointerstitial diseases: in Lovozersky (+71%) and Kovdorsky (+35%) Districts, and in the town of Olenegorsk (+13%), for urolithiasis: in Pechengsky District (+24%), Lovozersky District (+12%), the towns of Kirovsk (+20%) and Apatity (+9%).

The incidence of diseases of the skin and subcutaneous tissue in the adult population of the MMC territories in 2014-2015 was 27% higher than the average rate in the Russian Federation, but 11% lower than its rate in the Murmansk Region. The highest incidence levels of the diseases of this category soundly exceeding the average rate in the MMC territories were registered in Lovozersky (+59%) and Kovdorsky (+36%) Districts, and in the town of Monchegorsk (+28%).

The adult incidence of diseases of the musculoskeletal system and connective tissue in the MMC territories in 2014-2015 exceeded the average rate in the Russian Federation by 78% and in the Murmansk Region by 10%. The common incidence was authentically higher than the average rate in the MMC territories in the towns of Kirovsk (+16%), Apatity (+7%) and in Lovozersky District (+7%).

A high prevalence of injuries, poisonings and certain other consequences of external causes stands out among the adult population of the MMC territories: in 2014-2015 they were registered 17% more often than in the Russian Federation and 24% more often than in the Murmansk Region on average. Among the MMC territories, the exceeding of the average incidence level was recorded in Kovdorsky (+52%) and Lovozersky (+15%) Districts, and in the town of Apatity (+9%).

From 1989-1990 to 2014-2015 the incidence in the adult population of the MMC territories has increased by 73%. For most of the disease categories, the common incidence increase rates have the following values:

- neoplasms – +3,2 times
- endocrine, nutritional and metabolic diseases – +3,9 times;
- diseases of the blood and blood-forming organs – +3,2 times;
- diseases of the nervous system and sense organs – +2,0 times;
- diseases of the circulatory system – +3,3 times;
- diseases of the genitourinary system – +3,1 times;
- diseases of the skin and subcutaneous tissue – +2,9 times;
- diseases of the musculoskeletal system and connective tissue –+2,9 times.

The highest incidence increase in the adult population of the MMC territories is registered in the first decade of the time period under study, from 1989-1990 to 1999-2000. At that, the common incidence increase for most of the disease categories is also observed in the first 10 years. The incidence of certain infectious and parasitic diseases, which overall increase in the period from 1989 to 2015 was only 6%, also reached its maximum value from 1989-1990 to 1999-2000, and started to decrease afterwards. This fact confirms once again that it was the population of the Russian Arctic zone, and of the MMC territories in the first place, that has been especially severely affected by the abrupt negative social and economic changes of the 1990s. The exceptions were the diseases of the circulatory system and the diseases of the musculoskeletal system and connective tissue; these categories of diseases have been showing the incidence increase throughout the whole period under study, from 1989-1990 to 2014-2015.

In most of the MMC territories, the maximum increase of the adult incidence was also registered in the first decade of the time period under study. The town of Kirovsk was an exception; the incidence increase was more or less uniform there from 1989-1990 to 2014-2015. In Kovdorsky and Lovozersky Districts, the maximum incidence increase was observed in the second decade of the period under study, from 1999-2000 to 2009-2010. To certain extent, this is due to crisis changes at the city-forming enterprises in these territories.

An extremely negative tendency towards the incidence increase in the adult population of the MMC territories from 1989-1990 to 2014-2015 stands out for the following particular nosological forms of diseases compared over the period under study:

- diabetes mellitus – +2,5 times;
- obesity – + 3,1 times;
- epilepsy – + 5,6 times;
- hypertensive diseases – + 2,8 times;
- ischemic heart diseases – + 3,1 times;
- cerebrovascular diseases – + 5,8 times;
- asthma – + 6,8 times;
- urolithiasis – + 3,3 times;
- contact dermatitis and other forms of eczema – + 2,2 times.

The adult incidence in the MMC territories in 2014-2015 was 24% higher than the average rate in the Russian Federation. The common incidence in all the MMC territories under study was higher than the average Russian rate, with the exception of Pechengsky District. The rank distribution of the MMC territories by the adult incidence level in 2014-2015 confirms a strong dependence of incidence on the average age of population.

Thus, the adult incidence in the MMC territories in 1989-2015 clearly tends to increase. An incidence increase has been registered for 11 out of 14 disease categories. A strong increase tendency (the coefficient of determination R2>0,7) has been registered in the adult population of the MMC territories during the period under consideration for the following disease categories: neoplasms; endocrine diseases; diseases of the blood and blood-forming organs; diseases of the nervous system and sense organs; diseases of the circulatory system; diseases of the genitourinary system; diseases of the musculoskeletal system and connective tissue; congenital malformations. Among particular groups and nosological forms of diseases comparable for the period of 1989-2015, the adult incidence increase tendency in the MMC territories is shown by asthma (R2=0,99), ischemic heart diseases (R2=0,96), hypertensive diseases (R2=0,92), epilepsy (R2=0,90), cerebrovascular diseases (R2=0,89), diseases of pancreas (R2=0,89), diabetes mellitus (R2=0,85), urolithiasis (R2=0,61). There is no doubt that a set of climatic, geographical and production factors, along with the pollution of the natural environment within the MMC territories in the Murmansk Region, has a negative impact on the health status of the adult population, including working individuals.

References:

1. Bykov V. R., Talykova L. V., Mikhaleva V. S. Risk razvitiya bolezney sistemy krovoobrasheniya u rabotnikov otkrytogo rudnika Severo-Zapadnoj fosfornoj kompanii v usloviakh Arktiki [Risk of Circulatory Diseases Development among the Open-Pit Mine Workers in the North-Western Phosphorous Company in the Arctic]. Ekologiya cheloveka [Human Ecology]. 2017, 11, pp. 29-33. (In Russian)
2. Gorbanev S.A., Nikanov A.N., Chashchin V.P. Aktual'nye problemy mediciny truda v Arkticheskoj zone Rossijskoj Federacii [Actual problems of occupational medicine in the Arctic zone of the Russian Federation] Medicina truda i promyshlennaya ekologiya, 2017, no. 9, pp. 50–51. (In Russian)
3. Gorbanev S.A., Nikanov A.N., Talykova L. V., Dorofeev V. M., Lukicheva L. A. Osnovnye demograficheskie tendencii sredi naseleniya evropejskoj chasti Arkticheskoj zony Rossijskoj Federacii (na primere Murmanskoi oblasti) [Main demographic trends among the population of the European part of the Arctic zone of the Russian Federation (on the example of the Murmansk region)]. Materialy nauchno-practicheskoy konferencii s mezdunarodnym uchastiem "Problemy sokhraneniya zdorov`ya b obespecheniya sanitarno-epidemioligicheskogo blagopoluchiya naseleniya v Arctike" []. SPb., 2017. pp. 61–69. (In Russian)
4. Gribanov A.V., Anikina N.Yu., Gudkov A.B. Tserebral`nyy energoobmen kak marker adaptivnykh reaktsiy cheloveka v prirodno-klimaticheskikh usloviyakh Arkticheskoj zony Rossijskoj Federatsii [Cerebral Energy Exchange as a Marker of Adaptive Human Reactions in Natural Climatic Conditions of the Arctic Zone of the Russian Federation]. Ekologiya cheloveka [Human Ecology]. 2018, no. 8, pp. 32-40. (In Russian)
5. Dorofeev V. M. Osobennosti zabolevaemosti i medicodemographicheskikh processov, proikhodaycshikh na Kolskom Severe. Avtoref. kand. diss. [Features of morbidity and medico-demographic processes occurring in the Kola North. Author's abstract. of Cand. Diss.]. Saint Petersburg, 1996, 22 p.
6. Dorofeev V. M. Ispolzovanie dannih o zabolevaemosti po obrashaemosti dlya izuchenia zdoroviya naseleniya [of morbidity]. Voprosi organizacii i informatizacii zdravoohraneniya [Issues of organization and information]. 2008, no. 2, pp. 61–63.
7. Nikanov A.N., Talykova L.V., Karnachev I.P., Gushin I.V., Kolosova O.L. Ocenka sostoyaybya zdoroviya i professionalnoi zabolevaemosti u rabotnikov promishlennih predpriyatii Arkticheskoi zoni Rossii (na primere Murmanskoi oblasti) [Health condition and occupational morbidity у работников промышленных предприятий Арктической зоны России (на примере Мурманской области) // Здоровье и безопасность на рабочем месте: материалы II международной конференции. Минск, 2018. С. 166–171.Minsk. 2018. pp. 166–171. (In Russian)
8. Nikanov A. N., Chashchin V. P., Gudkov A. B., Dorofeev V. M., Sturlis N. V., Karnachev P. I. Medico-Demographic Indicators and Formation of Labor Potential in the Russian Arctic (in the Context of Murmansk Region). Ekologiya cheloveka [Human Ecology]. 2018, no. 1, pp. 15-19. (In Russian)
9. Popova A.Yu. Sostoyanie uslovii truda i professionalnaya zabolevaemost v Rossijskoj Federacii [State of working conditions and occupational morbidity in Russian

Federation] Medicina truda i ekologiya cheloveka, 2015, no. 3. pp. 7–13.
10. Talykova L.V., Nikanov A.N., Bykov V.R. Demographic situation and professional risk of workers of mining industry of the Arctic Zone of the Russian Federation. Vestn. Ural. Med. Akad. Nauki. (Journal of Ural Medical Academic Science). 2019, Vol. 16, no. 2, pp. 245–252. (In Russian)
11. Chashhin V.P., Gudkov A.B., Popova O.N., Odland Ju.O., Kovshov A.A. Characteristics of the main risk factors for health disorders of the population living in the territories of active nature management in the Arctic [Harakteristika osnovnyh faktorov riska narushenij zdorov'ja naselenija, prozhivajushhego na territorijah aktivnogo prirodopol'zovanija v Arktike]. Human Ecology [Jekologija cheloveka]. 2014, no. 1, pp. 3–12. (In Russian)
12. Nieminen P., Panychev D., Lyalyushkin S., Komarov G., Nikanov A., Borisenko M., Kinnula V. L., Toljamo T. Environmental exposure as an independent risk factor of chronic bronchitis in northwest Russia. International Journal of Circumpolar Health, 2013, Vol. 72, no. 1, P. 19742.

DOI: 10.24411/2658-4255-2019-10064

INDUSTRIAL VIBRATION AND VIBRATION-RELATED PATHOLOGY IN THE ARCTIC FACILITIES

S.A. Syurin, S.A. Gorbanev
Northwest Public Health Research Center, St.Petersburg, Russia
s-znc@mail.ru; kola.reslab@mail.ru

Introduction. Industrial vibration is a common harmful effect, ranking third among physical factors after noise and adverse lighting conditions. The purpose of the study was to investigate the nature of industrial vibration and its influence on formation of occupational pathology among workers at enterprises in the Arctic. Materials and methods. The data of social and hygienic monitoring “Working conditions and occupational morbidity” of the population of the Arctic zone of Russia in 2007-2017 were studied. Research results. It was found out that vibration occupies 7.13% in the structure of harmful production factors, and its impact causes development of 29.9% of occupational diseases. General vibration, as compared to local vibration, causes development of vibration disease (87.8% and 61.9%, p<0.001) and radiculopathy (4.7% and 0.9%, P<0.01), and less frequently - mono-polineuropathy (6.0% and 22.0%) and vegetative-sensory polyneuropathy (0.4% and 14.4%, P<0.001). In 2007-2017, Arctic enterprises registered an excess incidence (from 2.55 to 3.80 per 10,000 workers) and vibration-related pathology risk (RR=1.49; CI 1.21-1.84), while in Russia as a whole there was a decrease in the incidence rate. In 99.3% of cases, exposure to vibration was a consequence of imperfection of technological processes and workplaces, structural defects of machines and equipment. Conclusions. In order to reduce the vibration-related pathology risk at the Arctic enterprises, it is necessary to reduce the vibration level, first of all, by improvement of technological processes and structural improvements of vibration-hazardous equipment.

Keywords: Industrial vibration, occupational vibration-related pathology, the Arctic.

Introduction. In modern conditions, industrial vibration is one of the most common harmful production factors [1].

In 2014-2017, within the structure of harmful physical factors of the work process, industrial vibration at the Russian enterprises ranked third in terms of prevalence (after noise and adverse conditions of workplace illumination) and second in terms of frequency of occupational diseases (after noise) [2, 3]. Hygienic standardization of industrial vibration is based on the criteria of human health under the influence of vibration. The maximum permissible level of vibration is a level which, during daily work (except for weekends), but not more than 40 hours a week during the whole working experience, should not cause diseases or deviations in the health condition, which are detected by modern methods of research in the process of work or in the distant terms of life of present and future generations [4].

Under the influence of industrial vibration, exceeding the permissible levels, numerous functional and morphological changes of musculo-skeletal, nervous, cardiovascular, endocrine and other systems occur in the human body [5, 6, 7]. In Russia, the complex of the above mentioned pathological changes among workers of vibration-hazardous professions is defined as a vibration disease - a term that is absent in most national classifications and the current International Statistical Classification of Diseases and Related Health Problems, 10th Revision.

The industrial vibration action is aggravated by simultaneous influence of such concomitant occupational hazards as general and local cooling, a forced working posture, increased static-dynamic load on muscles and joints, noise and some others [8, 9]. It has been proven that industrial activities in the extreme Arctic climate, especially chronic cold stress, form additional threat to the working population health through increased exposure to harmful factors of production, including industrial vibration [10, 11, 12]. It should be understood that the largest mining and processing enterprises are located in the Arctic, the workers of which are most frequently and intensively exposed to the industrial vibration effects [13, 14, 15]. Considering dramatically limited labour resources of the Arctic region, improvement of working conditions and preservation of health of the working population is a priority and long-term political task for the state in the Arctic region [16, 17].

The purpose of the study was to investigate the nature of industrial vibration and its influence on formation of occupational pathology among workers at Russian Arctic enterprises.

Materials and methods. The results of the social and hygienic monitoring upon section “Working conditions and occupational morbidity” of the population of the Arctic zone of Russia in 2007-2017 have been analysed (Federal Hygiene and Epidemiology Centre of the Federal Service for Supervision of Consumer Protection and Welfare, Federal State-Funded Healthcare Institution, Moscow). Statistical data processing was carried out using Microsoft Excel 2010 software and Epi Info, v. 6.04d. The Student’s t-test for independent samples, approval criterion, relative risk (RR) and 95% confidence interval (CI) were determined. The numbers are given as an arithmetic mean and a standard error (M ± m). The null hypothesis significance level was assumed 0.05.

Results of the study. In 2007-2017, the number of workers exposed to industrial vibration at the enterprises of the Russian Arctic zone ranged from 5.85% to 8.04% of the number of persons who had contact with the harmful production factors. The average annual value of this figure was 7.13%, less prevailing than such harmful production factors as noise (21.5%), intensity (8.6%) and severity (8.2%) of the labour process, non-ionizing electromagnetic fields and radiation (7.3%), chemical factors (7.2%). As in previous years, the highest degree of exposure to industrial vibration was observed among workers of mining enterprises and iron and steel works [18, 19, 20].

In view of significant differences in health disorders arising from exposure to general and local vibration [5, 21, 22], their proportion in the structure of the harmful production factors by years and types of economic activity was evaluated separately. It is established that in 2007-2017 in the Arctic region, within the structure of all harmful production factors, the proportion of total vibration was 4.55%-6.34%. Amongst the exposed to general vibration, there were 94.3% men and 5.7% women. The highest absolute number of employees was exposed to total vibration in 2007, and the lowest in 2010. The relative number of employees exposed to total vibration (taking into account the number of employees exposed to all harmful production factors) was maximum in 2017 and 2012 (6.34% and 6.17%). It is important to note that in 2017 this indicator was higher than in 2007. The impact of general vibration was most often observed among those employed in transport, mining enterprises and iron and steel works in the region. The trend of the number of workers exposed to general vibration in 2007-2017 was various. Thus, it decreased significantly in the mining industry, but increased in metallurgy, processing industry and construction. In view of the changes of absolute and relative indicators, there is reason to believe that there is no significant dynamics of the general vibration impact on employees of the enterprises in the Arctic for the analysed eleven-year period (table 1).

Table 1

Number of employees of enterprises of various types of economic activities who were exposed to general vibration

Types of economic activities	Year					Average annual figures
	2007	2010	2012	2014	2017	
Transport	7365	5404	8345	5251	6711	6615.2 (28.1%)
Extraction of mineral resources	8448	4734	7791	4284	4664	5984.2 (25.5%)
Steelmaking industry	3495	3220	3214	4738	4977	3928.8 (16.7%)
Processing industry	1344	1116	1446	3118	3471	2099.0 (8.9%)
Electric power, water and steam production and distribution	2808	1930	1240	1785	1963	1945.2 (8.3%)
Construction	937	1551	1260	2219	2146	1622.6 (6.9%)
Healthcare Service	221	177	368	306	125	239.4 (1.0%)
Agriculture	196	174	204	164	192	186.0 (0.8%)
Other types of activities	1291	444	404	1047	504	738.0 (3.1%)
All types of economic activity (totally)	26878	18750	24272	22913	24753	23513.2 (100.0%)
Total vibration / all harmful production factors, %	5.36	4.55	6.17	5.52	6.34	5.59

The proportion of local vibration in the structure of all harmful production factors was 1.30%-1.86%, which is 3-4 times less than total vibration. The most frequent exposure to local vibration was observed among workers of mining companies, and less often among employees of transport enterprises and iron and steel works of the region. Amongst the exposed to local vibration, there were 90.7% men and 9.3% women. The dynamics of workers' exposure to local and general vibration had similar features. Thus, the highest absolute number of employees was exposed to local vibration in 2007, and the lowest in 2010. The relative number of employees exposed to local vibration was the highest in 2007 and it exceeded the 2017 figure.

