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Crude oil lines accident rate analysis in Nizhnevartovsk district KhMAO-Ugra for years 2014-2018

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Abstract. On the territory of Nizhnevartovsk district Khanty-Mansiysk Autonomous Okrug-Ugra, accidents on pipelines still have a complex destructive impact on the environment, leading to pollution and aggravation of the environmental situation in the region. Possible impact on the environment during the exploitation of deposits, even if minimized (formally), yet negative changes in the environment continue to accumulate and manifest themselves. In this case, it is impossible to completely avoid accidents. Usually, as a result of pipeline breachings, the largest emissions of oil and petroleum products occur. The reasons for the high number of accidents on pipelines operating in the district and area are equipment operation, including pipelines, in excess of the standard period; insufficient investment by oil companies of funds allocated for the reconstruction and overhaul of pipelines; as well as the progressive aging of existing networks and poor production equipment with reliable automation and remote control systems. In recent years, numerous environmental protection measures cited in the oil and gas complex have not led to a significant improvement in the environmental situation in the region. This article analyzes the results of accidents on oil pipelines from fields in the Nizhnevartovsk district Khanty-Mansiysk Autonomous Okrug-Ugra for 2014–2018 and determines the seasonal indexes of accidents on the oil fields of a given territory.

1. Introduction

In the system of forecasting and planning the social and economic development of a country or a region, an important place should be given to predicting the state of the environment, environmental protection activities and the rational use of natural resources.

The growth of environmental pollution cannot be attributed to any particular type of production activity or a specific modern technology. This is the result of the complex influence of numerous factors.

In the process of developing oil and gas fields, the most active influence on the natural environment is within the territories of the fields themselves, in the mainland pipelines and the nearest populated areas.

The degree of air pollution due to an accidental oil spill is determined by the mass of volatile low-grade hydrocarbons evaporated from the oil-covered surface of the land or water body.

Upon crude-oil production, large volumes of highly mineralized water are extracted along with oil. Oil gas may contain hydrogen sulphide H_2S and carbon dioxide CO_2 , which are very harmful to the environment and human health. H_2S content in the air greater than 3 mg/m^3 is dangerous to human life, and the discharge of reservoir of highly mineralized water into open water bodies and rivers can lead to the destruction of flora and fauna [1].



There is evidence that, in particular, in the groundwaters of Sredneobskaya oil and gas province (Western Siberia), specific to oil production oil and oil products, phenols and other pollutants have been found in concentrations exceeding the permissible values. The most vulnerable are drinking water and food contaminated with hydrocarbons at the production stage, a direct consequence of the poor state of the groundwater in the oil-producing regions. According to experts, Nizhnevartovsk area is the most unfavorable region in KhMAO-Ugra, where the number of oncology diseases is 2-3 times higher than in the rest of Russia [2].

The protection of the environment needs to increase the reliability of equipment and pipelines for various purposes, depending on their durability. Unfortunately, known technologies for dealing with large-scale oil spills are still ineffective.

Currently, most of the in-field oil pipelines in the Nizhnevartovsk area operate under conditions of intense internal corrosion, which leads to equipment deterioration and results in pipeline accidents accompanied by salvo emissions of oil into the environment.

Nominally, the possible harmful effects on the environment during the exploitation of deposits and the transportation of hydrocarbon raw materials are minimized. However, experience shows that negative changes in the natural environment continue to accumulate and manifest. In this case, it is not possible to completely avoid emergencies [3].

2. Objects, data and methods

According to the Ugra Natural Survey (Prirodnadzor) [4], in the oil pipelines of the fields of the Nizhnevartovsk area in 2014–2018, 2,399 accidents were recorded, and, at the same time, the areas polluted with oil and oil products at the fields of the region during these years were 117.5 hectares; the largest areas of polluted lands are accumulated by “Samotlorneftegaz”, JSC (OJSC NK “Rosneft”), 26% of the total area.

In 2014-2018, at the time of the accident, in the territories of the enterprises of oil companies of the Nizhnevartovsk area, the mass of pollutants with oil and oil products equals 996.6 tons, and after reclamation it equals 192.7 tons.

