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WHY SHOULD WE STAND FOR GEOTHERMAL ENERGY? EXAMPLE OF THE NEGATIVE IMPACTS OF OIL AND GAS EXPLORATION ACTIVITIES OVER THE MARINE ENVIRONMENT

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Geothermal energy is a clean, environmentally friednly, renewable resource that provides energy around the world. Heat flowing constantly from the interior of the Earth ensure to be an inexhaustible supply of energy. However, existing traditional sources of energy, such as oil and gas are still popular nowadays. Current paper gives a remarkable example of how eco - non friendly and environmentally dangerous these sources of energy are. The given example of oil and gas operations within the Timan-Pechora basin in the shelf and the coast of the Pechora Sea causes contamination of waters by phenol and its accumulation in the bottom sediments and life tissues of the marine habitants. At the same time, the ecosystems of the south-eastern part of the Barents sea, the Pechora Sea, are characterized by their high biodiversity and high level of primary production. The last one is the fundamental biological characteristics for the marine ecosystems meaning the formation of the organic substance in the water by the chlorophyll-contains organisms – phytoplankton. The primary production plays an exceptional role in the functionality of the marine ecosystem's components as the level of primary production is a basic element in the ecological food-chain hierarchy and therefore, the ecosystem with damaged phytoplankton operation and low level of primary production dooms to die.

Therefore, the broad objective of the study was to identify location of main carbon deposits as sources of phenol contaminations accordingly to the nature features of the Pechora Sea ecosystem and to compare them with the distribution of the areas with high biological productivity and higher level of the primary production within the Pechora Sea. The results of the research demonstrate that both are located in the south-eastern part of the Pechora Sea. Thus, the major deposits of oil in Pechora Sea and amongst the Prirazlomnoe oil-field with large reserves of hydrocarbons are situated exactly in the eastern part of the Pechora Sea, some of them are located in immediate proximity to the coast. At the same time, shelf zone of the Pechora Sea is distinguished for its high level of the primary production, high bioproductivity and uniqueness of its natural resources, extremely hardly renewable under the conditions of the polar environment.

This paper details question of the ecological interrelation of the natural ecosystems and man's activities in this region, where any negative industrial human impacts can have an un-compensable consequences for the unique environment of this little sea. Also, the capability of aquatic ecosystem to resist towards human negative effects was examined, depending on the structure and character of its fundamental ecological components (e.g. types of bottom sediments, relief of the sea floor, and the direction of currents transferring).

Introduction. At present, among all the types of the sea water contaminations in the Arctic Ocean, the most vital part plays phenol and hydrocarbon contamination, what could be taken up as an example of global technogene contamination. Annual entrance of oil products from different sources into the marine environment of World Ocean in general estimates of about 1.7—8.7 mil tons, what exceeds natural confluent of oil [5]. Main causes of the seawater pollution by phenol and other contaminants are consequences of the oil spilling during the mining works, the damages and the

accidents at the pipelines, shipwrecks, oil drilling and rigs. Besides phenol contamination, petroleum extraction brings others 'satellite' contaminants e.g. heavy metals, nitric oxides, benz(a)pyrene etc. Phenol contamination is closely related with more and more increasing oil-drilling activities within the marine aquasystems of Barents, Pechora, Norway Seas, its transportation as a fuel of lubricanting oils and other secondary chemical products.

Determinative factor in formation of modern ecological conditions of the hydrochemistry in the Pechora Sea has anthropogenic impact, namely, geological activities in the shelf and coastal regions [11]. It is closely connected with the intensity of the exploitation of the Timan-Pechora carbon basin and the Pechora coal-basin – major parts of industrial structure of the Nenets autonomous region. The Timan-Pechora oil-gas carbon basin is the largest source of raw fuel-energy materials in the northern part of Russia. Within the Nenets, autonomous region 76 deposits of oil and gas are discovered, including 64 oil-fields, 6 oil-gas, 4 gas-fields and 1 gas-oil deposit [16].