It is important to note that in 2007-2017 there was a decrease in the number of workers exposed to local vibration at mining and transport enterprises. In view of the levels of absolute and relative indicators in 2007 and 2017, we can talk about a decrease in the local vibration impact on the employees of the Arctic region for the analysed period (tab. 2).

Table 2
Number of employees of enterprises of various types of economic activities who were exposed to local vibration

Types of economic activities	Year					Average annual figures
	2007	2010	2012	2014	2017	
Transport	1883	710	1947	855	817	1242.4 (18.9%)
Extraction of mineral resources	4064	1272	871	801	1184	1638.4 (24.9%)
Steelmaking industry	1138	1013	882	1169	1763	1193.0 (18.1%)
Processing industry	521	423	453	996	1134	705.4 (10.7%)
Electric power, water and steam production and distribution	322	274	166	350	351	292.6 (4.4%)
Construction	680	595	634	796	672	675.4 (10.3%)
Healthcare Service	485	688	565	509	441	537.6 (8.2%)
Agriculture	17	21	38	64	63	40.6 (0.6%)
Other types of activities	229	378	127	342	199	255.0 (3.9%)
All types of economic activity (totally)	9339	5374	5683	5882	6624	6580.4 (100.0%)
Local vibration / all harmful production factors, %	1.86	1.30	1.44	1.42	1.70	1.54

In 2007-2017, for the first time, 2,372 employees of enterprises in the Arctic were diagnosed with occupational diseases caused by exposure to industrial vibration. Employees of the enterprises of the Arctic zone of Krasnoyarsk Krai (1196 people or 50.4%), Murmansk Oblast (614 people or 25.9%) and the Komi Republic (460 people or 19.4%) were among the diseased. In the rest of the Arctic region there were only isolated cases of vibration-related pathology: in the Chukotka Autonomous Okrug and the Yamalo-Nenets Autonomous Okrug - 42 (1.8%) and 17 (0.7%) respectively, in the Arctic zone of the Arkhangelsk region - 28 (1.2%), in the Arctic zone of the Karelian Republic and the Sakha Republic - 8 (0.3%) and 7 (0.3%) patients respectively. In the Nenets Autonomous Okrug, no cases of occupational diseases caused by vibration were registered in the period of 2007-2017.

Vibration-related pathology was diagnosed in the vast majority of cases (93.8%) in mining (1125 people), iron and steel (677 people) and construction (422 people) enterprises. Vibration-related pathology from the general vibration impact most often occurred among drivers of various mining equipment (425 people), drillers (217 people), drivers of mine dump trucks and other vehicles (201 people). The group of professions with the highest risk of vibration pathology due to local vibration consists of shaftmen (486 people), machine operators of various mining equipment (290 people) and stope miners (223 people).

Among the diseased, there were 2355 (99.3%) men and 27 (0.7%) women, the average age of whom was 51.1±0.1 years old, and the work experience of whom was 24.2±0.1 years. The age and work experience of the diseased workers exposed to local vibration were less than that of those exposed to general vibration. In the work experience range of 11-20 years, the vibration-related pathology developed more often due to the local vibration impact, and when work experience exceeded 30 years, the reason was general vibration.

In the structure of vibration-related pathology vibration disease occupied 73.4%, and among all professional diseases - 22.0%. Indicators of the vibration disease prevalence in the Arctic region did not differ significantly from those in the Murmansk region (12.55%-28.1%), exceeded their level in the Samara region (7.0%-18.9%), but was lower than in the Irkutsk region (21.1%-35.9%) [23, 24, 25]. It is hard to compare with the similar indicators of other countries, because terms “white finger syndrome”, “hand-arm vibration”, “low back pain”, which are widely used abroad, are not identical to the Russian term “vibration disease due to local or general vibration impact” [26, 27, 28]. Development of nervous system diseases (23.3%) and musculoskeletal system diseases (3.3%) was related to the vibration impact less frequently. No circulatory diseases, which are a distinctive manifestation of vibration disorders, were revealed [6, 29].

The nature of health disorders under the influence of general and local vibration had significant differences. Thus, health disorders related to the category of diseases “Injuries, intoxication and other consequences of external causes” more often arose at exposure to general vibration, and diseases of musculoskeletal and nervous systems - on exposure to local vibration. Persons, exposed to general vibration, most often had vibration disease ($p<0.001$) and radiculopathy ($p<0.001$). When exposed to local vibration in the structure of vibration-related pathology, mono-polineuropathy and vegetative-sensory polyneuropathy dominated ($p<0.001$) (Table 3). The occupational pathology risk due to the influence of local vibration was higher than the general risk: RR=3.91; CI 3.62-4.23; $\chi2=1369.4$;

p<0.001. According to the results of periodic medical examinations, 1348 (56.8%) patients with vibration-related pathology were revealed. In 1024 (43.2%) cases, the diagnosis was established when workers consulted a doctor on their own due to deterioration of health.

Table 3

General characteristics of patients and number of occupational diseases of vibration etiology under influence of general and local vibration (cases)

Indicator	Industrial vibration		
	General	Local	All cases
Sex: men women	 1040 (99.0%) 10 (1.0%)	 1315 (99.5%) 7 (0.5%)	 2355 (99,3%) 17 (0,7%)
Age (y.o.) Work experience (years), including ≤ 10 years 11– 20 years 21– 30 years ≥ 30 years	52,1±0,1 25,3±0,2 8 (0,8%) 242 (23,1%) 558 (53,1%) 241 (23,0%)	50,3±0,2* 23,3±0,2* 19 (1,4%) 410 (31,0%)* 743 (56,3%) 150 (11,3%)*	51,1±0,1 24,2±0,1 27 (1,1%) 653 (27,5%) 1301 (54,8%) 391 (16,5%)
Categories of diseases:			
injuries, intoxication and some other con-sequences of external causes	922 (87,8%)	818 (61,9%)*	1740 (73,4%)
musculoskeletal disorders	58 (5,5%)	21 (1,6%)*	79 (3,3%)
nervous disorders	70 (6,7%)	483 (36,5%)*	553 (23,3%)
Nosological entities:			
vibration disease	922 (87,8%)	818 (61,9%)*	1740 (73,4%)
mono-polyneuropathy	63 (6,0%)	291 (22,0%)*	354 (14,9%)
vegetative-sensory polyneuropathy	4 (0,4%)	190 (14,4%)*	194 (8,2%)
radiculopathy	49 (4,7%)	12 (0,9%)*	61 (2,6%)
arthrosis, periarthrosis, osteoarthritis de-formans	7 (0,7%)	4 (0,3%)	11 (0,5%)
arm polyneuritis (polyneuropathy)	3 (0,3%)	3 (0,2%)	6 (0,3%)
internal epicondylitis	2 (0,2%)	1 (0,07%)	3 (0,1%)
forearm myofibrosis	-	2 (0,2%)	2 (0,08%)
degenerative disk disorder	-	1 (0,07%)	1 (0,04%)

Note * statistically significant differences of indicators ($p<0.05$) on exposure to general and local vibration

Under the harmful working conditions of classes 3.1-3.2), vibration-related pathology was more often caused by general vibration, and under the hazardous working conditions (classes 3.3-3.4) the most common reason for development of occupational pathology was local vibration. The revealed rare cases of vibration-related pathology development at permissible levels of industrial vibration (0.7%) call for individual hypersensitivity, which may have both congenital and evoked (vascular diseases, consequences of cold injury, etc.) character [5, 6]. Almost in all cases (99.3%) the exposure to unacceptable levels of industrial vibration at the enterprises in the Arctic was a consequence of imperfection of technological processes, structural defects of machines and other equipment, as well as imperfection of workplaces. Unacceptable levels of general vibration were more often conditioned by imperfection of technological processes and workplaces, and by local structural defects of machines, mechanisms, equipment, devices and tools. Only in one case the development of vibration pathology was related to the so-called "human factor" (violation of the established work and rest schedule), which emphasizes importance of technological retrofit of the industry in the Arctic region (Table 4).

Table 4

Number of occupational diseases of vibration etiology in different classes of working conditions and circumstances of their development (cases)

Indicator	Industrial vibration		
	General	Local	All cases
Class of working conditions:			
Class 2	6 (0,6%)	11 (0,8%)	17 (0,7%)
class 3.1	286 (27,2%)	160(12,1%)*	446 (18,8%)
class 3.2	637(60,7%)	362(27,4%)*	999 (42,1%)
class 3.3	110(10,5%)	438(33,1%)*	548 (23,1%)
class 3.4	8 (0,8%)	254(19,2%)*	262 (11,0%)
class 4	3 (0,3%)	97 (7,3%)*	100 (4,2%)
Circumstances of occupational pathology development			
technological process imperfection	669(63,7%)	643 (48,6%)*	1312 (55,3%)
design defects of machinery, mechanisms, equipment, devices and tools	243(23,1%)	612 (46,3%)*	855 (36,0%)
imperfection of workplaces	132(12,6%)	57 (4,3%)*	189 (8,0%)
malfunctioning of machinery, mechanisms, equipment, devices and tools	3 (0,3%)	9 (0,7%)	12 (0,5%)
imperfection of technical medical equipment	3 (0,3%)	-	3 (0,1%)
violation of the established work and rest schedule	1 (0,1%)	-	1 (0,04%)

*Note * statistically significant differences of indicators ($p<0.05$) on exposure to general and local vibration.*

In 2007-2017, there was an increase in the number of cases and morbidity of occupational pathology of vibrational genesis at Arctic enterprises, while nationwide we have observed their decrease recently [2, 3]. The number of newly detected cases varied from 154 (2007) to 329 (2015). The proportion of vibrational pathology in the total structure of occupational diseases was in the range from 24.4% (2013) to 38.0% (2015), making an average of 29.9% and having a rising trend. From 2007 to 2017, the proportion of vibration disease in the structure of vibration pathology increased from 48.1% to 95.1% (an exponentially rising trend).

In 2017, as compared to 2007, there was a negative trend due to an increase in the number of cases of vibration-related pathology (by 1.33 times), an increase in its incidence (from 2.55 to 3.80 per 10,000 employees) and a higher risk of development (OP=1.49; CI 1.21-1.84; $\chi2=14.2$; $p=0.00016$). It is also necessary to note a steep increase in the prevalence of vibration disease - a nosological form of vibration-related pathology with the most unfavourable clinical prediction. Changes in the number of all newly detected nosological forms of occupational pathology differed from the vibration-related pathology dynamics by the fact that in the first case, in 2010-2013, there was an increase in morbidity rate, and in the second case we observed its stabilization (Fig.).

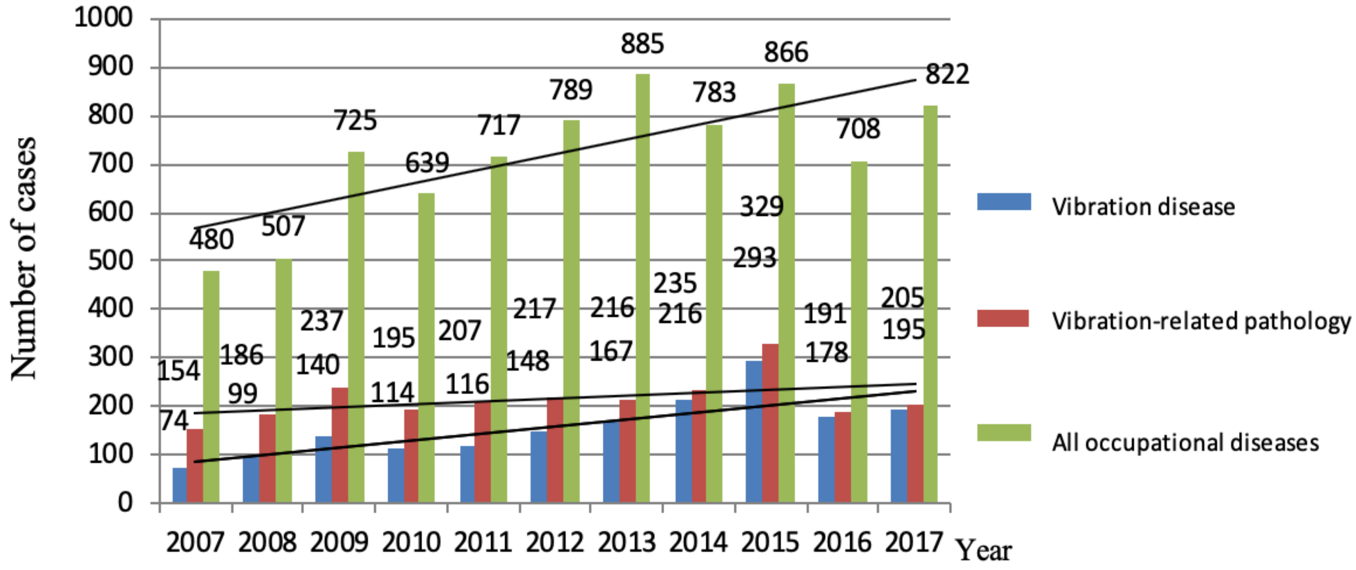


Figure. The number of newly diagnosed vibration diseases, vibration-related pathology and all occupational diseases in the Arctic in 2007-2017.

As a result of these studies, no cause-and-effect relations were established between changes in working conditions and frequency of detection of incipient cases of vibration-related pathology. Their growth and reduction occurred regardless of the dynamics of workers' exposure to general and local vibration. Difficulty of detection of such relations is known both because of a time lag between the two phenomena, and simultaneous action of many other factors, including therapeutic and preventive measures, quality of medical examinations, work motivation, administrative resources of employers to control the indicators of occupational diseases and others [30]. At the moment, we can particularly note that the eleven-year observation period is not sufficient to establish a cause-and-effect relation between changes in working conditions and levels of occupational diseases. By no means has this fact downplayed the importance of production measures to reduce the level of industrial vibration and improve anti-vibration personal protective equipment.

Conclusion: Almost 30% of the occupational diseases in the Arctic are caused by the industrial vibration impact. Over the past eleven years, their number, morbidity rates and risk of incidence have tended to grow. To prevent vibration-related pathology, it is necessaryto improve vibration-hazardous equipment and technological processes, as well as to introduce effective anti-vibration personal protective equipment.

