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UDC 91

COMPARATIVE ANALYSIS OF THE IMPACT OF OIL AND GAS PRODUCTION FACILITIES ON SURFACE WATER QUALITY (THE CASE OF THE OB AND THE MEDVEZHIE DEPOSITS)

SUMMARY. Assessment of the ecological status of the surface waters of the Ob and the Medvezhie deposits is made on the basis of the calculation of the combinatorial index of water pollution (CIWP) which indicates their low quality. The water in rivers and lakes of the industrial area are specified as "very dirty" and "extremely dirty".

KEY WORDS. Surface water, Priobsky deposit, the Bear deposit, combinatory index of impurity of water.

According to Russia's Energy Strategy, Tyumen region will retain a position of the main oil and gas producing province of Russia by 2030. Oil production is expected to reach the level of 340-360 million tones and gas production — 580-610 bln m^3 per year [1]. Currently, there are more than 600 proven oil fields (OF), oil-gas condensate fields (OGCF), gas fields (GF) and gas condensate fields (GCF) in Tyumen region.

The problem of river pollution in the region is a topical issue at the moment. The impact of oil and gas complex on the surface waters is coming from the industrial and economic-household water supply and the usage of waters as waste water receivers (either regulated spillways or diffuse pollution). Dissolved petroleum hydrocarbons (and other specific pollutants) are found in the doses exceeding the maximum permissible concentration (MPC) even outside the fields. The problem is a lot acute especially in spring when melt waters from the fields carry away a huge amount of pollutants that are found in the soils of the area. The cryogenic factor is an indirect one in the surface water pollution. As a result, in spring and summer melt waters from the catchment area fall into water through frozen soils, the filtration properties of which are negligible.

Discussed in this paper, the deposits are located in various regions and natural environment of the Russian Federation. Thus, the Ob OF is in the Khanty-Mansiysk Autonomous District in taiga zone, and the Medvezhie OGCF is located in the Yamal-Nenets Autonomous District in tundra and forest tundra.

Method. The assessment of the ecological status of the surface waters of the Ob OF and the Medvezhie OGCF is made on the basis of the calculation of the combinatorial index of water pollution (CIWP) as the most proper for the study [2], [3].

To provide better the initial information at the first stage of CIWP calculation, we specified the values exceeding MPC of the water chemical elements for the objects of fishery, i.e. the rate of MPC excess for each element was calculated.

Further, the calculations of all parameters, needed to establish water quality class, were carried out. For each ingredient there were determined: the frequency of contamination cases or the frequency of concentration detection, exceeding MPC — a; assessment score S1; average rate of MPC excess — b; assessment score S2, the total assessment score S. Further, for the entire facility, for a period of time there were determined: CIWP (combinatorial index of water pollution), SCIWP (specific combinatorial index of water pollution) and CIP (critical indicator of pollution). The classes of water quality were based on these results [3].

The results of the study. The results show that the main pollutants in the Ob OF are iron, zinc, manganese, ammonia, phosphates and phenols. An example of CIWP calculation for the Ob OF is presented in Table 1.

Table 1

The combinatorial index of surface water pollution in the territory of the Ob oil field (2008)

Index	*a* (%)	S_1	MPC_m	S_2	S	CIWP	SCIWP	CIP	Quality class
Total iron	100	4	26,2	3,405	13,62	41,19	8,24	2	4 "g"
Ammonium	25	2,75	2,76	2,095	5,76				
Phosphates	25	2,75	1,06	1,06	2,91				
Zinc	100	4	1,95	1,95	7,8				
Manganese	100	4	8,2	2,77	11,1				

The main pollutants in the territory of the Medvezhie OGCF are total iron, phosphates, oil products, nitrite, ammonium.

CIWP calculation for the Medvezhie oil-gas condensate field is shown in Table 2.

Table 2

The combinatorial index of surface water pollution in the territory of the Medvezhie OGCF (2004)

Index	*a* (%)	S_1	MPC_m	S_2	S	CIWP	SCIWP	CIP	Quality class
Total iron	100	4	5,78	2,47	9,88	27,42	6,85	2	4 "v"
Ammonium	6,7	1,627	2,60	2,2	3,58				
Phosphates	100	4	4,23	2,28	9,12				
Nitrite	25	2,75	1,76	1,76	4,84				

This method of calculating the combinatorial water pollution index makes possible to assess the quality of individual water bodies and to trace the dynamics of class quality. The capability of this analysis is shown in Table 3, which is made by the example of water bodies in the Ob OF. The inflow of pollutants into surface waters is caused by both natural and anthropogenic factors. Therefore, analyzing the status of water bodies, these two factors should be considered in equal measure.

Table 3

The class of water quality of southern water bodies in the Ob oil field

Water intake	Water body	Date	SCIWP	Quality class
1	The lake without a name	2006	10,32	5
		2007	9,73	5
		2008	10,69	5
		2009	10,12	5
2	Intake 2 River Shapshinskaya	2006	13,52	5
		2007	10,91	5
		2008	9,83	5
		2009	10,96	5
3	Intake 3 River Levaya Shapshinskaya	2006	8,28	4 "g"
		2007	10,88	5
		2008	10,59	5
		2009	9,26	5
4	Intake 4 River Shapshinskaya	2006	8,98	5
		2007	8,48	4 "g"
		2008	9,26	5
		2009	9,57	5

All the calculations (for the territories of the Khanty-Mansiysk Autonomous District and the Yamal-Nenets Autonomous District) indicated a high level of iron compounds. However, it should be mentioned that iron is a typomorphic element of western Siberia's natural waters. Its content is particularly high in the soil, wetland and lake waters. The interaction of mineral and organic substances, contained in natural waters, form a complex set of iron compounds in suspension, dissolved and colloidal phases [4]. Iron, being a biologically active element, to some extent, affects the intensity of phytoplankton and qualitative composition of microbial flora in a pond.

