Preliminary zoning of negative impact of the projected oil waste polygon at the Samotlor field

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Abstract. This paper provides a comprehensive analysis of the building expediency of a polygon for processing oil wastes in KhMAD-Yugra. Preliminary research has shown the environmentally dangerous impact of its project location relative to Nizhnevartovsk city, village Izluchinsk and village Bolshetarkhovo, as well as other important objects. The method of location estimation based on the main rules of life safety is proposed. Its application will reduce the environmentally dangerous impact and make it possible to choose the most optimal location of the polygon. An environmental pollution assessment scale has been developed, presented in tabular form for convenience. The area of zones of different dangerous influence degrees is calculated. The article describes the increase in the probability of earthquakes, wildland fires and floods in the area of the Samotlor field polygon due to global warming. The article also considers the prospect of using GIS programs in modeling environmental phenomena that affect oil and gas production facilities.

1. Introduction

The object of the study is the negative impact of the oil waste polygon.

Subject-the optimal location of the oil waste polygon relative to localities, strategic locations (structures) in case of natural and man-made accidents for minimizing negative consequences.

The purpose is to develop evaluation criteria for choosing the optimal location of the oil waste polygon.

Objectives:
1) consider the dynamics of natural hazards (fires, floods, earthquakes) under the influence of global warming;
2) analysis of negative consequences and zoning of the territory at the project location of the oil waste polygon;
3) development of evaluation criteria for choosing the optimal location of the oil waste polygon.

Emergency oil spills, oil-contaminated land, oil sludge waste – the main and serious problem for the environment, the health of Yugra population, and life safety. In 2018, 3624 accidents occurred in the oil industry of Yugra. About 4.7 million tons of waste are generated annually [1]. More than 4700 hectares of district land, in total, taking into account the previous years' spills, are polluted and require reclamation. In addition, today, considering 2017, there are more than 1,600 sludge pits on the territory of the fields – places where oil waste is drained. In the Khanty-Mansi Autonomous Okrug-
Yugra, more than 80% of pollutants, entering water objects, are contained in the wastewater of chemical and petrochemical enterprises [2].

The relevance of the polygon for processing oil wastes in our district is not in doubt. Since it is necessary to solve the problem of processing of oil wastes in KhMAD-Yugra. This problem is really enormous and is caused by a significant amount of accumulated and annually generated waste, their negative impact on the environment,[3] It may be necessary to make changes to environmental legislation affecting the conduct of tenders with the selection of contractors on the principle of the presence or absence of modern non-polluting technologies. Today, oil companies and subsurface users conclude agreements with external agencies that plan to eliminate these oil-contaminated wastes and sludges. But in fact, only a small part of them are able to comprehensively solve this problem. Many of them often do not have their own bases and facilities to place, store, and recycle waste. They are often inearthed or thrown into inaccessible places. In the course of the research we studied various works on the environmental hazard assessment of oil and gas industry facilities [4-8].

The described polygon was planned to be built in 2012 on the territory of the Samotlor field in the area of the dismantled CS-16. The construction was supposed to be carried out in accordance with the Federal target program "Reducing risks and mitigating the consequences of natural and man-made emergencies in the Russian Federation until 2015". The program was approved by Decree of the Government of the Russian Federation № 555 of 07.07.2011. The first section of this program indicates that the number of natural hazards and major man-made disasters on the territory of the Russian Federation has been growing annually over the past decade. The document mentioned natural disasters related to natural hazards and fires, water accidents. As well as man-made accidents and terrorist acts are the main sources of emergency situations and pose a significant threat to the citizens’ security, the national economy and, as a result, to the sustainable development and national security of the Russian Federation [9]. The polygon was supposed to work on the basis of innovative technologies and equipment, reduce the number and area of oil-contaminated sites and accumulations of oil wastes. Experts assured that as a result of the project implementation, the threat of an emergency will be reduced, and it will even be possible to return previously infected lands and water objects to circulation. Theoretically, everything looked fine and safe. But in fact, it turned out the opposite since the polygon became a source of increased danger.

2. Materials and methods
3 public hearings were held on this project, initiated by the public, citizens and environmental specialists, who were against its construction and considered that the polygon poses a serious environmental threat [10]. But the directions indicated by us (radius of negative impact, earthquakes, fires and floods) were not considered.

In the course of our work, we conducted research in these directions. We believe that the polygon is necessary to solve the problem of processing oil-wastes, since there is no unified scheme for processing or recycling waste. They are often buried in the ground or dumped along rivers and lakes. But it is required to choose another place for its construction. The former project location actually included Nizhnevartovsk, Izluchinsk some other localities in the zone of negative environmental impacts, as well as a strategic location — Nizhnevartovsk conventional thermal power station (SDPS), located in the Izluchinsk village.