References:

1. Gigiena truda: uchebnik / pod red. N. F. Izmerova, V. F. Kirillova [Occupational health: a textbook / ed. N.F. Izmerov, V.F. Kirillov]. M.: GEOTAR-Media, 2016. (In Russian).
2. O sostoyanii sanitarno-epidemiologicheskogo blagopoluchiya naseleniya v Rossijskoj Federacii v 2016 godu: Gosudarstvennyj doklad. Federal'naya sluzhba po nadzoru v sfere zashchity prav potrebitelej i blagopoluchiya cheloveka [On the state of sanitary and epidemiological welfare of the population in the Russian Federation in 2016: State report. Federal Service for Supervision of Consumer Rights Protection and Human Welfare]. M.: 2017. (In Russian).
3. O sostoyanii sanitarno-epidemiologicheskogo blagopoluchiya naseleniya v Rossijskoj Federacii v 2017 godu: Gosudarstvennyj doklad. Federal'naya sluzhba po nadzoru v sfere zashchity prav potrebitelej i blagopoluchiya cheloveka [On the state of sanitary and epidemiological welfare of the population in the Russian Federation in 2017: State report. Federal Service for Supervision of Consumer Rights Protection and Human Welfare]. M.: 2018. (In Russian).
4. Sanitarnye normy i pravila 2.2.4.3359-16 «Sanitarno-epidemiologicheskie trebovaniya k fizicheskim faktoram narabochih mestah» ot 21 iyunya 2016 goda № 81[Sanitary norms and rules 2.2.4.3359-16 "Sanitary-epidemiological requirements for physical factors at workplaces" of June 21, 2016, No. 81]. (In Russian).
5. Vibracionnaya bolezn' / Babanov S.A., Azovskova T.A., Vakurova N.V. Vuzovskij uchebnik [Vibration disease / Babanov SA, Azovskova T.A., Vakurova N.V. University textbook]. M.: NIC INFRA, 2016. (In Russian).
6. Vakurova N.V. ,Azovskova T.A., Lavrent'eva N.E. O sovremennyh aspektah diagnostiki i klassifikacii vibracionnoj bolezni [On the modern aspects of diagnosis and classification of vibration disease]. Regulyarnyevypuski «RMZh». 2014. № 16. Available at: https://www.rmj.ru/articles/nevrologiya (датаобращения: 08.06.2019). (In Russian).
7. Vibracionnaya bolezn' i mery po ee preduprezhdeniyu: Uchebnoe posobie [Vibration disease and measures to prevent it: Tutorial] / E.R. Shajhlislamova, A.B. Bakirov, G.G. Gimranova i dr. - Ufa: Izd-vo, 2016. (In Russian).
8. Profilaktika professional'nyh zabolevanij, vyzvannyh sochetannym vozdejstviem vibracii, shuma i ohlazhdayushchego mikroklimata na predpriyatiyah gornodobyvayushchej promyshlennosti: Metodicheskie rekomendacii [Prevention of occupational diseases caused by the combined effect of vibration, noise and a cooling microclimate at mining enterprises: Guidelines]. M, 1991.(In Russian).
9. Burström L., Nilsson T.,Walström J. Combined exposure to vibration and cold. Barents Newsletters on Occupational Health and Safety. 2015. Vol. 18. № 1. P. 17-18.
10. Myshinskaya Zh.M. Vliyanie klimaticheskih i ekologicheskih faktorov na zdorov'e cheloveka v usloviyah Krajnego Severa [The influence of climatic and environmental factors on human health in the Far North]. Yamal'skij vestnik. 2016. Vol. 2. № 7. P. 79-80. (In Russian).
11. Hasnulin V. I., Hasnulin P. V. Sovremennye predstavleniya o mekhanizmah formirovaniya severnogo stressa u cheloveka v vysokih shirotah [Modern ideas about the mechanisms of formation of northern stress in humans in high latitudes]. Ekologiya cheloveka. 2012. № 1. P.4-11. (In Russian).
12. Gorbanev S.A., Nikanov N.A., Chashchin V.P. Aktual'nye problem mediciny truda v Arkticheskoj zone Rossijskoj

Federacii [Actual problems of occupational medicine in the Arctic zone of the Russian Federation]. Medicina truda i promyshlennaya ekologiya. 2017. № 9. P. 50–51. (In Russian).
13. Buhtiyarov I.V., Golovkova N.P., Chebotarev A.G., Sal'nikov A.A., Nikolaev S.P. Usloviya truda, professional'naya zabolevaemost' na predpriyatiyah otkrytoj dobychi rud [Working conditions, occupational morbidity in open-pit mining enterprises]. Medicina truda i promyshlennaya ekologiya. 2017. № 5. P.44-49. (In Russian).
14. Preobrazhenskaya E.A., Suhova A.V., Zor'kina L.A., Bondareva M.V. Gigienicheskaya ocenka uslovij truda i sostoyanie zdorov'ya rabotnikov gorno-obogatitel'nyh kombinatov [Hygienic assessment of working conditions and health status of workers of mining and processing plants]. Gigiena i sanitariya. 2016. Vol. 95. № 11. P. 1065-1070. DOI: http://dx.doi.org/10.18821/0016-9900-2016-95-11-1065-1070. (In Russian).
15. Syurin S.A., Shilov V.V. Osobennosti vibracionnoj bolezni gornyakov pri sovremennyh tekhnologiyah dobychi rudnogo syr'ya v Kol'skom Zapolyar'e [Features of the vibration disease of the miners with the modern technologies of mining of ore raw materials in the Kola Polar Region]. Zdravoohranenie Rossijskoj Federacii. 2016. № 6. P. 312-316. (In Russian).
16. Rudenko D.YU. Analiz demograficheskih processov v Rossijskoj Arktike [Analysis of demographic processes in the Russian Arctic].MIR (Modernizaciya. Innovacii. Razvitie). 2015. Vol. 6. № 4. P. 51-57. (In Russian).
17. «Ob osnovah gosudarstvennoj politiki RF v Arktike na period do 2020 goda I dal'nejshuyu perspektivu» ["On the fundamentals of the state policy of the Russian Federation in the Arctic for the period up to 2020 and beyond"]. Rossijskaya gazeta. № 4877 (Oct.,18, 2080). (In Russian).
18. Skripal' B.A. Professional'naya zabolevaemost', ee osobennosti na predpriyatiyah gorno-himicheskogo kompleksa Kol'skogo Zapolyar'ya [Occupational morbidity, its features in the enterprises of the mining and chemical complex of the Kola Arctic]. Ekologiya cheloveka. 2008. № 10. P. 26-30. (In Russian).
19. Skripal' B.A. Sostoyanie zdorov'ya I zabolevaemost' rabochih podzemnyh rudnikov gorno-himicheskogo kompleksa Arkticheskoj zony Rossijskoj Federacii [The health status and morbidity of workers in underground mines of the mining and chemical complex of the Arctic zone of the Russian Federation]. Medicina truda I promyshlennaya ekologiya. 2016. № 6. P. 23-26. (In Russian).
20. Syurin S.A., Gorbanev S.A. Osobennosti formirovaniya narushenij zdorov'ya u gornyakov podzemnyh rudnikov Kol'skogo Zapolyar'ya [Features of the formation of health disorders in the miners of the underground mines of the Kola polar region]. Profilakticheskaya i klinicheskaya medicina. 2017. № 4. P. 12-18. (In Russian).
21. Shen S., House R.A. Hand-arm vibration syndrome. What family physicians should know //Canadian Family Physician. 2017. Vol. 63. № 3.P. 206–210.
22. Burström L., Hyvärinen V., Johnsen M., PetterssonH. Exposure to whole-body vibration in open-cast mines in the Barents region. International Journal of Circumpolar Health. 2016. Vol. 75. № 10. 3402/ijch.v75.29373. doi: 10.3402/ijch.v75.29373. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4749864/ (accessed June 6, 2019).
23. Rocheva I. I., Zhelepova O. V., Leshtaeva N. R., Mihajlov S. S. Vibracionnaya bolezn' u gornorabochih Murmanskoj oblasti [Vibration disease in miners of the Murmansk region]. Medicina truda i promyshlennaya ekologiya. 2004. № 2. P. 44–47. (In Russian).
24. Popov M.N., T.A. Azovskova T.A., Vasyukova G.F. Vyyavlenie i profilaktika naibolee rasprostranennyh professional'nyh zabolevanij v Samarskoj oblasti [Identification and prevention of the most common occupational diseases in the Samara region]. Izvestiya Samarskogo nauchnogo centra Rossijskoj akademii nauk. 2015. Vol. 17. № 2. P. 362-366. (In Russian).
25. Kuleshova M.V., Pankov V.A., D'yakovich M.P. Vibracionnaya bolezn' u rabotnikov aviastroitel'nogo predpriyatiya: factory formirovaniya, klinicheskie proyavleniya, social'no-psihologicheskie osobennosti [Vibration disease in aircraft building workers: factors of formation, clinical manifestations, socio-psychological features]. Gigiena i sanitariya. 2018. Vol. 97. № 10. P. 915-920. DOI: http://dx.doi.org/10.18821/0016-9900-2018-97-10-915-920.
26. Kurtul S., Türk M. Vibration related white finger disease: a case report. The European Research Journal. 2019. Vol. 5. № 1.P. 226-229. DOI: 10.18621/eurj.379091. Available at: https://dergipark.org.tr/download/article-file/480116 (accessed June 6, 2019).
27. Campbell R. A., Matthew B.A., Janko R., Hacker R.I. Hand-arm vibration syndrome: A rarely seen diagnosis. Journal of Vascular Surgery Cases and Innovative Techniques.2017. Vol. 3. № 2.P. 60–62. doi: 10.1016/j.jvscit.2017.01.002. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5757815/ (accessed June 6, 2019).
28. Bovenzi M., Schust M., Mauro M. An overview of low back pain and occupational exposures to whole-body vibration and mechanical shocks. La Medicina del lavoro. 2017. Vol. 108. № 6. P. 419-433. DOI: 10.23749/mdl.v108i6.6639. Available at: https://www.researchgate.net/publication/321833438 (accessed June 6, 2019).
29. Poole C.J., Cleveland T.J. Vascular hand-arm vibration syndrome - magnetic resonance angiography. Occupational Medicine (London). 2016. Vol. 66. № 1.P. 75-8. doi: 10.1093/occmed/kqv151. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26470947 (accessed June 6, 2019).
30. Babanov S.A., Budash D.S., Bajkova A.G., Baraeva R.A. Periodicheskie medicinskie osmotry i professional'nyj otbor v promyshlennoj medicine [Periodic medical examinations and professional selection in occupational medicine]. Zdorov'enaseleniyaisredaobitaniya. 2018. № 5. P. 48-53. (In Russian).

DOI: 10.24411/2658-4255-2019-10065

ABOUT THE NECESSITY OF ECOLOGICAL MONITORING SYSTEM FOR THE FAR NORTH ENVIRONMENT

M.V. Volkodaeva[1], Ya.A. Volodina[1], A.Yu. Lomtev[2], S.N. Noskov[3]
[1]Saint-Petersburg Mining University
[2]Institute of Design, Ecology and Hygiene, St. Petersburg, Russia
[3]Northwest Public Health Research Center, St.Petersburg, Russia
Volkodaeva_MV@pers.spmi.ru, lomtev@atr-sz.ru, sergeinoskov@mail.ru

Development of the Far North territories is such a process of human interference that causes certain changes in natural environment. Fields development and relative technological processes, being the main type of man-made burden, have negative influence on all components of the environment. The ecosystems of the Far North are characterized by their low ability of self-recovery, so the impact of extraction of mineral resources and its consequences in severe climate conditions increase manyfold. In order to solve the existing environmental problems and ensure sustainable development of the region, it is necessary to have objective information about the state of the environment. The only possible way to obtain such information is monitoring, which includes a system of observations, assessment and forecast of the state of the natural environment, the results of which will provide a comprehensive assessment of the ecological state of the environment, the degree of anthropogenic impact, as well as allow to make forecasts of environmental situations taking into account external and internal environmental factors.

Keywords: the Far North, environmental monitoring, human impact, environmental control.

The Far North is a part of the Earth's territory, located mainly to the North of the Arctic Circle, including regions of the Arctic zone, Northern taiga, forest tundra and tundra. The climate in some areas is extremely severe. The main features of the territory are low values of the radiation balance, low average summer air temperatures close to 0°C (with average annual temperature below freezing point), prevailing glaciers and permafrost (up to 500 m), thin layer of seasonal thawing (not more than 70 cm).

The territory of the Far North of Russia is about 11.4 million square kilometers, and this territory is inhabited by about 10 million people [1]. Despite the small population density, the natural environment of the Far North is subject to significant anthropogenic impact.

Human impact is primarily associated with the search for oil and gas fields and their further exploitation. Construction and operation of oil and gas facilities always affect flora and fauna of the territory. The main types of impact are: alienation of territory, flooding or drainage of land, pollution of environmental components, laying of roads and communication lines, deforestation and change of land use patterns, violation of tundra coat in the Far North, change of hydrological regime of water bodies, as well as noise, light, vibration and electromagnetic effects.

Thus, serious damage to the environment is caused in the process of construction and operation of oil fields. Drilling rigs, oil and gas collection stations, treatment stations, pipelines, slurry barns are potential sources of pollution. One of the dangerous types of technogenic impact on the landscape is drilling of oil and gas wells, accompanied by contamination of soils, surface and groundwaters with chemical reagents, oil, drilling fluids, physical disturbance of soil and vegetation cover and temperature regime of permafrost soils [2]. It shall be also kept in mind that pollutants penetrating in one of the natural environments (air, water, soil) are involved in the overall migration of substances and then spread in all environments [3].

Low air temperatures and high water content of the territory do not contribute to the intensification of chemical processes and lead to the accumulation of industrial waste. Deformations typical for the region of landscape elements result in stimulation of thermokarst, erosion, heaving processes, flooding and waterlogging [4].

Moreover, the geographical location, climatic and meteorological conditions, specific terrain relief, characterized by a high degree of waterlogging, also contribute to the occurrence of emergency situations in the mining fields.

Various physical and geographical processes, as well as human activity, significantly change the hydrological system of the Far North, affect both landscape in general and vegetation in particular. There are significant changes in permafrost landscapes. So, for example, sphagnum-lichen swamps pass into thicket swamps and push permafrost top layers deeper and build up topwaters horizon. The basins of the drained lakes are gradually occupied by sedge-sphagnum swamps. Various subtypes of sphagnum swamps appear on the site of newly formed thermoerosional hollows. Flooding within permafrost areas contributes to the formation of non-permeable taliks with a thickness of frozen rocks for several meters and the formation of biologically dead bodies of water. Floodings of pine forests cause the death of trees layer, grass and shrub layer, and also cause the formation of

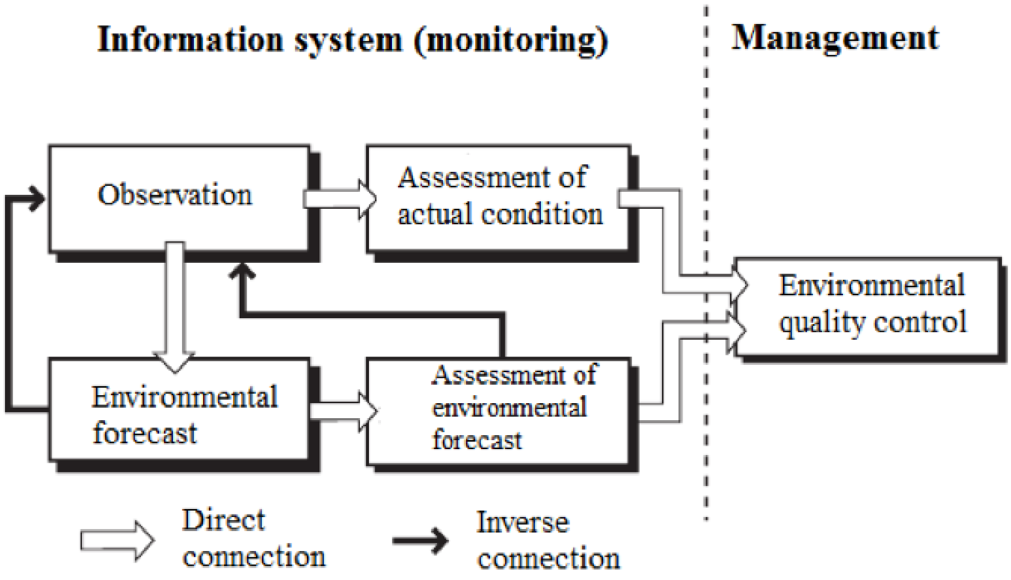


Figure 1. Monitoring system block scheme

grassy swamps, usually of a small size. But the worst possible damage is caused to the most productive North Taiga floodplain forests, where all vegetative layers are completely destroyed and barely-passable horsetail swamps are formed [4].

Due to the increase in anthropogenic impact, it is necessary to monitor changes of the natural environment both during natural processes and during the construction, operation, repair and liquidation of various industrial facilities. Based on the above said, it can be concluded that there is a strong need for environmental monitoring, both background and operational.

Monitoring, in general, is a set of measures to determine the state of the environment and to observe changes occurring in it, including a system of observation, assessment and forecast. The block scheme of the monitoring system is shown in Figure 1.

It shall be taken into account that the monitoring system itself does not include any activities on environmental quality management, but, ideally, it becomes a source of information necessary for making some environmentally significant decisions.

Background environmental monitoring

It is extremely important to observe the state of the natural environment and the changes occurring in it during natural processes, especially in the Far North. This type of environmental monitoring is called background monitoring. The regularity of such studies allows to determine the long-term dynamics and assess the state of the environment. The objects of observation are the components of the natural environment. During the background monitoring constant hydrometeorological observations and determination of pollutants are carried out.

The indicators of hydrometeorological observations are: air temperature and humidity, wind speed and direction, atmospheric pressure, cloudiness, sunshine, atmospheric phenomena (fog, snowstorm, thunderstorm, etc.), the amount and intensity of precipitation, snow cover, soil temperature (at a depth of 20 cm), the state of the soil surface, temperature, humidity, wind speed, thermal balance. Following indicators are determined for the water bodies: level, flow rate, water temperature, waves, currents, ice cover, distribution of aquatic vegetation, groundwater level. The frequency of observations is standard as per the hydrometeorological service.

In addition to determining the hydrometeorological parameters, the atmospheric air is determined by the content of suspended solids, aerosol turbidity, concentrations of ozone, carbon oxides, sulfur and nitrogen, sulfates, petroleum hydrocarbons, 3,4-BP, DDT and other organochlorine pesticides, lead, cadmium, mercury, arsenic.

Atmospheric precipitations and snow are checked for lead, cadmium, mercury, arsenic, 3,4-BP, DDT and other organochlorine pesticides, pH, major cations and anions. Frequency of observations: wet precipitation integral sample for 10 days and 1 month; dry precipitation integral sample for 1 month; snow integral sample to the full depth prior to melting of snow cover.

Surface waters and groundwaters, suspensions, bottom sediments and soil are checked for lead, cadmium, mercury, arsenic, 3,4-BP, DDT and other organochlorine pesticides, pH and biogenic elements. Frequency of observations: water and suspensions are checked during their characteristic hydrological periods (high water, summer runoff low and winter runoff low, rainfall floods); bottom sediments and soil are checked once a year.

Biological objects are checked for lead, cadmium, mercury, arsenic, 3,4-BP, DDT and other organochlorine pesticides. The frequency of observations depends on the nature of the object.

One of the special cases of background monitoring is the background monitoring of areas for proposed construction of industrial and energy enterprises, geological exploration and subsequent mining. The purpose of such background monitoring is to determine the impact of a new anthropogenic source of pollutants on the region. Therefore, it shall be organized and started as early as possible, preferably at the beginning of the development of the technical project, and continue during the construction period. If the observation period before the launch of the object is long enough, the reliability of the forecast of the background state of the region and the assessment of the impact of a new source of pollution increases. The observation program in this case shall consider the pollutants that will be emitted by the new object, and the frequency of observations shall be increased as much as possible.

