Specific environmental risks of the Lena-Tunguska oil and gas province

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Abstract. Oil and natural gas make up a significant part of the global economy, and the extraction of these natural resources is an essential industry. Recently, the rate of extraction of natural resources has increased significantly, the accumulated growth in exploration and discoveries of new and previously mothballed deposits, of course, entail the huge costs for restoring the natural environment. Currently, most of the deposits are located in the northern territories, where there are additional risks to the natural environment. In addition to unfavorable climatic factors that complicate the process of extraction and restoration of land, soils of natural areas are also represented by permafrost, which complicates both the extraction process itself and the process of subsequent land restoration. The impact on the atmospheric air has its negative consequences, at present most of the negative emissions and flaring have been significantly reduced. Nevertheless, there are undoubtedly risks for workers and the living environment in mining areas. In this article, we have tried to present and calculate the environmental risks for the deposits of the Lena-Tunguska oil and gas province. The paper presents the main indicators of the impact on the environment: atmospheric air, soil (waste drilling mud and industrial waste), and the impact of harmful factors on the health of workers. Currently, this impact makes the main negative contribution. The damage is given in a specific equivalent, which gives us an equivalent impact, due to the fact that the total cost of the negative impact is divided by the volume of extracted raw materials.

1. Introduction
The extraction of hydrocarbon resources continues to remain the basis of the economy of modern Russia, and it is moving to the regions of the Far North, the territories of North-Eastern Siberia and the Arctic shelf are being developed [1].

Anthropogenic and technogenic loads have overpowered the ability of the environment to self-purify, which already leads to irreversible processes of degradation and pollution of existing natural environments. But at this stage of its development, humanity is not able to exist otherwise. The modern process of technological development contributes to even greater consumption of resources, the depletion of the subsoil, the divestment of animal habitats, which ultimately affects humans themselves [2]. One of such strategically important elements for the development of any country is the reserves of hydrocarbon resources, namely oil, gas and oil and gas condensates.

The negative impact of enterprises on the environment is controlled at the legislative level. For newly designed facilities, the legislation prescribes an assessment in accordance with Art. 32 of the...
Federal Law No. 7-FZ of January 10, 2002 “On Environmental Protection”, and, in accordance with Art. 67, subsoil users are obliged to conduct industrial control in the field of environmental protection. And the oil and gas industry is no exception.

Earlier, when assessing the environmental impact of the operation of oil and gas production facilities, some of the natural indicators were either not taken into account at all or were concealed. Such an approach was aimed at achieving maximum economic benefits. With increasing intensity and development of the mining industry, the consequences of the negative impact have become more significant. The environment no longer has the opportunity for self-recovering, and without the developed measures aimed at reducing the negative impact, the accumulated damage over the entire period of mining operations is enormous. This incompetence and dishonesty of subsoil users caused the current deplorable environmental situation, equating mining zones with ecological disaster zones [3].

The current trend persists in almost all areas of oil and gas production. The reason is banal - the lack of interest among subsoil users themselves and, as a result, the lack of sufficient material means necessary for the restoration of resource-developed territories. At the present stage, this problem is becoming more acute for companies, but the main reason is not the consciousness of enterprises, but the tightening of requirements at the legislative level and the decline in the profitability of extracted raw materials. That is, environmental problems are becoming the most significant, but it is also more difficult to regulate them because of the significant neglect of the problem [4].

Together with a decrease in the profitability of deposits, depreciation of technological equipment and funds, leading to a deterioration in the quality of raw materials, a deterioration in the efficiency of work due to social problems only aggravates the environmental situation. These aspects have a significant impact on the productivity of companies, especially when it comes to the environmental, which lack investment [5].

The aim of this paper is to estimate a specific indicator of the environmental management risk in areas of development of oil and gas fields in the conditions of North-Eastern Siberia with specific natural and climatic conditions.

2. Study Objects and Methods

The object of our study was the assessment of the environmental risks of oil production, transportation and refining activities in the regions with specific features in the northern territories of the Irkutsk Region and the Republic of Sakha-Yakutia [6].

The object we have chosen to study is the fields in the Lena-Tunguska oil and gas province, which is located within the western part of Yakutia, northern and central regions of the Krasnoyarsk Territory, western and northern regions of the Irkutsk Region (figure 1). The area covered is 2.8 million m².

The objects of the study were the Yarakta, Iktekh, Markovo and Dulisma fields operated in the regions of North-Eastern Siberia.

In this work, to assess environmental risks, we used known methods modified by us, namely, we estimated emissions into the atmosphere, without which it is still impossible to imagine the production of hydrocarbons [7]. Sources of emissions are the combustion of associated gas and excess amounts of hydrocarbons during testing and operation of wells, emissions of “greenhouse gases” CO₂ and CH₄, NOx emissions, emissions of carcinogenic substances, soot and inorganic dust [8]. We calculated the volumes of liquid waste entering the sludge pits and possible spills and emergencies by the area of spills [9] and the area of contaminated soils [10], as well as the direct impact on the life quality of the local population and personnel working at the fields [11]. As the objects of research, we chose the gas fields most promising in the development: The Yarakta, Dulisma, Iktekh and Markovo fields [12].
Figure 1. Lena-Tunguska oil and gas province.