According to experts on the territory of the area as a result of accidents at oil and gas production facilities, there is up to four million tons of oil on surface water bodies and the ground [5].

There are many causes of accidents on oil pipelines such as the intervention of an external factor, a construction defect, a material defect, corrosion, soil movement, a tie-in defect and others. It is necessary to timely assess the risk of such damage and the possibility of further operation of the damaged section of the pipeline. Due to external influence, more than 5% of the total number of accidents occurs on domestic pipelines, and they are ranked first in damage [6].

Pipeline accidents occur not only for technical reasons; there are some other reasons, the main of which is the so-called human factor. A huge number of accidents occurs as a result of negligence, both workers and superiors.

3. Results and discussion

In Nizhnevartovsk area in 2014–2018, the main cause of emergencies on oil pipelines was the progressive aging of existing networks, internal and external corrosion of the pipeline -, 93.6% on average over five years. The repair of such pipelines is carried out in a primitive way, by applying patches on the outer surface of a worn-out pipe after its rupture.

The use of corrosion inhibitors, electrochemical protection of pipelines, various anti-corrosion coatings drastically reduces accidents, preventing from oil and formation waters spills, which favorably affects the environment [1].

The important causes of pipeline accidents along with the known ones (corrosion and manufacturing defects) are the heterogeneity of the physical and mechanical properties of the peat base along the pipeline, as well as the change in the nature and magnitude of the load transferred to it [7].

Disturbance of vegetation, soil and snow cover, surface runoff, etc. lead to shifts in the thermal and wet conditions of the ground layer and to a significant change in its general condition, which causes an active, often irreversible development of exogenous geological processes.

Research materials on accidents and oil spills on pipeline transport of fields of Nizhnevartovsk area (table 1) show that, as in previous years, the highest number of local accidents on pipeline transport, on average 58.7% of the total number of accidents in the area for five years, occurs in the licensed areas of the enterprises of "Samotlorneftegaz", JSC.

Table 1. Accidents in the oil fields of Nizhnevartovsk area of Khanty-Mansiysk Autonomous Okrug-Ugra for 2014-2018 (according to the Nature Supervision (Prirodnadzor) of the Khanty-Mansiysk Autonomous Okrug-Yugra).

N o.	The company that contributed to the accident	Years	Number of accidents	Cause of accidents	Mass of pollutants (bottom water), tons		Polluti on area, hectare
				Corrosion	at the time of the accident	after the elimination of the accident	
1	OJSC «Tomskneft» VNK	2014-2018	224	219	5.8	0.4	2.75
2	PJSC "Varioganneftegaz"	2014-2018	52	50	16.2	1.3	1.49
3	OJSC JSOC "Bashneft"	2014-2018	27	25	1.4	0	0.002
4	JSC "Samotlorneftegaz"	2014-2018	1344	1248	570.2	165.6	86.02
5	"North-Varioganskoye" LLC	2014-2018	139	138	8.2	0.3	1.535
6	JSC "Nizhnevartovsk Oil and Gas Production Enterprise"	2014-2018	201	192	59.7	2.7	8.41
7	"Tarkhovskoye" LLC	2014-2018	9	9	1.2	0	0.27
8	"Slavneft-Megionneftegaz" OJSC	2014-2018	28	14	2.4	0.8	4.8
9	TPE "Langepasneftegaz" LLC "LUKOIL-Western Siberia"	2014-2018	44	31	51.3	0	3.13
10	TPE "Pokachevneftegaz" LLC "LUKOIL-Western Siberia"	2014-2018	23	22	6.1	4.2	0.33
11	OJSC "Ermakovskoe"	2014-2015. 2017	109	109	34.3	0,5	1.96
12	OJSC "Varioganneft"	2014-2015. 2017	6	5	5.0	0	0.34
13	LLC "JV "Vanieganneft"	2014-2015	51	51	9.1	1.0	1.11
14	"White Nights" LLC	2015-2016. 2018	5	3	3.2	0	0.41
15	OJSC "Corporation Ugranefit"	2014. 2017-2018	5	5	1.686	1.461	0.13

Climatic factors of the Nizhnevartovsk area also affect the condition of the pipeline [3, 9, 10]. The most unfavorable hydrometeorological conditions of a possible oil spill in the Nizhnevartovsk area are: spring, when the swamps had not yet thawed out and the surface water formed as a result of snowmelt floods the swamps and overflows the rivers, ice drift begins and spring flooding occurs; winter as the period of low temperatures and the period of snowstorms; autumn as the period of

autumn rains, when the water level in the marshes rises, and in the watercourses an autumn flood occurs.