Operational environmental monitoring

In addition to background monitoring, it is also necessary to monitor changes in the state of the natural environment both during operation and during construction periods, as well as during repair and liquidation of various industrial facilities. This leads to the need for operational environmental monitoring.

The system of operational environmental monitoring is an obligatory component of the system of operational environmental control of an object or enterprise. Operational environmental control is carried out to ensure and comply with the current environmental legislation, rational environmental management, development and implementation of environmental action plans, environment enhancement[1].

It shall be borne in mind that observations under normal environmental conditions are recommended to be carried out at least twice during the period of work. Sampling shall be carried out selectively in accordance with the schedule binding to the warm season (June-September) – when sampling natural surface waters, sediments and soils; and in winter – when sampling snow. Checking background indicators shall be made before the start of work, re-examination – upon completion of construction or liquidation of objects [5].

Means of ecological control

Operational and background monitoring involves the use of the means of ecological control, which, from the point of view of the research methods, can be divided into remote and ground methods.

Remote methods are based on registration of own or reflected signal of wave nature and are carried out by means of sounding fields (electromagnetic, acoustic, gravitational) and transfer of the received information to the sensor. The remote sounding scheme is shown in Figure 2.

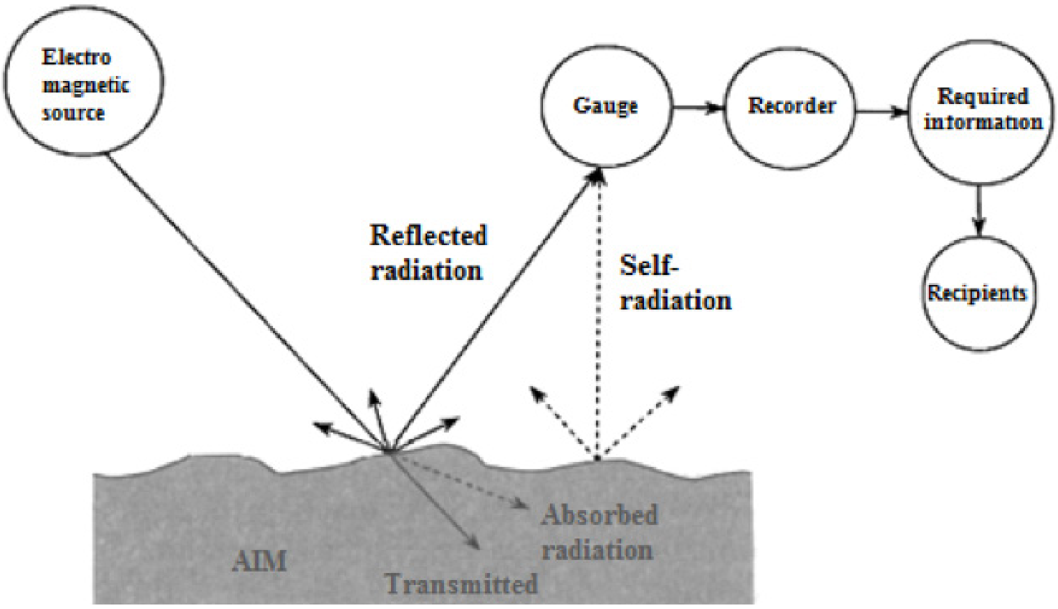


Figure 2. Remote sounding scheme

1 Ministerial directive document 39-1.13-081-2003. System of operational environmental monitoring at gas industry facilities. The rules of design.

The obvious advantage of remote measurement, especially in the Far North, is the possibility of continuous and remote determination of average concentrations of harmful substances at some area (in contrast to ground methods, which give concentrations only at one point), as well as the assessment of the vertical distribution of impurities characterizing the potential of pollution. In addition, these methods allow to assess the movement of pollutants in the atmosphere without analyzing samples at different points and, thus, to determine the influence of the source of pollution located at a distance of several kilometers, and to predict possible emergencies.

Ground methods are based on physicochemical and biological research methods. Conditionally, biological methods can be divided into methods of water bioindication and biotesting. The system of assessing the degree of pollution of atmospheric air, water bodies and soil, based on the account of the state of the respective ecosystems, is called bioindication. Bioindication methods are based mainly on two principles: registration of detection of characteristic organisms (bioindicators) and analysis of species structure of biocenoses. In contrast to bioindication, biotesting methods are a characteristic of the degree of impact on aquatic biocenoses. These methods make it possible to obtain sufficiently reliable data on the toxicity of a particular sample of contaminated water, that is why such methods are considered to be almost chemical.

Physico-chemical methods are methods of analysis used in modern laboratories engaged in environmental control, including many variants of optical methods of analysis (for example, spectrophotometry in visible spectrum, UV- and IR- spectra), separation methods based on gas, liquid and thin-layer chromatography, radiometric methods (used in a limited way, as they require specially prepared laboratories) and electrochemical methods, such as voltammetry and ionometry, which have certain advantages as per low cost and the necessary expenses on operation. Physico-chemical methods, giving the opportunity to accurately determine the concentration of pollutants, however, do not allow to assess the real biological effects of individual substances and their complexes and, moreover, of the products of their transformation.

When determining hydrometeorological indicators, as a rule, the following equipment is used: actinometers, anemometers, barometers, hygrometers, thermometers and other devices. Meteorograph is used for complex measurements of atmosphere meteorological characteristics, it includes devices that record changes in humidity, temperature and pressure. Also, the study of the state of natural processes involves the use of non-contact methods of control (acoustic, radio-acoustic, radar), allowing to obtain spatial and temporal information about changes in environmental parameters.

Control of air pollution is carried out by various remote methods of research. Recently, lidar (laser) methods have been actively developed for monitoring the atmosphere. However, if it is impossible to use expensive equipment for remote assessment of the state of the air environment, ground methods are used, implying initial sampling on the ground and their further analysis in a specialized laboratory. The study of selected samples of atmospheric air is often carried out by spectroscopy and chromatographic methods of analysis [6].

The monitoring system for the state and quality of the water environment includes monitoring of the water level using water meters, as well as various recorders. The measurement of water surface temperature is usually carried out with the help of thermometers, but it is also possible to use active radar methods. Radio brightness method is used for water temperature measurement. For continuous remote control of the depth of the reservoir, profilographs are used, which are divided into mechanical, hydrostatic and acoustic ones according to the principle of operation. The float method is used to measure the flow rate of rivers, with the use of surface, depth and integration floats, as well as hydrometric current meters. Monitoring of water pollution by remote non-contact methods is carried out using aerial photography. The most promising remote non-contact methods of oil control are laser fluorescent, radiometric and some others. When using ground methods to control water pollution, it is necessary at first to take samples and then determine the content of substances in the laboratory.

Radar aerial photography is used to monitor the biolithosphere. Radar aerial photography is used for large areas, it helps to get the image of small scales, so it is a great summering way to study the landscape features, which is especially important for the territories of the Far North.

One of the practically useful methods of soil control is the method of studying surface radio waves in its various variants. But, nevertheless, in practice, the use of ground-based methods of soil research is more common.

Remote monitoring of seasonal snow cover plays an important role in environmental research. The study of snow cover (the boundary of the cover, depth, density, temperature, moisture content) is carried out, as a rule, with the help of active and passive radio brightness methods.

The following methods of remote indication are used to study the geological structure of the earth's crust, development and exploration of mineral deposits: photography, magnetic methods, gamma-ray photography, electrical exploration, gravitational exploration, radiolocation. Currently, environmental interest in these methods is especially evident in the design of fuel and energy complexes, the survey of railway tracks, the choice of the location of dams, power plants, the design of pipelines, canals, tunnels and other facilities.

Thus, when monitoring the environment, it is possible to use a variety of means and methods of control. The choice of means of environmental control depends, first of all, on the tasks set, and the information received must be reliable, complete and up-to-date.

Development of the Far North territories is such a process of human interference that causes certain changes in natural environment. Fields development and relative technological processes, being the main type of man-made burden, have negative influence on all components of the environment. The ecosystems of the Far North are characterized by their low ability of self-recovery, so the impact of extraction of mineral resources and its consequences in severe climate conditions increase manyfold. In order to solve the existing environmental problems and ensure sustainable development of the region, it is necessary to have objective information about the state of the environment. The only possible way to obtain such information is monitoring, which includes a system of observations, assessment and forecast of the state of the natural environment.

Continuous background monitoring shall be carried out in order to monitor changes occurring in natural processes, while increased attention shall be paid to industrialized areas, their environmental safety during the design, construction, operation and liquidation of various industrial facilities. To carry out a full-fledged analysis of the state of the natural environment, observations shall be comprehensive, cover all components of the environment, be periodic, and the obtained data shall be representative.

In order to improve the quality of environmental information, it is necessary to develop and revise scientific-methodological basis for determining levels of contaminants, carry out comprehensive research assessments of the environment of the Far North, it is also necessary to improve technical support of the monitoring network, and also to expand the list of observable parameters. There is a high need to pay attention to the optimization of the process of information support based on geoinformation technologies, to create environmental databases, to make them publicly available. It is also necessary to ensure functioning and further development of the monitoring system in order to develop mechanisms for environmental quality management and rational environmental management. It shall develop on the basis of existing and prospective services, observation systems and modern information technologies. For this purpose, it is also necessary to develop new methods and elaborate uniform methodical and metrological bases.

The results of the surveys carried out within the framework of monitoring will provide a comprehensive assessment of the ecological state of the environment, the degree of anthropogenic impact, as well as allow to make forecasts of the development of environmental situations taking into account external and internal environmental factors.

References:

1. Ekonomicheskie i sotsial'nye pokazateli rayonov Kraynego Severa i priravnennykh k nim mestnostey: sayt Federal'noy sluzhby gosudarstvennoy statistiki [Economic and social indicators of the Far North and equivalent localities: website of the Federal State Statistics Service.]. Available at:http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1140096401359 (accessed: 15.07.2019). (In Russian).
2. Anderson R.K., Mukatanov A.Kh., Boyko T.F. Ekologicheskie posledstviya zagryazneniya pochv neft'yu [Environmental effects of oil pollution of soils]. Ekologiya [Ecology], 1980, no. 6, pp. 21-25. (In Russian).
3. Saksonov M.N., Abalakov A.D., Dan'ko L.V. et al. Ekologicheskiy monitoring neftegazovoy otrasli. Fiziko-Khimicheskie i biologicheskie metody: ucheb. Posobie [Environmental monitoring of the oil and gas industry. Physico-Chemical and biological methods: textbook. allowance.]. Irkutsk: Irkutsk University, 2005, 114 p. (In Russian).
4. Bykovskiy V.A. Okhrana prirody pri razrabotke neftyanykh mestorozhdeniy Kraynego Severa [Environmental protection in the development of oil fields in the Far North. Dis. cand. tech. of sciences]. Yekaterinburg, 2000, 161 p. (In Russian).
5. Kustysheva I.N. Razrabotka metodiki okhrany zemel' pod ob"ektami neftegazovogo kompleksa s uchetom regional'nykh osobennostey Kraynego Severa. Dis. kand. tekhn. nauk [Development of land conservation methods under oil and gas facilities taking into account regional features of the Far North. Dis. cand. tech. of sciences]. Novosibirsk, 2016, 131 p. (In Russian).
6. Volkodaeva M.V., Volodina Ya.A. O metodakh opredeleniya kontsentratsii formal'degida v atmosfernom vozdukhe [On methods for determining the concentration of formaldehyde in atmospheric air]. Ekologicheskie sistemy i pribory [Ecological systems and devices]. 2017, no. 2. pp. 3-9. (In Russian).

DOI: 10.24411/2658-4255-2019-10066

SOME ASPECTS OF THE SAFETY OF NAVIGATION IN POLAR WATERS

V.N. Nikitina, N.I. Kalinina, G.G. Lyashko, E.N. Pankina
North-West Public Health Research Center, Saint Petersburg, Russia
nikitina@s-znc.ru, kalinina@s-znc.ru, lyashko@s-znc.ru, pankina@s-znc.ru

Nowadays, the Arctic zone of Russia is being intensively developed, the cargo turnover of the Northern Sea Route is increasing, oil and gas fields are being developed, fishing and polar tourism are being developed as well. Navigation in polar waters is characterized by many unavoidable adverse factors for the ship crews, such as rotating shift schedule, noise, vibration, electromagnetic fields, etc. Automation of ship navigation, which is aimed at reducing the voyages accident rate, has significantly changed the conditions and nature of work for the seafarers. There appeared to be a problem of discrepancy between functional capabilities of a human operator and requirements of modern sea equipment control systems. The reduction of personnel, the expansion of the functional duties range of crew members leads to significant loads on the whole crew. Frequent and intense disturbances of the geomagnetic field in the Polar regions and the Far North have an adverse effect on the human body functions overall. Crew fatigue becomes one of the main problems of navigation. Irrational light environment can lead to visual fatigue, attention failure, reduced clarity of signals perception, which, in turn, can provoke the accidents. It is highly necessary to develop special organizational and technical measures aimed at optimizing the working conditions of the crew when navigating in polar waters. It is also necessary to develop scientifically based criteria for determining the professional suitability of seafarers based on the results of psychophysiological testing. It is necessary to develop scientifically grounded regimes of work and rest of seafarers.

Keywords: automation of navigation, safety, Polar code, working conditions

The accelerated development of the Arctic zone of Russia and significant increase in cargo turnover of the Northern Sea Route (NSR) are the priorities of economic development of the country. By 2024, it is planned to increase cargo turnover along the Northern Sea Route up to 80 million tons. In the circumpolar regions, oil and gas fields are being developed on the Arctic continental shelf. Fishing and polar tourism are being developed as well. The key condition for achieving the goals of Arctic development is the expansion of the icebreaking, transport and dredging fleets [1,2]. Safety of navigation is one of the most important issues when arranging seafaring on the Northern Sea Route.

In recent years, a number of international and national regulatory documents have been adopted. They address the issues of ensuring the safe operation of ships in polar waters. In order to improve the safety of navigation, the Maritime Safety Committee of the International Maritime Organization (IMO) has adopted an international code for ships operating in polar waters – the Polar Code. IMO makes the Polar Code be mandatory under both the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL). The Polar Code and SOLAS amendments were adopted during the 94th session of IMO's Maritime Safety Committee (MSC), in November 2014. The environmental provisions and MARPOL amendments were adopted during the 68th session of the Marine Environment Protection Committee (MEPC) in May 2015. The Polar Code entered into force on 1 January 2017. The goal of this Code is to provide for safe ship operation and protection of polar environment by addressing risks present in polar waters and not adequately mitigated by other regulatory documents. Every ship to which this Code applies shall have on board a special ship operation document – Polar Water Operational Manual (PWOM), which in its turn is obligatory for issuance of the Polar Ship Certificate together with the list of equipment and provision. The goal of this document is to provide the owner, captain and crew with sufficient information regarding the ship's operational capabilities and limitations in order to support their decision-making process. The Polar Code does not abolish national rules when sailing in the Arctic waters. The document sets out requirements for safety measures, which are provided by the design of ships taking into account icing, mechanical installations for safe ship operation at low temperatures, the strength of the screws and the steering device, etc. There are certain requirements for the means of navigation and communication [3]. The Russian Maritime Register of Shipping, which has leading position in the development of safety standards for ships in ice navigation, in 2017 issued a document on the application of the provisions of the Code for ships operating in polar waters [4].

When considering the safety of navigation as measures aimed at reducing accidents on ships, it is necessary to point out further development of the science of navigation, training programs for marine personnel, improving the design of vessels and shipbuilding. An important factor is the availability of high-quality regulatory documents, providing a high level of safety of navigation when complying with their requirements [5]. Based on the statistics analysis of Maritime accidents, the causes of those at maritime transport are errors of maneuvering; low qualification of crew members; wear and tear of mechanisms and equipment of ships; inattention of shipowners to safety at sea. The human factor remains one of the main factors affecting the safety of marine vessels [6].

We would like to point out the importance of working conditions of seafarers in ensuring the safety of navigation, including the specific conditions of navigation in polar waters. Working conditions of ship crews are characterized by a number of unavoidable adverse factors (rotating shift schedule, noise, vibration, electromagnetic fields, etc.). In recent years, the most advanced achievements of science and technology have been introduced into the practice of vessel design, shipbuilding and navigation, and the latest technologies have been used as well. These include automation of navigation, which is aimed, among other things, to reduce the ship accident rate due to the human factor. However, the introduction of automation has significantly changed the conditions and nature of the work of seafarers [7]. As a result of the complexity of marine technology, the number of control and monitoring elements has increased, accompanied by an increase in the intensity of the work of boat masters, due to the need for operational analysis of information coming from numerous screens. The technical basis of ship automation is usage of the electronic computing machines (ECM), as well as microprocessors and microcomputers with numerous screens to display operational information about the navigation process. In addition, the bridge has auxiliary means of displaying navigation information on small screens (digital displays, alphanumeric displays, situation plan displays). In the process of work, ship masters perform analysis of graphic and text information, simultaneously using several screens of different sizes, located at different distances from the eyes, having different contrast, color and brightness characteristics. There appear to be a problem of discrepancy of functional capabilities of the human operator to requirements of control system of modern sea equipment. Introduction of modern automated systems of control cause the reduction of crew members. It is a process of combining professions and expanding the range of functional duties of seafarers. In the absence of scientifically based modes of work and rest, under the condition of minimal staffing of automated vessels, the load on the crew increases significantly and, as a consequence, there is a rapid development of fatigue, which negatively affects the safety of navigation. Crew fatigue becomes one of the main problems of navigation [8].