It is doubtful that choosing the location of this polygon, the natural hazards that arise periodically in the area, such as seismic hazards, floods and fires, have been taken into account, which in the perspective of global warming may increase in scale.

The trend of global warming is no longer a myth, but a scientifically based fact. We live in an unstable period in terms of climate fluctuations. It lasts about 500-700 years, compared to others that last millions of years, this is a rather short period [11].

All these changes, which seem anomalous, are just characteristic of the period in which we live. The coming warming is similar to the Holocene climate optimum — the Atlantic period (about 5-6 thousand years ago).
2.1. Analysis of negative consequences from the polygon in the case of project location.
Seismic hazards continue to pose a significant threat to the population [12].

![Figure 1. A schematic map showing the connection of the geological structure with the earthquake's manifestations along the tectonic faults of the foundation of the Western Siberian young epipaleozoic plate. Explanation of figure 3. 1 – earthquake of 1966 in the area of Kamen'-na-Obi; 2 – the district of the Altai earthquake in 2003 with the epicenter within the Kuray mountain range; 3 – earthquake of 2003 in the area of the lake Samotlor and Nizhnevartovsk. According to figure 1, the project location of the polygon is located in the zone of intersections of longitudinal and transverse breaks (lineaments) of the crystalline basement. If the phases and amplitudes of seismic waves coincide at the intersection of longitudinal and transverse lineaments, then the tremors are intensified, otherwise, the tremors are reduced [13]. In the case of an earthquake hazard, accidents may occur at the polygon, as a result of which the depressurization of sludge pits and containers with oil wastes and the inevitable leakage of waste into the environment is possible, as well as their further ignition. As a result, the pollution zone will expand, the area of which includes Nizhnevartovsk, and Izluchinsk village.

Since the beginning of 2017, 510 forest fires have been registered in the Nizhnevartovsky district on an area of 52685.3 Ha, and 69 fires on the Samotlor field on an area of 2611.6 Ha [14].

It is very difficult to avoid fires in this area, since there is a high swampiness, and therefore a large accumulation of peat deposits.

![Figure 2. Increasing flood peaks of the river Ob in Nizhnevartovsk]
In the case of oil waste ignition at the polygon, the plumes will take on terrifying dimensions. Nizhnevartovsk, Izluchinsk village, Bolshetarkhovo village, as well as many others, will be included in the zone of dangerous environmental impact. Even if there is no direct contact, there will be very strong smog and smoke, making it impossible for people to live and function equipment.

Another characteristic natural feature of the Nizhnevartovsky district is the long spring-summer flood. Its duration is about 100 days. Based on the topographical basis, as well as on hydrological data, it is possible to predict what will happen when the water rises in the river Ob relative to the maximum level of 1979 year.

Based on the graph data in Figure 2, we can say that the peaks of spring-summer flooding are increasing, which is influenced by the global warming trend. The greater the sum of positive air temperatures during the snowmelt period, the more intense the melting of snow cover and ice is. Also, the period of rise becomes shorter and the maximum flood occurs faster [15].

An excess of 12-13 m can lead to almost complete flooding of the Nizhnevartovsk’s territory. An excess of 14-15 m will lead to flooding of a large part of the Samotlor field. As a result of the analysis, an increase in flood peaks on the Ob River in the area of Nizhnevartovsk was revealed. It should also be taken into account that in the case of flooding, there will be a chain of interconnected water objects connecting the oil waste polygon, Nizhnevartovsk, and Izluchinsk urban settlement, primarily through the Vakh river. When the water level rises, another complex of processes is expected, related to the aggravation of swamping processes and the restructuring of swamp systems.

For environmental analysis and evaluation of the optimal placement of the described polygon, we offer the following criteria:

1) reducing the level of danger and harmfulness of the negative factors source by improving its construction and working process implemented in it;
2) increasing the distance from the source of danger to the object of protection;
3) installation of means that reduce the level of dangerous and harmful factors between the source of danger or damage effect and the object of protection.

2.2. Zoning of territory at project location of oil waste polygon

Based on the previously developed tables, a comparative analysis of the impact of the possible negative consequences of accidents at the oil waste polygon for Nizhnevartovsk city, Izluchinsk urban settlement, Bolshetarkhovo village. (figure 3) [16].