Changes in outdoor temperature cause a change in the temperature of the soil, in which the pipeline is laid. Under the influence of destructive atmospheric influences and aggressive media, such as deformation, soil movement or erosion of the underwater passage, proximity to groundwater, long frost periods, metal structures gradually lose their original appearance and lose their qualities, which leads to emergencies. The pipeline bends as a result of uneven precipitation of the soil, resulting from the weight of the pipe. The creation of additional bending stresses in the pipeline in the presence of other unfavorable factors (for example, poor welding quality), as a rule, leads to a breakdown in the strength of individual joints [8].

Frozen wet soils during thawing give significant sediment, both due to the ongoing compaction and a decrease in shear resistance, while the more clay particles in the soil, the less shear.

Such factors as lightning discharges, tornadoes, hurricanes, snow drifts, etc. can also be attributed to external impacts of a natural origin, which can lead to depressurization of pipelines and cause an emergency of any magnitude at the facility.

Statistical data on accidents on oil pipelines of the Nizhnevartovsk area have determined the seasonal indexes of the number of accidents in recent years. Table 2 shows a comparative assessment of the seasonality on the number of accidents in the oil fields of the Nizhnevartovsk area of Khanty-Mansiysk Autonomous Okrug-Ugra for the years 2003-2017.

Table 2. Seasonality on the number of accidents in the oil fields of the Nizhnevartovsk area of KMAO-Ugra.

Months	Average monthly number of accidents, pcs		Average seasonal index, %		
	2003-2005 yy.	2014-2017 yy.	2003-2005 yy.	2014-2017 yy.	2003-2017 yy.
January	78	47	97.3	101.6	99.4
February	54	41	66.4	89.7	78.1
March	73	48	95.7	103.3	99.5
April	86	44	115.4	95.6	105.5
May	71	45	87.0	97.3	92.2
June	73	42	88.6	90.2	89.4
July	72	45	86.7	96.7	91.7
August	74	50	60.7	109.3	85.0
September	76	48	96.8	103.8	100.3
October	109	44	145.7	94.6	120.2
November	85	47	117.8	101.7	109.8
December	87	42	113.3	93.4	103.4

4. Conclusions

Despite that in recent years the number of accidents in the oil fields of the Nizhnevartovsk area has significantly decreased, the analysis of seasonal changes in the number of accidents on the oil pipelines of the region for 2003–2017 show that the probability of origin of a large number of accidents occurs mainly in the spring months and autumn-winter periods of the year. At this time, the accident rate is from 5-15% (April) to 20-45% (October) higher, which is due to severe frosts in winter, sharp transitions of average daily temperatures through +5°C and 0°C in autumn and spring as well as a high probability of the influence of cryogenic processes occurring in the grounds of the pipelines on their failures.

Knowledge of the seasonal indexes can predict the number of accidents for a given month in a particular year and take the necessary measures to prevent them or to reduce the accident rate in pipelines [3, 9, 10].

The results of the study allow us to conclude that pipes, especially mainland ones, should have increased wear resistance and corrosion resistance in different climatic conditions.

Forced stopping of the production fields for the oil and gas producing enterprise can be much more expensive than direct losses from emergencies in the pipeline transportation system. The high accident rate is mainly due to the condition of technical equipment and equipment, which is physically worn out and morally obsolete and has a low degree of reliability. Many facilities require modernization or radical reconstruction, and some are subject to decommissioning.

For trouble-free operation of the pipeline, a set of measures for environmental safety and environmental protection, in general, is needed, which will minimize the damage to nature.

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