In addition to the above mentioned adverse factors of working conditions and labor process on ships, in the Northern latitudes seafarers are exposed to long-term effects of irreversible natural factors. These include low temperatures, squally winds, difficult ice conditions. In high latitudes (Polar regions and the Far North) there are frequent and intense disturbances of the geomagnetic field (GMF). The effect of geomagnetic disturbances is noticed for the functional state not only of individual organs and systems, but also of the human body as a whole [9]. According to the results of research, in the Arctic and the Far North, the functional state of the organism significantly depends on the variations of GMF. In high latitudes, frequent and intense geomagnetic disturbances can be one of the causes of desynchronization of biological rhythms. And, in the case of chronic and persistent violations of the phase architectonics of rhythms, contribute to the depletion of reserve capabilities and adaptive-regulatory systems of the body. Significant seasonal change in daylight of polar days and nights is one of the extreme climatic factors of the Arctic region, affecting human body [10]. Seasonal changes in daylight in the Arctic region cause changes in the sleep-wake rhythm. These disorders are associated with a high risk of cardiometabolic disease, depression, drowsiness, and decreased working capacity. It becomes obvious that age-related changes in many physiological functions accelerate, which causes premature aging of the body. The results of researches testify the existence of proved interrelation between sleep duration patterns and frequency of the incidents leading to accidents on vessels [11]. Providing optimal environment in marine premises and workplaces of the crew is of special importance for safety of navigation in polar waters in terms of automation of navigation and the specific light climate of the Arctic regions. There are actual issues of energy saving on ships, so an important step is the introduction of modern efficient lighting products on ships and vessels. At the same time, the desire to save energy can lead to deterioration of lighting quality, and new light sources can be perceived by seafarers as less comfortable than the old and familiar ones, especially in the light climate of the Arctic regions [12]. It is necessary to consider possible adverse influence of lamp blinding action on the visual analyzer, as well as its pulsations and color characteristics of light sources.

Conclusion

The specific conditions of navigation in polar waters reveal the need to develop special organizational and technical measures aimed at optimizing the working conditions of the marine crews. Irrational light situation with a high probability can lead to visual fatigue, impaired attention, reduced clarity of signals perception, which, in turn, can provoke the occurrence of ship accidents. It is required to develop scientifically based criteria for determining the professional suitability of crew members based on the results of psychophysiological testing, it is also important to develop work and rest regimes of seafarers.

The most important component of the system of ensuring the navigation safety is the establishment of requirements for the optimal composition of the ship crews. The Ministry of Transport of Russia has announced the beginning of development of Regulations on the minimum composition of ship crews. According to the Federal Portal of Draft Regulations, the relevant draft provides for the formation of a minimum composition for a certain type of vessel, sufficient to meet the requirements of safety of navigation, environmental, sanitary, fire and transport safety; meeting the requirements for compliance with the working time and rest time of crew members on board. The draft document has not yet been published. It is hoped that the Regulation will be developed on the basis of comprehensive scientific research and taking into account the specific adverse natural factors affecting the ship crew in polar waters.

References:

1. Erohin V.L. Arkticheskoe sudostroenie i morskaya tekhnika Rossii: sostoyanie, potrebnosti, perspektivy razvitiya. [Arctic shipbuilding and marine engineering of Russia: state, needs, development prospects] Marketing i logistika. [Marketing and logistics]. 2019, no.1 (21), pp.12-31. (In Russian).
2. Kovalenko A.S., Morgunova M.O., Gribkovskaya V.V. Infrastrukturnaya sinergiya Severnogo morskogo puti v mezhdunarodnom kontekste. [Infrastructure synergy of the Northern sea route in the international context] Energeticheskaya politika. [Energy policy]. 2018, no. 4, pp. 57-67. (In Russian).
3. Shurpyak V.K. Polyarnyj kodeks IMO: predvaritel'nyj analiz pervoj chasti (trebovaniya po bezopasnosti) [IMO polar code: preliminary analysis of the first part (safety requirements)] Nauchno-tekhnicheskij sbornik Rossijskogo morskogo registra sudohodstva. [Scientific and technical collection of the Russian Maritime register of shipping]. 2015, no.38/39, pp. 8-17. (In Russian).
4. Rukovodstvo po primeneniyu polozhenij Mezhdunarodnogo kodeksa dlya sudov, ekspluatiruyushchihsya v polyarnyh vodah (Polyarnogo kodeksa) [Guidelines for the application of the provisions of the International code for ships operating in polar waters (Polar code)] St. Petersburg, FAU «Rossijskij morskoj registr sudohodstva». 2017, 27 p. (In Russian).
5. Kajman F.M., Ershov A.A. Avarijnost' morskogo flota i problemy bezopasnosti sudohodstva [The accident rate of the Navy and the problems of safety of navigation] Transport Rossijskoj federacii. [Transport of the Russian Federation]. 2006, no. 5, pp.82-84. (In Russian).
6. Avramenko D.V., Kasatkin I.P. Prichiny avarijnosti morskih sudov i povyshenie bezopasnosti moreplavaniya [Causes of accidents of ships and increase safety of navigation] Sbornik dokladov 59-j mezhdunarodnoj molodezhnoj nauchno-tekhnicheskoj konferencii «Molodyozh' – nauka – innovacii» [Collection of reports of the 59th international youth scientific and technical conference "Youth – science – innovation»]. Vladivostok, 2011, vol.1, pp. 276-279. (In Russian).
7. Nikitina V.N., Lyashko G.G., Razletova A.B. Problemy obespecheniya bezopasnosti moreplavaniya avtomatizirovannyh morskih sudov. [Problems of ensuring the safety of navigation of automated ships] Nauchno-tekhnicheskij sbornik Rossijskogo morskogo registra sudohodstva. [Scientific and technical collection of the Russian Maritime register of shipping]. 2015, no.38/39, pp.113-116. (In Russian).
8. Nikitina V.N. Znachenie sistemnogo analiza v reshenii zadach profilaktiki avarijnosti sudohodstva po prichine chelovecheskogo faktora. [The importance of system analysis in solving the problems of prevention of accidents of navigation due to the human factor] Nauchno-tekhnicheskij sbornik Rossijskogo morskogo registra sudohodstva. [Scientific and technical collection of the Russian Maritime register of shipping]. 2017, no.46/47, pp. 119-124. (In Russian).
9. Belisheva N.K., Konradov S.A. Znachenie variacij geomagnitnogo polya dlya funkcional'nogo sostoyaniya organizma cheloveka v vysokih shirotah. [The value of geomagnetic field variations for the functional state of the human body in high latitudes] Geofizicheskie processy i biosfera. [Geophysical processes and the biosphere]. 2005, vol.4, no.1/2, pp. 44-52. (In Russian).
10. Bochkarev M.V., Korostovceva L.S., Kolomejchuk S.N., Petrashova D.A., SHalamova E.YU., Ragozin O.N., Sviryaev YU.V. Rol' sna i izmenenij ritma sna–bodrstvovaniya v adaptacii k usloviyam Arktiki. [The role of sleep and changes in the rhythm of sleep–wakefulness in adaptation to Arctic conditions] Vestnik ural'skoj medicinskoj akademicheskoj nauki. [Bulletin of the Ural medical academic science]. 2019, vol.16, no.2, pp. 86-95. DOI: 10.22138/2500-0918-2019-16-2-86-95. (In Russian).
11. Analysis of background factors in marine accidents and incidents caused by watch keeper drowsiness in Japan. Shinsuke Urushidani at al 2011. Aktual'nye problemy transportnoj mediciny. [Actual problems of transport medicine]. 2011, no.4 (26), pp.62-67. (in English).
12. Razletova A.B., Nikitina V.N., Kalinina N.I. Znachenie svetovogo klimata v celyah obespecheniya bezopasnosti moreplavaniya. [The importance of light climate for the safety of navigation] Nauchno-tekhnicheskij sbornik Rossijskogo morskogo registra sudohodstva. [Scientific and technical collection of the Russian Maritime register of shipping]. 2015, no. 40/41, pp. 80-84. (In Russian).

DOI: 10.24411/2658-4255-2019-10067

TERRITORIAL SCHEMES OF WASTE MANAGEMENT IN THE RUSSIAN ARCTIC: A STARTING POINT FOR A DISCUSSION

P. F. Agakhaniants[1], A. Yu. Lomtev[1], E.A. Primak[2], D.S. Vyucheyskaya[3]
[1]Ltd Company "Institute of Design, Ecology, and Hygiene", St. Petersburg
[2]Russian State Hydrometeorological University, St. Petersburg, Russia
[3]North-West Public Health Research Center, St. Petersburg, Russia
agahanyants@atr-sz.ru, lomtev@atr-sz.ru, vyucheyskaya.ds@gmail.com

The problems of household waste management in the Arctic region are complicated by low temperatures at which the waste freezes and plastics burst, as well as by an undeveloped (or completely absent) road network and a low population density. Another issue is that the legal system of the Arctic regions requires harmonization. Requirements that seem to be difficult to meet in settlements located in temperate climates become impossible to achieve in the North. The usual logistic schemes can't be drawn up as well, and even a small distance can become an obstacle to the regular transportation of municipal solid waste. Furthermore, a need for an individual approach to the issue of waste management in the Arctic should be emphasized, on the one hand, and on the other, close coordination among different regions and justification of the use of the best available technologies in the field of waste management in the Russian Arctic are necessary.

Key words: the Arctic, Arctic zone of the Russian Federation, water supply, socio-economic development, the best available technologies, territorial schemes of waste management.

The natural and climatic conditions of the Arctic as well as its current economic conditions establish special requirements for individuals, the society and the country in general. The routine actions that don't present difficulties in favorable climatic conditions become extremely challenging and require special solutions in the North. This can be fully applied to the sphere of waste management, which is one of the country's most problematic and conflict fields on the whole.

Municipal solid waste (MSW) is disposable materials generated by households in the process of use by individuals, as well as the goods that have lost their usefulness in the process of use by individuals in residential accommodations for personal and domestic needs. The waste generated by juridical persons and individual entrepreneurs with a composition similar to that of the waste generated in the process of use by individuals in residential accommodations also belongs to MSW [1]. According to the law, MSW management is a public service [2]. The main stages of MSW management include waste accumulation, its collection, one-step or multiple-step transportation to waste processing facilities, waste processing (sorting), recycling or burial of MSW and/or the resulting products of processing or recycling [3]. Each stage possesses its own managerial, ecological and economic properties and has its own ecological and economic cost.

The most significant issues of MSW management in the Russian Federation include:

- a lack of demand for recycled resources (as a result of absence of any incentive for this field until recent times);
- a lack of any inducements for the population residing in private houses to conclude a contract for MSW removal;
- a lack or a poor technical condition of vehicles used for waste transportation;
- technological complexity and comparatively high cost price of MSW processing with a risk of secondary environment pollution;
- in case of waste burial: taking of valuable land, interference in natural landscape, soil pollution, surface and groundwater pollution, air pollution, loss of valuable components contained in MSW etc. [3-5].

The MSW management in the far northern environment is substantially complicated by a number of objective reasons including:

- Extreme climatic conditions that threaten the financially affordable technological operations to collect, transport and neutralize waste. Another issue caused by low temperature is an impossibility of waste composting within house estates.
- Large areas of land that are little-developed and difficult of access; lack of development or total lack of transport infrastructure. In certain cases (for instance, in the insular territories) the only way to access the area is by water (during the navigational period), by an all-terrain vehicle (not for the whole year, as well) or by small aircraft. A year-round car road connection is unavailable in many cases. Recently, the ice-roads are also not always fully functional due to climate change.
- Absence of a waste management infrastructure. In most settlements, there is no system of regularly scheduled MSW collection; waste processing plants are lacking.
- Small population size. This factor significantly increases the specific costs of any MSW management processes.

Consequently, MSW gets into the environment, ends up in unequipped dumps or is mixed with unneutralized hazardous waste. These difficulties are aggravated by high vulnerability of the northern ecosystems, low intensity of self-purification processes in all mediums and at all levels, and high activity of contaminant bioaccumulation and biomagnification processes.

To this must be added such factors as the rapid development of oil-and-gas and metallurgical industry in the Arctic zone in the conditions of insufficient elaboration of the issues of environmental and hygienic safety guaranteeing or even a failure to take them into account; long-term waste accumulation within the region, including persistent toxic substances; absence or poor development of public health and ecological monitoring systems, as well as the monitoring systems taking proper account of the peculiarities of the Arctic zone and its individual regions; the making of decisions concerning MSW management under conditions of high uncertainty caused by insufficient database of primary information on the environmental conditions, waste volume and composition [6, 12].

There are numerous environmental and sanitary requirements for the MSW management in the Russian Federation [1], [7-9]. Requirements that are difficult to meet in settlements located in temperate climates become impossible to achieve at affordable cost in the North. This applies above all to waste disposal frequency [9], duration of waste accumulation [1], licensing [1], landfill organization etc. In the great majority of cases, these requirements were not fulfilled (and still are not at present); the household waste that has been managed by the municipal government for a long time is now stored in dumps.

In the last decade, it became apparent that the waste problem must be solved in a comprehensive way, at the strategic level. In 2014, a notion of a «territorial scheme of waste management, including municipal solid waste» (TSWM) was included in the Federal Law No. 89-FZ of June 24, 1998 «On Production and Consumption Wastes» [1]. A territorial scheme is a strategy document prepared by each federal subject of the Russian Federation, with a minimum validity period of 10 years. This document contains data on the sources and the amount of waste, targets of the sphere of waste management and a description of the existing scheme of waste management [10]. Territorial schemes must also contain a description of the development prospects of the waste management sphere: plans to build new waste management establishments and to decommission landfills; the amount of necessary investments; tariff forecasts etc.

Currently, the territorial schemes are elaborated for all the Arctic regions (the Arctic Zone of the Russian Federation encompasses the territories of the Murmansk Region, the Nenets, Chukotka and Yamalo-Nenets Autonomous Areas, some municipal formations of the Republic of Karelia, the Komi Republic, the Sakha Republic (Yakutia), the Krasnoyarsk Territory and the Arkhangelsk Region [11]).

In some of the regions these schemes have already been updated in accordance with the decree of the Government of the Russian Federation «On the Development, Public Discussion, Approval, Adjustment of Territorial Schemes in the Field of Waste Management of Production and Consumption, Including Solid Municipal Waste, as well as Requirements for the Composition and Content of Such Schemes» which came into force a year ago [10]. These documents are diverse; their length ranges from several pages without annexes and up to thousands pages. Their comprehensive analysis goes beyond the scope of a single article. In the present article, the question is put as follows: to what extent do these documents that are aimed at the description of the development prospects of the waste management sphere take into account the specific features of the Arctic region? Do they offer any possible solutions of the existing issues?

The weakest spots of waste management in the Arctic region are MSW accumulation and transportation, construction of new landfills that match up to modern requirements, and MSW processing. The northern conditions should be taken into account in these interrelated stages of waste management.

An explanatory note to the territorial scheme of the Murmansk Region [13] is startlingly short: 6,5 pages only. An annex to the explanatory note includes 388 pages of tables and graphic materials. The explanatory note doesn't give any clear indication that the scheme concerns a northern region.

The scheme of the waste stream in the Murmansk Region includes 8 waste transfer stations; technical solutions to the problems of waste transfer and transportation are not presented in the document. Several remote settlements located along the White Sea coast will not be covered by the transportation routes, and yet, neither landfills nor waste incinerators are planned for construction in these areas. Instead, a «waste sorting system» which lacks a description is envisaged for these settlements. This establishes the prerequisites for emergence of unauthorized waste dump sites. A system of containerless MSW accumulation in the apartment houses equipped with the refuse collection rooms providing MSW transfer to a waste collection vehicle directly from a collection room is also questionable. This system is contrary to SanPiN 42-128-4690-88, according to which the waste dumping through a refuse chute directly on the floor of a refuse collection room is strictly forbidden.

Further, the TSWM specifies a direction of several MSW streams straight to waste burial repositories. As the existing waste placement areas are filled, the MSW streams must be redirected to Murmansk. The issues of a year-round MSW transportation are not addressed in the TSWM. A specific character of 5 closed administrative units including Vidyayevo within the territory of which a MSW landfill is present is also not revealed in this territorial scheme.

A description and a comparison of waste processing technologies are absent from the TSWM; a technology selection is not made. In Murmansk, the construction of a combustion plant and a waste sorting complex (WSC) with secondary raw materials extraction and burial of remains is planned. The efficiency ratings for these enterprises are not provided. Waste accumulation and incineration are specified in Krasnoshchelye [10].

In general, the scheme under consideration leaves many questions and does not provide solutions to the issues of MSW management in the region.