Conditions for oil contamination. Climatically, eastern part of the Pechora Sea differs a lot from its western part, being similar to this of Kara Sea. The temperature of the eastern part of the Pechora region is extreme, very likely to Kara Sea, whereas the air temperatures of the western part of the Pechora are generally continue the Barents Sea climatic conditions. The Pechora Sea has one of the mildest wind climate among other Arctic seas. The magnitude of the wind speed in the neighbouring seas (Barents and Kara) is quite similar, and this of Pechora is differs from them. Meanwhile, the characteristics of the wind (its magnitude and directions) are responsible for different climate, currents and certain ice conditions in the Pechora Sea [6]. Western part of the Barents Sea has the most severe wave climate [6]. The Gulf Stream continues here, thus making westerns Barents Sea turbulent [12]. In contrast to it, the Pechora Sea is sheltered by consequently lowest waves, compared to the western Barents Sea. A constant current of the water in the Pechora Sea is mostly induced by Kanin, Kolguev and Litke through the Kara Gates. The average speed of the Pechora's currents is about 0.02–0.05 m/s, which is lower than in the Barents Sea with its 0.05–0.5 m/s. Significantly higher speeds of water motion are induced only by the drift and tides. Generally, rather passive tempo of currents in the Pechora Sea calls forth certain stagnation and makes favorite conditions for the holding of the oil spills and contaminants within the waters.

Table 2

Monthly mean air temperature and extreme minimum t C° [8].

	January		February		March		April	
	T_{mean}	T_{min}	T_{mean}	T_{min}	T_{mean}	T_{min}	T_{mean}	T_{min}
Barents Sea (central)	-5.0	-24	-7	-25	-6	-24	-3	-22
Western Pechora Sea	-10.6	-40	-12.6	-40	-11.6	-42	-6.7	-32
Eastern Pechora Sea	**-17.5**	**-48**	**-18.3**	**-48**	**-17**	**-46**	**-9.8**	**-37**
Kara Sea	-18.3	-50	-20.1	-50	-20.7	-48	-12.4	-38

Oil and gas activities in the region of Timan-Pechora. Actually, four deposits of the oil-fields are being exploited at the territory of Nenets autonomous region with the total size of 3,5 mil ton annually. At present, the main activities that are been carrying out are the as follows: exploration of the Varandey oil gas field (under construction), the exploratory boring and preparation of the Prirazlomnoe deposit for further exploitation and others. Taking into account the oil drilling and production from Prirazlomnoe and Varandey deposits, the volume of carbon extraction will be increased until the 15-20 mil ton annually [16]. Maximal content of the phenols and oil products in the bottom sediments of the Pechora See is fixed up in the samples, taken in the region Bolvanskiy Nos and also at the sandbar of the Pechora river, where the bottom sediments are represented by the silty sands. High levels of the phenols are fixed in the samples of the bottom sediments, taken by the shelf zone of the cape Konstantinovskiy, which can be explained by the drain of rivers Khylchiya and Dresvyanka where test oil-drilling is being practiced. The content of the phenols in the samples, taken by cape Bolvanovskiy Nos (0.8-0.9 mg/kg) exceeds 8-10 times those in the bottom sediments of the border zone 'bay-sea'. Higher content of the phenols are located in the zones with the siltstone-silty sediments [16].

Sources of the oil contamination in the Pechora Sea. One of the main sources of oil contamination in the Pechora Sea is maritime transportation. At present, due to the exploration of the oil-fields in the Pechora and Barents seas, discharge of the oil products is essentially increased both in the process of exploitation of the deposits, and by the transportation. What is more alerting, the intensity of the navigation, shipping and the oil-loading navy fleet is increased recently as well, which brings additional

sources of the oil contamination in the Pechora Sea [12]. During the oil transportation, the oil spilling do take place occasionally, including the wrecking (by its extraction), which often becomes a disaster. Additional source of the oil products into the Barents Sea is presented by the Gulf Stream currents system, which brings its waters into the Barents basin. The Gulf Stream transfers annually ca. 1-1.5 mil tons of phenols and of oil products within the World Ocean. Separate streams of the Gulf Stream, containing phenols and oil products have different places of discharge, namely, at the coasts of the North America and Europe, among which the Sargasso Sea, the Norway Sea and the Barents Sea.

Distribution of the phenol contaminants within the Pechora Sea. Unequal geographical distribution of the phenol contaminants within the space of the ecosystem is specified and conditional by the different geographic location of the sources of the contaminations, by their chemical features (e.g. forms of their existing in the water), and what is more important, by the particularities of the circulation of the seawater: its vertical structure and currents.

Maximal concentration of the contaminants in the Pechora Sea is detected in the coastal shelf waters, relatively calm and without intensive tiding, where the damping may occur and where they are being accumulated constantly. Some concentrations are occasionally take place (but definitely lesser) in the vast open regions of the sea, where they are curried out from the rest parts of the Gulf Stream and from the North-Atlantic currents systems, being generally transferred from the Barents Sea [7]. High concentrations of the oil aggregation are fixed along the main transport roots, in the shelf zones of the separated seas, and also in the waters coming from the Atlantic Ocean, carrying contaminations from the western Europe and north-western part of Africa [3].