The Dulisma oil and gas condensate field is located in the Katangsky Municipality, 90 km northwest of the city of Kirensk. The design capacity of the Dulisma field amounts to 400-450 thousand tons of oil per year. The license for the development of the field belongs to NK Dulisma, CJSC [13].

The Yarakta oil and gas condensate field is geographically located 140 km northeast of the city of Ust-Kut, closer to the northern part of the Ust-Kut Municipality and the southern part of the Katangsky Municipality of the Irkutsk Region of the Russian Federation. The oil and gas potential of the field is primarily associated with sediments of the Vendian and Cambrian ages, namely, sandstones of the Yarakta horizon with a total thickness of up to 40 m. The resource oil reserve is estimated at 102.5 million tons, and its density is 0.830 g/cm³ or 34° API. The density of the condensate is the same as 0.67-0.71 g/cm³. The license holder for the development of the Yarakta field is a subsidiary of INK LLC – Ust-Kutneftegaz OJSC [14].

The Iktekh oil and gas field is located on the eastern slope of the Mirny ledge in close proximity to the Vilyuchanskaya saddle and is confined to the eponymous brachyanticline of the north-east strike. Reserves of oil (extr.) amount to: category C2 - 6.248 mn tons, category D1l (as of January 1, 2009) - 3.24 mn tons; gas: category C1 - 6.201 bn m³, category C2 - 10.535 bn m³, category D1l (as of January 1, 2009) - 11 bn m³; condensate (extr.): category C1 - 0.147 mn tons, category C2 - 0.248 mn tons [15]. The Markovo oil and gas condensate field is located 160 km south-west of the city of Kirensk, near the village of Verkhnemarkovo in the Irkutsk Region. The oil and gas potential is associated with sediments of the Vendian and Cambrian ages. The first gas-oil (emergency) release with an open flowing with flow rate of about a thousand tons per day was obtained in evaluation well No.1 laid down in the crest position of the Markovo anticline, from a depth of 2162-2164 m (limestone-clay porous fractured reservoir rock of the Osinsky reservoir) [16]. The initial reservoir pressure is not less than 216 atm. Oil reserves amount to 20 million tons. The density of oil is 0.850 g/cm³ or 34° API. The operator of the field is Irkutsk Oil Company [17].
3. Results and Discussion
We have made an assessment of the integral damage in the process of environmental management at 4 exploited fields in the NES regions per ton of oil produced. Table 1 and figure 2 show specific environmental risks for objects of the natural environment and humans.

Specific damage is calculated as an integral indicator of the impact of a specific pollutant per ton of produced raw materials.

Table 1. Indicators of specific environmental risks.

| Environmental management risk                                      | Yarakta field | Iktekh field | Markovo field | Dulisma field |
|-------------------------------------------------------------------|---------------|--------------|---------------|---------------|
| **Specific damage caused by emission into the atmosphere, rub/ton** | 0.0029        | 0.002        | 0.0017        | 0.0025        |
| CO₂, CH₄                                                           | 1317.9        | 148.4        | 1439          | 52.48         |
| NOₓ                                                               | 2102.82       | 2348.46      | 3985          | 5025.94       |
| SO₂                                                               | 26.05         | 395.86       | 1.3           | 130.29        |
| Carcinogenic substances (benzo(a)pyrene), soot                    | 1.14          | 42.96        | 580           | 28.45         |
| Inorganic dust                                                    | 0.01          | 813.14       | 15.7          | 2323.66       |
| Hydrocarbons                                                      | 6105.24       | 4445.17      | 353           | 140.4         |
| Specific damage to soils, rub/ton                                 | 1532275.04    | 3350571.30   | 1384114.98    | 1527131.07    |
| Damage caused by waste discharges from sludge pits, rub/ton       | 21731585.06   | 1667888.31   | 10708624.08   | 29149815.29   |
| **Specific damage caused by waste discharges from sludge pits, rub/ton** | 8.69          | 0.55         | 3.56          | 12.95         |
| Damage caused by liquid waste discharges from sludge pits, rub/ton| 2784815.66    | 1016682.12   | 364295.76     | 1392806.21    |
| **Specific damage caused by liquid waste discharges from sludge pits, rub/ton** | 1.11          | 0.33         | 0.12          | 0.61          |
| Damage to the health of workers, rub/ton                          | 141211.9      | 96987.3      | 114373.6      | 100331.2      |
| **Specific damage to the health of workers, rub/ton**             | 0.047         | 0.024        | 0.038         | 0.033         |
| Total damage caused by subsoil use, rub/ton                       | 9.8499        | 0.906        | 3.7197        | 13.5955       |

Figure 2. Indicators of specific environmental risks.
As can be seen from the above data, the integral damage of environmental management depends on a number of factors, primarily climatic factor and productivity. The maximum values are observed at the Dulisma field.

4. Conclusion

The article provides a comprehensive specific assessment of the man-made hazard of oil and gas production at four fields. Using indicators of environmental risks for geospheres: atmosphere, soil, and occupational risks for production workers (who in this study represent not only a valuable labor resource, but also an object of the living environment of oil and gas production areas), we have identified the factors that form the greatest risks. Based on the results of the calculations, the greatest specific impact has been attributed to the Dulisma field and amounts to 13.5955 rubles/ton of produced hydrocarbon raw materials. The obtained results will be used for further research and measures to improve the environmental situation in the oil and gas production areas.

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