The TSWM of the Nenets Autonomous Area [14] suggests MSW transportation directly to waste sorting stations or its primary accumulation in 40 accumulation areas with subsequent transportation to the burial repository in Naryan-Mar or to the waste processing facilities in the neighboring regions: the city of Arkhangelsk, a town of Mezen (the Arkhangelsk Region), a town of Usinsk (the Komi Republic). However, the territorial schemes of the Arkhangelsk Region and the Komi Republic do not involve MSW receiving from the Nenets Autonomous Area; the agreements between the neighboring regions haven't been concluded yet.

Waste is planned to be transported by barges, all-terrain vehicles and cars; particularly, during the summer period the MSW transportation should be carried out by means of a tractor with a trailer; in winter a tractor with trailer skid shoe runners should be used; for swampy terrains a caterpillar tractor is recommended, and in the areas that are difficult to access all-terrain vehicles are planned to be used. Such a decision may be faced with licensing difficulties of waste transportation by means of non-standard types of transport. An original regional waste management operator in the Nenets Autonomous Area, which was selected by a competition, refused to work in the region. As a consequence, the region was subdivided into 2 service areas of regional operators which will start their work on January 1, 2020.

The TSWM contains plans for the construction of 4 small-size waste sorting stations with a capacity from 80 t/year to 12,000 t/year in the future. Given that small-scale MSW sorting is not recompensed, a market for the obtained salvage will be hard or impossible to find in the conditions of transport inaccessibility.

An explanatory note to the TSWM of the Chukotka Autonomous Area [15] emphasized the absence of intraregional MSW transit. This fact justifies the creation of 24 isolated service areas of regional operators. In fact, this is the only way to organize waste transportation: there will always be isolated areas from which it's impossible to transport MSW without using a helicopter. However, in the TSWM of the Komi Republic, for instance, these isolated areas are called «technological zones», and they don't require separate regional operators.

The reason of this contradiction is a wording from the Federal Law No. 89-FZ of June 24, 1998 «On Production and Consumption Wastes», according to which it's a regional operator, the data on whose zones of activity should be included in a territorial scheme of waste management. Thus, the issue solution is referred to the TSWM technical authors, and not to the regional authorities.

The creation of regional operators' service zones is a decision more of a political nature. Within a single region, several technological zones (the territories which domestic waste is transported to a single final unit of utilization and storage) can be formed. The problem is that in the areas that are difficult to access some of these zones are small and unprofitable. In cases like this, it would be appropriate to unite several more or less profitable technological zones into a single service area of a regional operator that would be more attractive to investors. But this decision can be made by regional authorities on the basis of a TSWM with the economic details planned and described. In practice, in the process of formation of such «microzones» it's municipal enterprises that become regional operators.

Among the advantages of the TSWM of the Chukotka Autonomous Area are the most realistic values of targets for waste neutralization, utilization and placement: 10% of MSW sent for processing (utilization is a more precise term here).

The territorial scheme of waste management of the Yamalo-Nenets Autonomous Area (YaNAO) [16] provides a single service area of a regional operator; these conditions are more attractive for an operator. The scheme includes creation of numerous MSW accumulation and collection areas in the future. In many routes, the MSW transport distance is 100 km and more. Practice will show the efficiency of this approach. This scheme is aimed at decentralization and the use of small waste incinerators. The TSWM of the Yamalo-Nenets Autonomous Area is in the process of actualization until the end of 2019.

The territorial scheme of waste management of the Komi Republic [17] provides a very complicated system of waste accumulation and transportation consisting of numerous transfers, areas of accumulation and sorting, and technology parks.

The TSWM of the Sakha Republic (Yakutia) [18] suggests 5 service areas of regional MSW management operators. The Arctic territories are included in the Northern Arctic zone. Needless to say, the operator was chosen not from the first attempt, and this important responsibility has been entrusted to a state unitary enterprise.

The territorial scheme of waste management of the Krasnoyarsk Territory [19] is one of the longest documents reviewed. However, we are only interested in the Arctic regions, namely Turukhansk District, Taimyr Dolgan-Nenets District and the urban district of Norilsk. All three municipal formations are separate technological zones which were created in order to overcome the above-mentioned problem. Still, the competitions were announced independently in each technological zone. The disadvantages of this approach were discussed above. As a result, in the Turukhansk technological zone a regional operator is not selected (in 3 other remote regions of the Krasnoyarsk Territory, which are not included in the Arctic zone, regional MSW operators were not found as well).

This TSWM reviews the specific character of the northern territories in detail. A series of decisions different from the ones for the central and southern areas of the Krasnoyarsk Territory is suggested for remote settlements.

· MSW neutralization in thermal neutralization plants in isolated settlements;

· MSW accumulation and storage areas that are suggested for small and very small settlements. Transportation from these places is possible only once in 11 months and once in few years, respectively.

However, the system of waste collection with the use of refuse sacks leaves a possibility for waste freezing. It should be noted that a uniform solution of the issue of transportation of neutralized waste (ashes) and MSW kept in storage areas is not reflected in the TSWM. For Turukhansk District, truck transportation by ice roads is suggested, while for Taimyr Dolgan-Nenets District the solution lays in the creation of storage areas. That is due to the requirements of the administration of these municipal formations.

An objective of complete neutralization of MSW that is to be buried is stated in the TSWM of the Krasnoyarsk Territory. Two ways of household waste neutralization are considered in the northern territories: with the use of small incinerators (no energy is generated in this case) and with the use of larger generating units. Not all the TSWMs of the Arctic territories include the exploration of the MSW neutralization.

Currently, the scheme is in the process of revision. The materials of the public discussions of the updated TSWM project published on the website of the Ministry of Ecology and Rational Nature Management of the Krasnoyarsk Territory prove that this scheme is functional. Specific issues of waste transportation, advisability of placing of waste storage areas in certain settlements etc. are discussed.

In the explanatory note to the territorial scheme of waste management of the Arkhangelsk Region [20] various options of MSW accumulation, transportation, utilization and neutralization are explicitly considered. The climatic conditions are taken into account in choosing a system of waste accumulation. In general, the TSWM authors have selected a two-container system of separate waste accumulation (earlier: «separate waste collection») in the zone of service of waste sorting and waste processing complexes. At the initial stages, the TSWM entails the deployment of separate waste collection in 10 most populated settlements with the most developed infrastructure.

For the settlements that are difficult to access and have low population density and a low waste generation rate (less than 5,000 t/year) the TSWM suggests waste separation by the local people:

· paper and carton waste is burnt in stoves;

· food waste is composted within house estates;

· secondary raw materials (plastic, glass, metal) are delivered to the secondary raw material reception points (in every settlement); the materials are periodically transported (by available land or air means) from these points for processing;

· for hazardous waste (accumulators, mercury-containing waste) reception terminals are installed in large infrastructure objects (shops, rural club-houses in every settlement); the waste is periodically transported (by available land or air means) from these points for neutralizing.

In fact, the TSWM relieves the regional operator of the MSW management responsibility in settlements that are difficult to access and shifts it onto the population's shoulders. In reality, no one can obligate population to burn and compost waste. Thus, conditions for continuing of dump formation are created. Another controversial point concerns the periodical transporting of secondary raw materials by available land or air means for processing. Since this process does not involve waste, this responsibility cannot be entrusted to the regional operator and included in the tariff.

The TSWM of the Arkhangelsk Region considers transportation by rail and by water as basic means of waste transit, which once again leads to the above-mentioned licensing issue of waste transportation by means of non-standard types of transport.

Conclusions

None of the territorial schemes examined allows specific solutions to the issues of MSW accumulation and transportation. The requirements of the Russian legislation concerning waste management cannot be completely fulfilled in the northern living conditions without excessive costs which, according to the law, must be borne by the population. These requirements include both waste processing and utilization priority over its landfill burial and sanitary standards for the frequency of MSW disposal and the organization of container areas. The usual logistic schemes can't be drawn up as well, and even a small distance can become an obstacle to the regular transportation of MSW. A need for an individual approach to the issue of waste management in the Arctic should be emphasized, on the one hand, and on the other, a close coordination among different regions and justification of the use of the best available technologies in the field of waste management in the Russian Arctic are necessary.

References:

1. Federal'nyj zakon ot 24.06.1998 N 89-FZ (red. ot 26.07.2019) «Ob othodah proizvodstva i potrebleniya» [Federal Law of June 24, 1998 N 89-ФЗ (as amended on July 26, 2019) «On Production and Consumption Wastes»]. (In Russian).
2. Postanovlenie Pravitel'stva RF ot 06.05.2011 N 354 (red. ot 13.07.2019) «O predostavlenii kommunal'nyh uslug sobstvennikam i pol'zovatelyam pomeshchenij v mnogokvartirnyh domah i zhilyh domov» (vmeste s «Pravilami predostavleniya kommunal'nyh uslug sobstvennikam i pol'zovatelyam pomeshchenij v mnogokvartirnyh domah i zhilyh domov») [Decree of the Government of the Russian Federation of 05.06.2011 N 354 (as amended on 07/13/2019) «On the provision of utility services to owners and users of premises in apartment buildings and apartment buildings» (together with the «Rules for the provision of utility services to owners and users of premises in apartment buildings

and residential buildings»)]. (In Russian).
3. Vajsman Ya.I. Upravlenie othodami. Sbor, transportirovanie, pressovanie, sortirovka tverdyh bytovyh othodov [Waste management. Collection, transportation, pressing, sorting of municipal solid waste]. Perm: Perm national research Polytechnic University Publ., 2012. 236 p. (In Russian).
4. Bespalov V.I., Adamyan R.G. Analiz osnovnyh harakteristik i osobennostej ekspluatacii poligonov po zahoroneniyu tverdyh othodov potrebleniya [Analysis of the main characteristics and operation features of landfills for the disposal of solid waste consumption]. Inzhenernyj vestnik Dona [Engineering Bulletin of the Don], 2013, no. 2. Available at: ivdon.ru/magazine/archive/n2y2013/1716/ (accessed: 24.05.2019). (In Russian).
5. Mihajlova N.V. Ispol'zovanie vtorichnyh resursov i othodov. Itogi II nauchno-prakticheskoj konferencii [Use of secondary resources and waste. The results of the II scientific and practical conference]. Tverdye bytovye othody [Municipal solid waste], 2009, no. 11, pp. 54-55. (In Russian).
6. Karelin A.O., Yeremin G.B. Problemy jekologicheskoj i gigienicheskoj bezopasnosti v Arktike [Problems of environmental and hygiene safety in the Arctic]. Sbornik dokladov V Mezhdunarodnogo foruma «Arktika: nastojashhee i budushee» [Collection of reports of the V International Forum "Arctic: Present and Future"]. St-Petersburg, 2012, pp. 320-322. (In Russian).
7. Postanovlenie Pravitel'stva RF ot 12.11.2016 N 1156 (red. ot 15.12.2018) «Ob obrashchenii s tverdymi kommunal'nymi othodami i vnesenii izmeneniya v postanovlenie Pravitel'stva Rossijskoj Federacii ot 25 avgusta 2008 g. N 641» (vmeste s «Pravilami obrashcheniya s tverdymi kommunal'nymi othodami») [Decree of the Government of the Russian Federation dated November 12, 2016 N 1156 (as amended on December 15, 2018) «On the management of municipal solid waste and amendments to the Decree of the Government of the Russian Federation of August 25, 2008 N 641» (together with the “Rules for the treatment of solid municipal waste»)]. (In Russian).
8. SanPiN 2.1.7.1322-03. Gigienicheskie trebovaniya k razmeshcheniyu i obezvrezhivaniyu othodov proizvodstva i potrebleniya [Hygienic requirements for the placement and disposal of production and consumption waste]. (In Russian).
9. SanPiN 42-128-4690-88. Sanitarnye pravila soderzhaniya territorij naselennyh mest [Sanitary rules for maintaining territories of populated areas]. (In Russian).
10. Postanovlenie Pravitel'stva RF ot 22.09.2018 N 1130 «O razrabotke, obshchestvennom obsuzhdenii, utverzhdenii, korrektirovke territorial'nyh skhem v oblasti obrashcheniya s othodami proizvodstva i potrebleniya, v tom chisle s tverdymi kommunal'nymi othodami, a takzhe o trebovaniyah k sostavu i soderzhaniyu takih skhem» (vmeste s «Pravilami razrabotki, obshchestvennogo obsuzhdeniya, utverzhdeniya, korrektirovki territorial'nyh skhem v oblasti obrashcheniya s othodami proizvodstva i potrebleniya, v tom chisle s tverdymi kommunal'nymi othodami, a takzhe trebovaniyami k sostavu i soderzhaniyu takih skhem») [Decree of the Government of the Russian Federation of September 22, 2018 N 1130 «On the development, public discussion, approval, adjustment of territorial schemes in the field of waste management of production and consumption, including solid municipal waste, as well as requirements for the composition and content of such schemes» (Together with the «Rules for the development, public discussion, approval, adjustment of territorial schemes in the field of waste management of production and consumption, including solid municipal waste, as well as requirements for composition and the contents of such circuits»)]. (In Russian).
11. Ukaz Prezidenta RF ot 02.05.2014 N 296 (red. ot 13.05.2019) «O suhoputnyh territoriyah Arkticheskoj zony Rossijskoj Federacii» [Decree of the President of the Russian Federation dated 02.05.2014 N 296 (as amended on 05/13/2019) «On land territories of the Arctic zone of the Russian Federation»]. (In Russian).
12. Karelin A.O., Agahanjanc P.F., Lomtev A.Yu., Yeremin G.B. Problemy upravlenija TKO v uslovijah krajnego severa [Problems of solid municipal waste management in the Far North]. Tverdye bytovye othody [Municipal solid waste], 2016, no. 10, pp. 8-10. (In Russian).
13. Postanovlenie Pravitel'stva Murmanskoj oblasti № 492-PP/10 ot 07.10.2016 «Ob utverzhdenii territorial'noj skhemy obrashcheniya s othodami, v tom chisle s tverdymi kommunal'nymi othodami, Murmanskoj oblasti» [Decree of the Government of the Murmansk region No. 492-PP / 10 of 10/07/2016 «On approval of the territorial scheme of waste management, including solid municipal waste, of the Murmansk region»]. (In Russian).
14. Prikaz Departamenta prirodnyh resursov, ekologii i agropromyshlennogo kompleksa Neneckogo avtonomnogo okruga № 17-pr ot 25.04.2019 «O vnesenii izmeneniya v Territorial'nuyu skhemu obrashcheniya s othodami, v tom chisle s tverdymi kommunal'nymi othodami, na territorii Neneckogo avtonomnogo okruga na perioda 2016-2030 godov» [Order of the Department of Natural Resources, Ecology and Agriculture of the Nenets Autonomous Okrug No. 17-pr dated 04.25.2019 «On Amending the Territorial Scheme of Waste Management, including Solid Municipal Waste, in the Nenets Autonomous Okrug for the period 2016- 2030 years»]. (In Russian).
15. Prikaz Departamenta promyshlennoj i sel'skohozyajstvennoj politiki Chukotskogo avtonomnogo okruga № 2-od ot 10.01.2018 «O vnesenii izmenenij v prikaz Departamenta promyshlennoj i sel'skohozyajstvennoj politiki Chukotskogo avtonomnogo okruga ot 27 sentyabrya 2016 goda № 553/1-od» [Order No. 2-od of the Department of Industrial and Agricultural Policy of the Chukotka Autonomous Okrug dated 01/10/2018 «On Amending Order No. 553/1-od of the Department of Industrial and Agricultural Policy of the Chukotka Autonomous Okrug» of September 27, 2016.]. (In Russian).
16. Prikaz Departamenta tarifnoj politiki, energetiki i zhilishchno-kommunal'nogo kompleksa YAmalo-Neneckogo avtonomnogo okruga № 101-od ot 02.08.2016 «Territorial'naya skhema obrashcheniya s othodami, v tom chisle s tverdymi kommunal'nymi othodami, na territorii Yamalo-Neneckogo avtonomnogo okruga na period 2016-2025 godov» (v red. Prikazov ot 28.11.2017 №125-od, ot 09.04.2018 №39-od, ot 02.10.2018. №120-od) [Order of the Department of Tariff Policy, Energy, and the Housing and Utilities Complex of the Yamalo-Nenets Autonomous Okrug No. 101-od of 08/02/2016 «Territorial scheme for waste management, including solid municipal waste, in the territory of the Yamalo-Nenets Autonomous Okrug for the period 2016-2025 years» (as amended by Orders dated November 28, 2017 No. 125-od, dated April 9, 2018 No. 39-od, dated October 2, 2018. No. 120-od)]. (In Russian).
17. Prikaz Ministerstva prirodnyh resursov i ohrany okruzhayushchej sredy Respubliki Komi i Ministerstva energetiki, zhilishchno-kommunal'nogo hozyajstva i tarifov Respubliki Komi ot 27.12.2018 № 2667/579-OD «Ob utverzhdenii territorial'noj skhemy obrashcheniya s othodami, v tom chisle s tverdymi kommunal'nymi othodami Respubliki Komi» [Order of the Ministry of Natural Resources and Environmental Protection of the Republic of Komi and the Ministry of Energy, Housing and Communal Services and Tariffs of the Republic of Komi dated December 27, 2018 No. 2667/579-OD «On Approving the Territorial Scheme of Waste Management, including Solid Municipal Waste Republic of Komi»]. (In Russian).
18. Prikaz Ministerstva zhilishchno-kommunal'nogo hozyajstva i energetiki Respubliki Saha (Yakutiya) № 360-p ot 14.09.2018 «Ob utverzhdenii territorial'noj skhemy obrashcheniya s othodami, v tom chisle s tverdymi kommunal'nymi othodami, Respubliki Saha (Yakutiya)» [Order of the Ministry of Housing and Communal Services and Energy of the Republic of Sakha (Yakutia) No. 360-p dated 09/14/2018 «On approval of the territorial scheme of waste management, including solid municipal waste, of the Republic of Sakha (Yakutia)»]. (In Russian).
19. Prikaz Ministerstva prirodnyh resursov i ekologii Krasnoyarskogo kraya ot 23.09.2016 N 1/451-od «Ob utverzhdenii territorial'noj skhemy obrashcheniya s othodami, v tom chisle s tverdymi kommunal'nymi othodami, v Krasnoyarskom krae» [Order of the Ministry of Natural Resources and Ecology of the Krasnoyarsk Territory of September 23, 2016 N 1/451-od «On Approving the Territorial Scheme of Waste Management, including Solid Municipal Waste, in the Krasnoyarsk Territory»]. (In Russian).
20. Postanovlenie Pravitel'stva Arhangel'skoj oblasti № 250-pp ot 29.05.2018 «O vnesenii izmenenij v territorial'nuyu skhemu obrashcheniya s othodami, v tom chisle s tverdymi kommunal'nymi othodami, na territorii Arhangel'skoj oblasti» [Decree of the Government of the Arkhangelsk region No. 250-pp dated 05.29.2018 «On amendments to the territorial scheme of waste management, including solid municipal waste, in the Arkhangelsk region»]. (In Russian).