Near the oil drilling stations and along the main ship transport roots the content of phenols and other oil products is higher than those in the open parts of the sea. In the estuaries where the ecological situation is worse, the concentration of oil in the bottom sediments reaches 5-160 mg/kg, coming down to the 0.1-1 mg/kg [2] in the sediments of the open deep sea regions. Distribution of the oil hydrocarbons in the shallow waters is rather homogeneous (0.05—0.15 mg/l) with maximal concentrations (0.4 mg/l) in the south-eastern part of the sea [9]. Vertical distribution of the pollutants within the water: the maximal concentrations of the oil hydrocarbons in the Pechora sea are located in the shelf waters, zone of interaction 'hydrosphere-atmosphere' [5]. At the same time, this layer of the water is very important for the biological activities of the aquatic ecosystem and for the functionality of the marine environment: the process of photosynthesis takes place constantly here [1]. Hence, it becomes clear that the contamination of the most important layer of waters may have extreme consequences for the life existing in the ecosystem of this small sea.

Data processing, methods and results. The distribution of oil and gaz deposits in bottom sediments of Pechora Sea and the contents of the chlorophyll in the shallow waters of the Pechora Sea were visuzlized on the maps. After digitizing the relief of Pechora basin using Autotrace software, the .shp-file was added to the map as a base layer for the thematic layers [13]. Using maps created by other authors and additional thematic information from the cited literature (containing geological and geomorphological characteristics, features of coastal and land relief, morfostructures of the Pechora submarine sea floor relief etc) the thematic maps were designed with the framework of this research [10]. Data containing various characteristics of objects (concentrations of contaminants) and spatial characteristics of objects were added to the current mapping project, References Maps: [1-27].

For mapping of oil and gas deposits within the Pechora basin its geographical natural specifics were studied, especially its geological, geomorphological conditions and tectonics that have impact on the environmental situation as such and distribution of its carbon deposits within the marine basin. For understanding the sustainability of the aquatic systems to resist the anthropogenic impacts, its climatic and meteorological conditions (current directions) were studied as well. Using information and data from the existing thematic maps and tables (References, Literature and Maps [1-27]) both ecological and geographical data of Pechora Sea were compared: first, its geographic aspects (geological, geomorphological and climatic factors) and second, the distribution of the main oil and gas fields within the Pechora basin, making a negative impact to the marine environment of unique Pechora ecosystem. Thematic information layers were stored in the different topological layers (.shp – files of ArcView system) and some mapping routines were executed for creating the final maps: data editing, overlay of different thematic layers thus making the synthesis of different information, creating of the legend, visualization of the layout. Maps visualize distribution of the main oil and gas deposits and the contents of the chlorophyll in the shallow waters of the Pechora Sea. Both maps show the element of the environment in the basin of the Pechora, demonstrating negative impact and effects of the oil and gas drilling activities under the condi-

tions of Arctic vulnerable tundra ecosystems. Two main zones of phenol concentrations are detected in the bottom sediments of the Pechora Sea: in the central part and in its eastern part (the most polluted area), containing Prirazlomnoe oil-field. In the western region the source of water contamination is not only caused by the geological activities, but also by the income of waters from the Barents and the Norway Sea, polluted by phenol and oil. In the south-wertern part of the Pechora Sea the inflow of the contaminated waters from the narrow entrance of the White and Barents Seas can be considered as additional source for the phenol pollution of the Pechora Sea waters. Besides, zone of the high level of contaminants exists in the Kola bay in the Barents sea and in the neighboring aquatory. In the eastern part of the Pechora Sea recent geological activities concerning developing of the Prirazlomnoe oil-field and other smaller oil deposits could give rise to the ecological crisis in the aquatic ecosystems of the Pechora Sea.

Conclusions. As demonstrated in this paper, disastrous impacts on the environment is caused by the oil and gas drilling activities in one of the most environmentally precious regions of our world – Arctic. So, what can we do with it, how can we handle such a problem? Alternative sources of energy, such as geothermal energy, or wind energy can be a perfect replacement for the traditional sources. Moreover, geothermal energy can be effectively used as a supplement for the integrity of the power grid, enhancing the efficiency of the entire system while providing clean, reliable power for the humanity. Geothermal energy is also capable of achieving high capacity factors in results without damaging the ecosystems and our world. Current paper contributed to the popularization of the effective replacement of traditional (oil and gas) energy source by new-generation "green" energy, such as geothermal or wind.

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