Our calculations show that in 2006 to 2009 water bodies in the Ob field are characterized as "extremely dirty".

The water bodies of the Medvezhie OGCF are an affluent water receiver. The assessment of the wastewater impact is indicated in Table 4.

The results testify that effluents discharge has no notable impact on the quality of the surface waters in the Medvezhie OGCF. This fact confirms the use of surface water bodies under the maximum permissible discharge (MPD) standards as waste water receivers does not influence the quality of these waters.

There was no regulated effluents discharge in the studied water bodies in the territory of southern part of the Ob oil field. In this regard, the pollutants flow into these water bodies through a diffusive drain. The quality of natural waters belongs to "very dirty" class and "extremely dirty" class. Pollutants flow through a diffusive drain from the catchments where a large number of bushes, pump stations and drilling rigs are located. The Ob oil field is surrounded with other license sites, and the rivers, originating in the territory of the next fields, have already a high degree of impurity. In general, the interfluve of the Irtysh and the Ob is characterized

as a zone of poor ecological situation [5]. Thus, in 2004-2005 the Ob water on Nizhnevartovsk — Belogorsk location was classified as "dirty" — the 4th class, A and B categories [6].

Table 4

The assessment of effluents discharge influence on the water quality in the territory of the Medvezhie OGCF

River	Monitoring section	Year	Quality class before effluents discharge	SCIWP	Quality class after effluents discharge	SCIWP
The Bolshoy Yarudey	GPP-1	2003	4b	7.09	4v	7.23
		2004	4v	8.08	4v	8.30
		2005	4v	8.12	4v	8.50
		2006	4b	6.58	4b	6.72
	GPP-3	2003	4b	7.86	4b	6.76
		2004	4b	6.40	4b	6.40
		2005	4b	6.05	4b	6.12
		2006	4b	7.10	4b	7.36
The Pravaya Hetta	GPP-2	2003	4b	6.39	4b	6.70
		2004	5	10.16	5	10.12
		2005	5	10.16	4g	9.08
		2006	4b	7.06	4v	8.88
The Pravaya Heyakha	GPP-4	2003	4b	7.95	4v	8.25
		2004	4b	7.20	4v	7.32
		2005	4b	7.44	4b	8.03
		2006	4v	8.68	4v	8.68
	GPP-5	2003	4b	7.61	4b	7.50
		2004	4g	9.25	4g	9.25
		2005	4v	8.43	4v	8.53
		2006	4v	8.88	4b	6.62
The Ngevayakha	GPP-6	2003	4b	6.78	4b	7.52
		2004	4a	5.68	4b	6.78
		2005	4a	4.85	4a	5.27
		2006	4a	5.22	4a	5.28

In most cases, the effluents discharge into the surface waters of the Medvezhie OGCF does not change the water quality class or a slight change in the quality of surface water is noted. For example, the 4th "v" class passes to the 4th "g" one (i.e. very dirty). Besides, a reverse process is noted, i.e. a water quality class improves. This was noted at the monitoring section of GPP-2 in 2005. Then the 5th quality class passed to the 4th "g" class (from "extremely dirty" to "very dirty") or at the monitoring section of GPP-5 in 2006. Then the 4th "v" quality class passed to the 4th "b" class (from "very dirty" to "dirty"). These results depend, in particular, on different hydrological characteristics during the study. These include both the water flow rate in these water bodies and the characteristics of water content. After analyzing the results, we can conclude that the effluents discharge has no significant impact on the status of water bodies in the Medwezhie OGCF and in some cases a mixture of waste water with natural water leads to a slight improvement of the

status of surface water bodies. This issue requires further study in each particular area. A diffusive drain plays a significant role in the flow of pollutants, because the calculations indicated no significant negative impact of regulated effluents discharges into surface waters [7]. This confirms the fact that the water quality in the Medwezhie OGCF is classified as "dirty" or "very dirty" before these waters get to the sites of regulated effluents discharge.

The results are supported by the ecological surveys and newsletters on the Khanty-Mansiysk Autonomous District and Tyumen region for the period of 1987 to 2007. It is found out that the natural waters of oil and gas production areas face increasing human impact. In Tyumen region the total annual water consumption (including recycling) increased by 11% from 8387.00 to 9441.69 million m^3 from 1987 to 1997. Over the same period the amount of discharge to surface water bodies increased by 66% (wastewater disposal increased from 471.40 to 709.60 million m^3), which allows to indicate annually an increasing anthropogenic pressure on surface waters [5].

Comparing the data from the previous studies, devoted to Arctic Circle fields [8], it is possible to conclude that although, the Yamal-Nenets Autonomous District is vulnerable to the negative effects of gas production complex but to a lesser degree than the territories of oil production.

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