DOI: 10.24411/2658-4255-2019-10068

HEALTH RISKS AND OCCUPATIONAL PATHOLOGY DURING EXTRACTION OF FUEL AND ENERGY MINERALS IN THE ARCTIC ZONE OF RUSSIA

S. A. Gorbanev, S.A. Syurin
North-West Public Health Research Center, St. Petersburg, Russia
s-znc@mail.ru, kola.reslab@mail.ru

Introduction. Combination of the harsh Arctic climate and harmful working conditions has a negative impact on many occupational diseases. The aim of the study was to assess the working conditions and occupational pathology of workers who are involved in oil, gas and coal production in the Arctic. Materials and methods. The data of social and hygienic monitoring "Working conditions and occupational morbidity" of the population of the Arctic zone of Russia in 2007-2017 were studied. Results. It has been established that there are no workplaces in coal mining with satisfactory working conditions, and more than 90% of miners have extremely unsatisfactory workplaces. In contrast, 51.8% of oil and gas workers have satisfactory working conditions and less than 4% work in extremely unsatisfactory conditions. The most common occupational diseases among miners were radiculopathy (32.1%), chronic bronchitis (27.7%) and mono-polineuropathy (15.4%). Within the structure of the occupational diseases of oil and gas industry workers, sensorineural hearing loss (48.8%), radiculopathy (20.9%) and vibration disease (18.6%) prevailed. In 2017, the level of occupational diseases among miners in the Arctic was 2.82 times higher than the national figure, while in oil and gas production it was 1.75 times lower than the national figure. The risk of occupational diseases in coal mining was significantly higher than that of oil and gas production workers (RR=331.1; CI 242.2-452.5). Conclusion. In view of the above, comprehensive measures to protect the health of coal miners in the Arctic are a priority area of work for occupational safety and medicine professionals.

Keywords: coal mining, oil and gas industry, working conditions, occupational pathology, Arctic.

Introduction Huge mineral resources of the Arctic zone of Russia have led to creation of the largest manufacturing facilities in the country in this area with extreme natural and climatic conditions. These include enterprises engaged in extraction of fuel and energy minerals. The largest oil and gas production enterprises are located in the Yamal-Nenets and Nenets Autonomous Okrugs. Oil and gas are produced to a lesser extent in the Taymyrsky Dolgano-Nenetsky District of Krasnoyarsk Krai and the Chukotka Autonomous Okrug. Coal is mainly mined in Vorkuta and in lesser amounts in the Chukotka Autonomous Okrug and the Taymyrsky Dolgano-Nenetsky District [1, 2, 3, 4].

It is known that the combination of severe natural and climatic conditions of the Arctic regions with harmful working conditions accelerate formation and aggravate progression of many occupational diseases (PD) [5, 6, 7]. Fibrogenic aerosols [8, 9, 10, 11] are considered to be a specific harmful production factor in coal mining, and sulphur-containing compounds (hydrogen sulphide, mercaptans, carbon disulphide, sulphur anhydrite, sulphuric acid anhydride, sulfuric dust), which belong to the substances of the 2nd - 4rth hazard classes [12, 13, 14, 15], are considered to be specific harmful production factors in coal mining. Diseases arising as a result of extraction of minerals, primarily musculoskeletal and nervous systems, respiratory organs, sensorineural hearing loss (noise effects of the inner ear) are the main reason for premature occupational capacity decrement or loss [16, 17, 18, 19].

At the same time, the highest level of occupational morbidity in Russia is observed in coal mining, which in 2017 amounted to 103.11 cases per 10,000 workers [20]. Under conditions of limited human resources, premature termination of employment by qualified specialists is a serious obstacle to the social and economic development of the Arctic region [21].

The "Fundamentals of the state policy of the Russian Federation in the Arctic for the period up to 2020 and long term" [22] has set the task to achieve reliable operation of life support systems and production activities in this important region. Part of this task is to develop a set of measures aimed at preservation of the health and work capacity of the Arctic population.

The purpose of the study was to compare the working conditions and occupational pathology of workers involved in oil, gas and coal production in the Arctic zone of Russia.

Materials and methods. The data of social and hygienic monitoring "Working conditions and occupational morbidity" of the population of the Arctic zone of Russia in 2007-2017 were studied. Information has been delivered by the Federal Hygiene and Epidemiology Centre of the the Federal Service for Supervision of Consumer Rights Protection and Human Well-Being, Moscow. They included data on the annual number of initially diagnosed patients with occupational diseases and their nosological form, the number of persons in contact with the harmful production factors and their nature, the types of economic activities of the diseased, and the type of economic facilities controlled by Rospotrebnadzor.

The research results were processed using Microsoft Excel2010 software and Epi Info, v. 6.04d. The Student's t-test for independent samples, approval criterion, relative risk (RR) and 95% confidence interval (CI) were determined. Numerical data are presented in the form of arithmetic mean and standard error (M±m). Differences in indicators were considered significant at $p<0.05$.

Table 1

Average annual number of employees (absolute, %) at the facilities of supervision groups engaged in coal, gas and oil production in the Arctic in 2007-2017

Group of the supervised facilities	Extracted raw materials		p
	Coal	Gas and oil	
1st	-	41873 (51.8)	<0.001
2nd	909 (9.8)	35782 (44.3)	<0.001
3rd	8331 (90.2)	3182 (3.9)	<0.001
Totally	9240	80837	

Results of the study. The data of 1,891 employees, who during the period of 2007-2017 were diagnosed with 2339 occupational diseases for the first time, were studied. Among them, 1,851 persons were employed in coal mining, including 1,777 in Vorkuta, 73 in the Chukotka Autonomous Okrug and 1 in the Taymyrsky Dolgano-Nenetsky District of the Krasnoyarsk Krai. There were 40 people employed in the oil and gas industry, including 34 in the Yamal-Nenets Autonomous Okrug, 4 in the Nenets Autonomous Okrug and 2 in the Taimyr Dolgano-Nenets district. The average age and length of service of the coal mining industry workers were less than that of the oil and gas industry workers, amounting to 50.9±0.1 and 54.2±0.8 years ($p<0.001$) and 24.5±0.1 and 26.9±1.2 years ($p<0.05$), respectively. Among the coal miners there were 56 (3.0%) women, while all the employees of oil and gas enterprises were men.

Working conditions in the mining industry were compared based on the average annual number of jobs at the facilities of various supervision groups of sanitary and epidemiological welfare in 2007-2017. It has been established that in coal mining there are no facilities of the first supervision group of sanitary and epidemiological welfare (jobs with satisfactory working conditions), and more than 90% of miners are employed in the facilities of the third supervision group (with extremely unfavourable working conditions). In contrast to miners, more than half of the oil and gas workers were employed in the facilities of first supervision group with satisfactory working conditions, and only 4% of them were employed at the enterprises of the third group of sanitary and epidemiological welfare with extremely unfavourable working conditions. For the number of workers present in each of the three supervised groups, the differences between coal miners and persons employed in the oil and gas companies were statistically significant. In general, there were almost 9 times as many oil and gas workers in the Arctic zone of Russia as there were miners of coal mining companies (Table 1).

Comparison of working conditions in the mining industry by the average annual number of persons who had contact with one or another harmful production factor also revealed significant differences between the two groups of workers.

When mining coal, miners are more likely to be exposed to strongly fibrogenic aerosols, have a worse illumination, and are effected by a

Table 2

Average annual number of employees (absolute, %) exposed to harmful production factors during coal, oil and gas production in the Arctic in 2007-2017

Harmful production factor	Extracted raw materials		p
	Coal	Gas and oil	
Strongly fibrogenic aerosols	3509 (21.3)	707 (1.4)	<0.001
Chemical factors	60 (0.4)	2372 (4.8)	<0.001
Severity of work	171 (1.0)	2717 (5.5)	<0.001
Intensity of work	210 (1.3)	626 (1.3)	-
Noise	688 (4.2)	16844(33.8)	<0.001
Infrasound	83 (0.5)	298 (0.6)	>0.1
General vibration	488 (3.0)	2214 (4.4)	<0.001
Local vibration	148 (0.9)	292 (0.6)	
Nonionizing electromagnetic fields and radiation	304 (1.8)	3638 (7.3)	<0.001
Ionizing radiation	11 (0.1)	464 (0.9)	<0.001
Illumination	2705 (16.4)	476 (0.9)	<0.001
Microclimate	332 (2.0)	4779 (9.6)	<0.001
Biological factors	-	379 (0.8)	<0.001
Joint action	7762 (47.1)	14022(28.1)	<0.001

Table 3

The number of occupational diseases arising from various working conditions in coal, oil and gas production in the Arctic in 2007-2017 (absolute, %).

Indicator	Extracted raw materials		p
	Coal	Gas and oil	
Class of working conditions:			
class 2	7 (0.3)	1 (2.3)	>0.2
class 3.1	273 (11.4)	18 (41.9)	<0.001
class 3.2	838 (36.4)	18 (41.9)	>0.2
class 3.3	625 (27.5)	6 (14.0)	<0.02
class 3.4	502 (22.0)	-	<0.001
class 4	51 (2.3)	-	>0.2
Factors causing development of occupational diseases:			
Severity of work (class 3.1 and more)	948 (42.7)	10 (23.3)	<0.001
Fibrogenic aerosols	581 (24.4)	1 (2.3)	<0.001
Local vibration	444 (19.5)	2 (4.7)	<0.01
Noise	199 (8.0)	21 (48.8)	<0.001
Substances of I-IV hazard classes	90 (4.1)	1 (2.3)	>0.5
General vibration	25 (1.0)	7 (16.3)	<0.01
Microclimate (cooling)	7 (0.2)	-	>0.5
Intensity of work	2 (0.1)	1 (2.3)	>0.5
Circumstances determining the development of occupational diseases:			
design defects of machinery, mechanisms, equipment, devices and tools	1620 (73.1)	52 (12.1)	<0.001
imperfection of workplaces	428 (19.5)	117 (27.1)	>0.1
technological process imperfection	214 (6.6)	255 (59.2)	<0.001
malfunctioning of machines and mechanisms	32 (0.8)	-	>0.5
derogation from the process regulation	-	5 (1.2)	>0.5
imperfection of technical medical equipment	2 (0.1)	2 (0.5)	>0.5
violation of safety regulations	-	2 (0.5)	>0.5

combination of several harmful factors.

Chemical and biological factors, severity of work, noise, infrasound, non-ionizing electromagnetic fields and radiation, ionizing radiation have a greater proportion in the structure of harmful production factors of oil and gas production enterprises workers (tab. 2).

Coal miners are more likely to have occupational diseases under working conditions of hazard classes 3.3 and 3.4. Harmful production factors determining development of occupational diseases are mainly severity of work, strongly fibrogenic aerosols and local vibration. All other factors account for only 13.4% of occupational diseases. In the vast majority of cases (92.6%), the reasons for harmful production factors are structural defects of machines, mechanisms and other equipment, as well as imperfection of workplaces.

Oil and gas industry employees are more likely to be diagnosed with occupational diseases when working under hazard class 3.1 conditions. In comparison with miners, occupational pathology is mainly developed because of exposure to noise and general vibration. A common risk factor for occupational diseases in both groups of workers is severity of work. In the oil and gas industry, 80.6% of cases of exposure to harmful production factors is related to imperfection of technological processes and workplaces (tab. 3).

The number of occupational diseases per miner was higher than an oil and gas worker had: 1.24±0.01 and 1.08±0.04 cases respectively ($p<0.001$). The nature of health disorders in the two groups of employees compared had significant differences (Table 4). Thus, within the structure of occupational pathology of miners, disorders of musculoskeletal system, respiratory organs and nervous system had a more significant proportion, and within the structure of pathology of workers of oil and gas enterprises, the most common were diseases of the ear and mastoid process, as well as injuries, intoxication and some other consequences of

Table 4
Nosological structure of occupational pathology of employees in coal, oil and gas production in the Arctic in 2007-2017 (abs., %).

Indicator	Extracted raw mate-rials		p
	Coal	Gas and oil	
Occupational disease classes			
musculoskeletal disorders	831 (36.2)	9 (20.9)	<0.02
respiratory disease	664 (28.9)	1 (2.3)	<0.001
nervous disorders	516 (22.5)	3 (7.0)	<0.001
diseases of the ear and mastoid process	199 (8.7)	21 (48.8)	<0.001
injuries, intoxication and some other consequences of external causes	77 (3.4)	8 (18.6)	<0.02
neoplasms	6 (0.3)	-	>0.5
circulatory diseases	3 (0.1)	-	>0.5
diseases of the skin and subcutaneous tissue	-	1 (2.3)	>0.5
The most common diseases:			
radiculopathy	737 (32.1)	9 (20.9)	>0.05
chronic bronchitis	637 (27.7)	-	<0.001
mono-polyneuropathy	354 (15.4)	3 (7.0)	<0.05
sensorineural hearing loss	199 (8.0)	21 (48.8)	<0.001
vegetative-sensory polyneuropathy	162 (7.1)	-	
vibration disease	75 (3.3)	8 (18.6)	<0.02
myofibrosis	52 (2.3)	-	>0.5
osteoarthritis deformans	32 (1.4)	-	>0.5

external causes. Miners had radiculopathy, chronic bronchitis and mono-polineuropathy among the three most common nosological units of occupational diseases. Sensorineural hearing loss (inner ear noise effects), radiculopathy and vibration disease were the most common diagnoses of those engaged in gas and oil extraction.

Mineworkers were more likely to be diagnosed with occupational pathologies through periodic medical examinations (56.7%), while oil and gas production personnel were more likely to be diagnosed through self-administration due to health problems (62.8%).

In the Arctic zone of Russia, the annual number of coal miners who had their first occupational diseases, ranged from 108 (2007) to 223 (2013). The level of occupational diseases over the course of eleven years had a significant tendency to increase. All the years it was significantly higher than in oil and gas production in the Arctic zone of Russia, as well as in all types of economic activities in the Arctic zone of Russia and in Russia as a whole (Fig.). In 2017, the level of occupational diseases in coal mining in the Arctic was 2.82 times higher than the same national indicator (103.11 per 10,000 employees). The risk of occupational diseases in coal mining in Vorkuta and the Chukotka Autonomous Okrug did not differ significantly (RR=1.12; CI 0.90-1.40; $\chi2$=1.11; p=0.2919).

The annual number of oil and gas production workers who first were diagnosed with occupational diseases varied from 0 to 7 people. The level of occupational morbidity in oil and gas production during the whole period of observation was lower than in coal production, as well as in all types of economic activities in the Arctic zone of Russia and nationwide. In 2017, these differences were 240.1 times, 9.28 times and 1.08 times, respectively (Fig.). In 2017, the level of occupational diseases in oil and gas production in the Arctic was 1.75 times lower than the same national indicator (2.12 per 10,000 employees). Employees of the main oil and gas producing regions - the Yamal-Nenets Autonomous Okrug and the Nenets Autonomous Okrug - did not have any significant differences in their health risks: RR=2.50; CI 0.89-7.05; $\chi2$=3.23; =0.0724.

Comparison of probability of occupational pathology in the process of extraction of various fuel and energy minerals has shown that it is higher than that of oil and gas in the process of extraction of coal (RR=331.1; CI 242.2-452.5; $\chi2$=1637.8; p<0.001), all economic activities in the Arctic (RR=15.1; CI 15.0-16.5; $\chi2$=20009.5; p<0.001) and nationwide (OP=224.6; CI 195.8-257.5; $\chi2$=44275.4; p<0.001). In oil and gas production, the risk of occupational diseases development was lower than in all economic activities in the Arctic (RR=0.05; CI 0.03-0.06; $\chi2$=767.0; p<0.001) and was close to the nationwide level of occupational diseases (RR=1.08; CI 0.52-2.27; $\chi2$=0.04; p=0.8334).