Figure 3. Zones of negative environmental consequences from a polygon for processing oil wastes in the case of project location. Explanation of figure: 1- project location of the polygon; 2 – Nizhnevartovsk city; 3 – Izluchinsk village; 4 – Nizhnevartovsk SDPS; 5 – drinking water intake from the Vakh River; 6 – Bolshetarkhovo village.
According to figure 3, it can be seen that the Bolshetarkhovo village, which is the closest of all the considered objects to the polygon, can only be negatively affected by the latter in the case of fire (through smog). A negative impact on the Nizhnevartovsk city and Izluchinsk village is caused, firstly, by the getting into the radius of a strategic location that provides electricity demand for the entire district - Nizhnevartovsk SDPS. Secondly, in the case of a leak of toxic oil wastes at the polygon, the waste inevitably falls into the Vakh river course, from where water intake is carried out to provide drinking water to Nizhnevartovsk’s citizens. We also developed pollution scales, in which the color corresponds to a certain level of pollution, and calculated the area of each zone. (table 1)

Table 1. The level of negative consequences from the oil waste polygon on objects entering the exposure zone in the case of project location

| Name         | Color | Level of environmental pollution, % | Area of contamination |
|--------------|-------|------------------------------------|-----------------------|
| [0] points   |       | no consequences                    | 32.845 322 sq.km      |
| [1] point    |       | about 20                           | 441.844529 sq.km      |
| [2] points   |       | 21-40                              | 301.813913 sq.km      |
| [3] points   |       | 41-60                              | 401.381378 sq.km      |
| [4] points   |       | 61-80                              | 632.731496 sq.km      |
| [5] points   |       | 81-100                             | 129.831483 sq.km      |

3. Results and Discussion
The proposed criteria were applied to the analysis of the location of toxic oil waste polygon relative to nearby cities and villages (table 2).

Table 2. The intensity of the negative impact from the oil waste polygon in the realization of the following hazards, taking into account the proposed principles that reduce the intensity of the negative impact of the oil waste polygon

| Hazards | Nizhnevartovsk city (31.5 km.) | Izluchinsk village (20 km.) | Bolshetarkhovo village (14.5 km.) |
|---------|-------------------------------|----------------------------|-----------------------------------|
|         | Factors                      | Factors                   | Factors                          |
|         | A    | B    | C    | A    | B    | C    | A    | B    | C |
| Earthquakes | [1] | [0]  | [0]  | [0]  | [0]  | [0]  | [0]  | [0]  | [0] |
| Fires    | [1]  | [0]  | [0]  | [1]  | [1]  | [0]  | [1]  | [1]  | [0] |
| Floods   | [2]  | [1]  | [0]  | [2]  | [1]  | [0]  | [0]  | [0]  | [0] |

Explanations for table 2:
The distance from the oil waste polygon to the locality is shown in brackets
Criteria that reduce the intensity of the negative impact of the oil waste polygon:
**A** - reducing the level of danger and harmfulness of the negative factors source by improving its construction and working process implemented in it (reducing production volumes);
**B** - increasing the distance from the source of danger to the object of protection;
**C** - placement of means that reduce the level of dangerous and harmful factors between the source of danger or damage effect and the object of protection (placing a polygon behind a natural barrier);
Table 2 shows that subject to the proposed safety criteria (A, B, C), there will be a significant reduction in the negative impact of the oil waste polygon, up to zero values.
Applying these criteria (B,C), we propose the most optimal location for the oil waste polygon (figure 4.)
Figure 4. Our proposed location for the oil waste polygon.

Placing the polygon behind the Aganskiy Uvals, we simultaneously apply two proposed criteria: B – increasing the distance from the source of danger to the object of protection, C – placing the source of danger so that there is a natural barrier between the source and the object of protection (elevation - Aganskiy Uvals). We are on the way of creating a unified, universal methodology for evaluating the location of such hazardous industrial facilities. The next stage of work is the implementation of software products with geographic information systems (GIS). The application of GIS programs can speed up and improve the process of evaluating the environmental hazard of facilities. At the moment, there are no similar software products that will comprehensively consider all factors (relief, hydrogeological terrain structure, wind rose, modeling of various emergencies taking into account local natural hazards).

4. Conclusions
The results obtained in the study show that we have achieved our goal – we have developed criteria for choosing the optimal location of the oil waste polygon, which made it possible to reduce the negative impact of the polygon on Nizhnevartovsk, Izluchinsk and the village Bolshetarkhovo. In addition, we conducted zoning of dangerous environmental consequences from the polygon, calculated the areas of these zones, developed pollution scales, and proposed the most optimal location of the oil waste polygon.

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