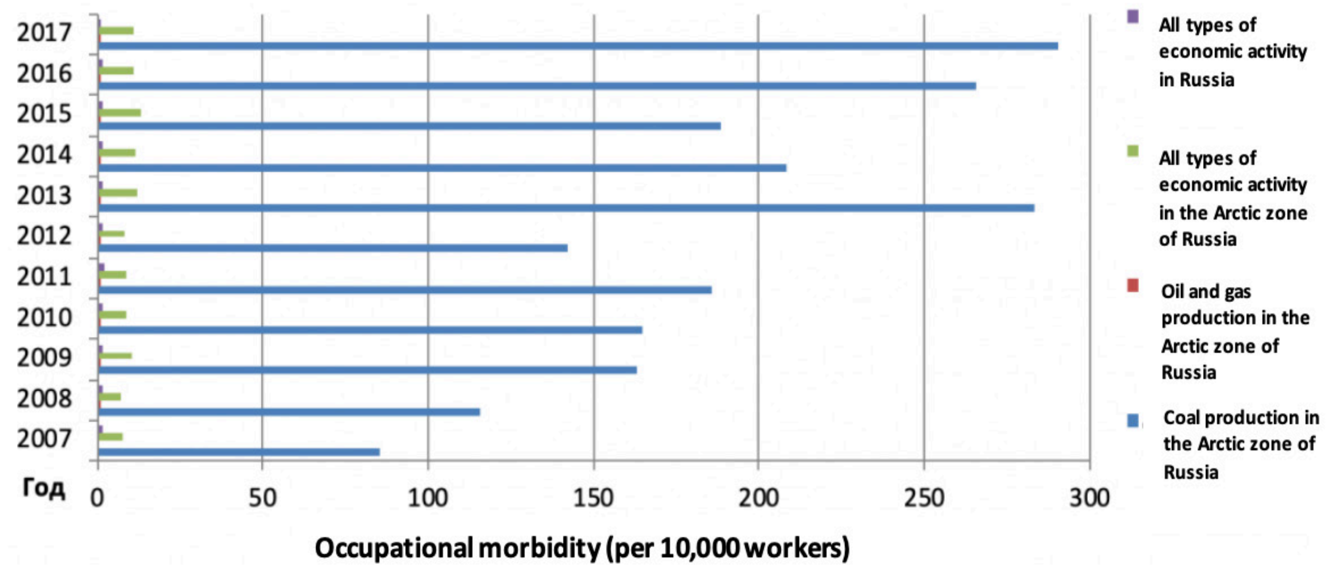


Figure 1. Annual occupational diseases in coal, oil and gas production in the Arctic, all economic activities in the Arctic and in Russia (per 10,000 workers).

Having analysed the results of the study, it can be reasonably stated that the working conditions of workers involved in coal, gas and oil production in the Arctic zone of Russia, have significant differences.

The fact that at the time of detection of an occupational disease, the age and length of service of employees of oil and gas enterprises were higher than that of miners, indicates an increase in the period of working capacity under more favourable working conditions.

Two groups of employees, in addition to the different intensity of exposure to harmful production factors, have significant differences in their structure, which probably determines the specifics of emerging health problems. At the same time, it should be noted that the proportion of harmful factors in their overall structure often does not correspond to the etiological significance of the factor in development of occupational pathology. Thus, if within the overall structure of harmful factors which influence coal miners, proportion of increased severity of work and local vibration is 1% and 0.9%, respectively, then within the impacts related to development of occupational diseases it is 42.7% and 19.5%, respectively. A similar situation is observed among the employees of oil and gas production enterprises. 23.3% and 16.3% of occupational diseases were caused by the severity of work and general vibration which made up 5.5% and 4.4% respectively within the total structure of harmful factors.

Since the study was conducted in the Arctic zone of the country, special attention was paid to the frequency of detection of the cooling microclimate of workplaces. It is well known that chronic cold stress contributes to reduction of physical performance and mental capacity, chronic pain syndrome, respiratory diseases, increased risk of industrial injuries [23, 24, 25]. Within the structure of harmful factors at the oil and gas industry enterprises, the cooling microclimate was one of the most widespread (9.6%). However, in none of the cases it was recognized as an etiological factor in development of occupational diseases. A similar situation was observed among coal miners. Within the structure of harmful factors, the proportion of cooling microclimate was 2.0%, and it was considered the reason for development of occupational diseases in 0.2% of the cases. The obtained data allow us to assume that in the course of expert assessment of occupational diseases, significance of some harmful production factors unreasonably increases (e.g., the severity of work), and significance of others is underestimated (e.g., the cooling microclimate).

The obtained data on relatively favourable working conditions and low level of occupational pathology defy stereotypes about the extreme nature of the work of oil and gas production workers in the Arctic [26].

Of course, factors that distort the true state of affairs may be unqualified special assessment of working conditions and periodic medical examinations of workers [27, 28]. It cannot be excluded that the low level of occupational morbidity of oil and gas industry workers can be related to some extent to the widespread work on a rotational basis, which makes it difficult to register all diseases [29, 30]. It may also be important that some workers hide their true health condition to maintain a highly paid job in the gas industry [31].

Conclusion: In 2007-2017, there was no significant improvement in working conditions at coal mining enterprises in the Arctic zone of Russia. The level of occupational morbidity of Arctic miners is 2.82 times higher than the national figures for coal mining and has no tendency to decrease. Compared to miners, oil and gas workers have significantly less harmful working conditions and a low level of occupational diseases. In view of the above, comprehensive measures to protect the health of coal miners in the Arctic are a priority area of work for occupational safety and medicine professionals.

References:

1. JSC Vorkutaugol. About company. (in Russian). Available at: vorkutaugol.ru/rus/about/index.phtml (accessed 13 Jan., 2019).
2. Chukotka Autonomous District. Passport. (in Russian). Available at: minpromtorg.gov.ru/common/upload/files/docs/pasregions/ (accessed 13 Jan., 2019).
3. Nenets Autonomous Okrug. Reference Information. (in Russian). Available at: http: //adm-nao.ru/ (accessed 13 Jan., 2019).
4. Kontorovich A.E. Neft' i gaz rossijskoj Arktiki: istoriya osvoeniya v XX veke, resursy, strategiya na XXI vek [Oil and gas of the Russian Arctic: development history in the twentieth century, resources, strategy for the XXI century]. Nauka iz pervykh ruk [First-hand science]. 2015. Vol. 1. № 61. (in Russian). Available at: http://nsu.ru:8080/6d3c28a920ac894f92c00d76835d4bc0.
5. Izmerov N.F. Problemy mediciny truda na Krajnem Severe [Problems of occupational medicine in the Far North]. Medicina Truda i Promyshlennaya Ekologiya [Russian Journal of Occupational Health and Industrial Ecology]. 1996. № 5. P. 1-4. (in Russian).
6. Profilaktika professional'nyh zabolevaniy, vyzvannyh sochetannym vozdeystviem vibracii, shuma i ohlazhdayushhego mikroklimata na predpriyatiyah gornodobyvayushhey promyshlennosti: metodicheskie rekomendacii [Prevention of occupational diseases caused by the combined effects of vibration, noise and cooling climate in the mining industry: guidelines]. Moscow, 1991. (in Russian).
7. Myshinskaya J.M. Vliyanie klimaticheskih i ekologicheskih faktorov na zdorov'e cheloveka v usloviyah Krajnego Severa [The influence of climatic and environmental factors on human health in the Far North]. Yamalskiy Vestnik [Yamal Bulletin]. 2016. Vol. 2. № 7. P. 79-80. (in Russian).
8. Laney A.S.,Weissman D.N. Respiratory Diseases Caused by Coal Mine Dust. Journal of Occupational and Environmental Medicine. 2014. Vol. 56. № 010. P. 18–22. doi: [10.1097/JOM.0000000000000260]. Available at: https: //www.ncbi.nlm.nih.gov/pmc/articles/PMC4556416/. (accessed 13 Jan., 2019).
9. Timofeeva S.S., Murzin M.A. Pylevaya nagruzka pri dobyche uglya i professional'nye riski [Dust load in coal mining and occupational hazards]. Vestnik IrGTU [Bulletin of IrTU]. 2015. Vol. 5. № 100. P. 68-71. (in Russian).
10. Blackley D.J, Halldin C.N., Laney A. S. Continued Increase in Prevalence of Coal Workers' Pneumoconiosis in the United States, 1970–2017. American Journal of Public Health. 2018. Vol. 108. № 9. P. 1220–1222. doi: 10.2105/AJPH.2018.304517. (accessed 13 Jan., 2019).
11. Beer C., Kolstad H. A., Søndergaard K., Bendstrup E., Heederik D., Olsen K. E. et al. A systematic review of occupational exposure to coal dust and the risk of interstitial lung diseases. European Clinical Respiratory Journal, 2017. Vol. 4. 1264711, doi: 10.1080/20018525.2017.1264711. Available at: https://doi.org/10.1080/20018525.2017.1264711. (accessed 13 Jan., 2019).
12. Esswein E.J., Alexander-Scott M., Snawder J., Breitenstein M. Measurement of area and personal breathing zone concentrations of diesel particulate matter during oil and gas extraction operations, including hydraulic fracturing // Journal of Occupational and Environmental Hygiene. 2018. Vol. 15. № 1. P. 63-70. doi: 10.1080/15459624.2017.1388512. Available at: ttps:// www.ncbi.nlm.nih.gov/pubmed/29053946 (accessed 19 Jan., 2019).
13. Witter R.Z., Tenney L., Clark S., Newman L.S. Occupational exposures in the oil and gas extraction industry: State of the science and research recommendations. //American Journal of Industrial Medicine. 2014. Vol. 57. № 7. P. 847–856. doi: 10.1002/ajim.22316. Available at: https://www.hcn.org/articles/cdc-reports-suspected-oil-and-gas-inhalation-fatalities (accessed 19 Jan., 2019).
14. Kireev I.R., Murzabaeva E.I., Saidova A.K. Ohrana zdorov'ya personala v neftyanoj promyshlennosti [Protecting the health of personnel in the oil industry] //Vestnik molodogo uchenogo UGNTU [Bulletin of the Young Scientist of USTU]. 2016. Vol. 8. № 4. P. 127–32. (in Russian).
15. DotsenkoYu.I., Boyko V.I., Gudinskaya N.I., Mukhamedzyanova R.I. Nekotorye aspekty gigieny truda v neftegazovoj promyshlennosti [Some aspects of occupational hygiene in the oil and gas industry] //Sovremennye Problemy Nauki i Obrazovaniya [Modern Problems of Science and Education]. 2017. № 5. Available at: http://www.science-education.ru/ru/article/view?id=26774 (accessed 19 Jan., 2019). (in Russian).
16. Solonin Yu., Pancheva G., Boiko E. Work environment and workers´ health risks in the coal industry of the Komi Republic (Russian Federation). Barents Newsletters on Occupational Health and Safety. 2009. Vol. 12. № 1. P. 5-6.
17. Gudimov D.V., Chemezov E.N. Professional'nye zabolevaniya v ugol'noj promyshlennosti Respubliki Saha (Yakutiya) [Occupational diseases in the coal industry of the Republic of Sakha (Yakutia)]. Gornyy informacionno-analiticheskiy byulleten' (nauchno-tekhnicheskiy zhurnal) [Mining Information and Analytical Bulletin (scientific and technical magazine)]. 2014. № 9. P. 348–351 (in Russian).
18. Ikonnikova N.V. Morbidity of gas-transport company workers, and measures to reduce it [Zabolevaemost' rabotnikov gazotransportnogo predpriyatiya i meropriyatiya po ee snizheniyu] // Meditsina Truda i Promyshlennaya Ecologiya [Russian Journal of Occupational Health and Industrial Ecology]. 2017. № 9. P. 83-4. (in Russian)
19. Manoj Kumar R.M, Karthick R.B, Bhuvaneswari V., Nandhini N. Study on Occupational Health and Diseases in Oil Industry. International Research Journal of Engineering and Technology. 2017. Vol. 4. № 12. P. 954-958. Available at: https://www.irjet.net/archives/V4/i12/IRJET-V4I12180.
20. O sostoyanii sanitarno-epidemiologicheskogo blagopoluchiya naseleniya v Rossijskoj Federacii v 2017 godu: Gosudarstvennyj doklad. Federal'naya sluzhba po nadzoru v sfere zashchity prav potrebitelej i blagopoluchiya cheloveka [On the state of sanitary and epidemiological welfare of the population in the Russian Federation in 2017: State report]. Moscow. 2018. (in Russian).
21. Krasulina O. Y. Arkticheskaya zona Rossijskoj Federacii: osobennosti prirodno-ekonomicheskih i demograficheskih resursov [Arctic zone of the Russian Federation: features of natural, economic and demographic resources]. Regional'naja ekonomika i upravlenie [Regional Economics and Management]. Available at: https://eee-region.ru/article/4805/ (accessed 19 Jan., 2019). (in Russian).
22. Ob osnovakh gosudarstvennoy politiki RF v Arktike na period do 2020 goda I dal'neyshuyu perspektivu [On the fundamentals of the state policy of the Russian Federation in the Arctic for the period up to 2020 and beyond] Rossiyskaya gazeta [Russian newspaper]. № 4877. 18.09.2008 (in Russian).
23. Anttonen H., Pekkarinen A., Niskanen J. Safety at work in cold environments and prevention of cold stress //Industrial Health. 2009. Vol. 47. № 3. P. 254–261.
24. Hassi J., Rytkönen M., Kotaniemi J., Rintamäki H. Impacts of cold climate on human heat balance, performance and health in circumpolar areas //International Journal of Circumpolar Health. 2005. Vol. 64. № 5. P. 459–467.
25. Kue T., Mäkinen T. The health of Arctic populations: Does cold matter? // American Journal of Human Biology. 2010. № 22. P. 129–133.
26. Syurin S.A., Gorbanev S.A. Professional'naya patologiya na predpriyatiyah Neneckogo avtonomnogo okruga: faktory riska, struktura, rasprostranennost' [Occupational pathology at the enterprises of the Nenets Autonomous District: risk factors, structure, prevalence] // Gigiena i sanitariya [Hygiene and Sanitation]. DOI: http://dx.doi.org/10.18821/0016-9900-2019-98-6-652-656 (in Russian).
27. Khoruzhaya O.G., Gorblyansky Yu.Yu., Piktushanskaya T.E. Kriterii ocenki kachestva medicinskih osmotrov rabotnikov [Criteria for assessing the quality of medical examinations of workers]. Meditsina Truda i Promyshlennaya Ekologiya, [Russian Journal of Occupational Health and Industrial Ecology]. 2015. № 2. P. 21-26. (in Russian)
28. Syurin S.A., Gorbanev S.A. Профессиональная пато-

логия: как сохранить здоровье работающего человека [Occupational pathology: how to maintain health of a working person]. Bezopastnost´ i OkhranaTruda [Occupational Safety]. 2018. № 3. P. 48-50 (in Russian)

29. Alekseenko V.D., N.N. Simonova N.N., Zueva T.N. Vliyanie proizvodstvennyh faktorov na sostoyanie zdorov'ya rabotnikov neftedobychi pri vahtovoj organizacii truda v Zapolyar'e [The impact of production factors on the health status of oil production workers in rotational labor organization in the Arctic]. Ekologiya Cheloveka [Human Ecology]. 2009. № 5. P. 47-50. (in Russian).
30. Korneeva Ya.A., Dubinina N.I., Simonova N.N., Degteva G.N., Fedotov D.M. Riski v professional'noj deyatel'nosti vahtovyh rabotnikov v usloviyah Krajnego Severa [Risks in the professional activities of rotational workers in the Far North]. Byulleten' VSNTs SO RAMN [Bulletin of WSSC of SB of RAMS]. 2013. Vol. 91. № 3. P. 83–88. (in Russian).
31. Dubinina N.I., Degteva G.N., Korneeva Ya.A. Osobennosti provedeniya predvaritel'nyh i periodicheskih medicinskih osmotrov personala v usloviyah raboty vahtovym metodom na Arkticheskom shel'fe [Features of the preliminary and periodic medical examinations of staff in working conditions on a rotational basis on the Arctic shelf]. Byulleten' VSNTS SO RAMN [Bulletin of WSSC of SB of RAMS]. 2012. Vol. 87. № 5. P. 127–30. (in Russian.).

«Russian Arctic» is a scientific peer-review journal, established in 2018. It publishes open access academic/scholarly research in Russian and English. Full text are available online.

ISSN (Online): 2658-4255

Focus and scope

- enable the scientists studying the Arctic to quickly publish the results of their research;
- provide scientific support to strategic projects in the Arctic;
- draw the attention of a wide audience to healthcare issues faced by the Arctic's indigenous population, to the environment and climate of the Russian North;
- provide Russian and foreign scientists with a platform for dialogue and exchange of knowledge;
- increase the prestige of Russian scientific research at the global level.

Sections

Manuscripts on the following subjects are accepted for publication:

- 1100 Agricultural and biological sciences
- 2737 Physiology (Medical)
- 2210 Mechanical engineering
- 2100 Energy
- 1900 Earth and Planetary Sciences

Publication frequency

4 times a year; special and thematic issues are published on request.

RUSSIAN-ARCTIC.INFO

Russian Arctic