Methodology of ecological and geological assessment of technogenic oil product deposits (on the example of the territory of the Burnakovsky lowland, Nizhny Novgorod)

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Abstract. The present study is devoted to the assessment of hydrogeological conditions in the field of discharge of the water-bearing horizon. The study is carried out on the territory of the Burnakovo Lowland tank farm, Nizhny Novgorod, and the adjacent areas. These areas are potentially adverse areas with disturbed surface runoff conditions. Within these anthropogenically modified areas of megacities, there is pollution due to additional infiltration nutrition. In this case, it is possible to form a layer of liquid oil products on the surface of the water-bearing horizon and subsequent migration of pollutants within the catchment areas of rivers and water bodies.

1. Introduction
The research area is located on the Burnakovskiy lowland in the city of Nizhny Novgorod. The width of the investigated area is 2.5 km. Lakes indent the surface of the lowland, and peat bogs, alternating with sand manes directed parallel to the river bank. Volga (Figure 1). Administratively, the worksite is located in the Moscow and Sormovsky districts of Nizhny Novgorod. Burnakovskaya lowland is the traditional name of the territory adjacent to the Volga River, covering an area of more than 700 hectares. Approximate borders – Kuibyshev street, Sormovskoe highway, Komintern street.

In the study area or the immediate vicinity of it, a limited amount of survey work was repeatedly performed. The data obtained are fragmented and do not contain some specific characteristics. However, in general, the available data is very informative and allowed the authors of this study minimizing the amount of work carried out.

Various specialists studied these territories and made many conclusions. The main characteristic feature of their conclusions is the convincingly proven multiplicity of sources of pollution of underground water with liquid petroleum products. Existing studies have provided data on the content of petroleum products in the study area. Existing data unequivocally indicate pollution both within and above the ground flow relative to the studied object.
According to the data of analogous objects, we have established [1, 3], oil products for a long time and systematically enter the Volga River. This conclusion is based on establishing the dispersion of pollution sources, a long period of their manifestation. The high filtration parameters of the host soils do not create conditions for significant local accumulations of liquid petroleum products on the surface of groundwater.

![Figure 1](image.png)

**Figure 1.** Scheme of the research area and the object of accumulated environmental damage in the territory of the former Sormovo oil depot

Thus, the objective of the research is to establish the volume of petroleum products and prepare recommendations on the creation of an in-system protection system from the pollution of the Volga River with liquid petroleum products [2, 4].

The territory of the tank farm and the adjacent area are confined to the right-bank floodplain of the Volga River. Absolute elevations of the floodplain surface are 69-73 m while maintaining a general slope towards the river.

The development of the territory in many places sprinkled with soils of various compositions. The combination of alternating lakes, swamps, and sand manes parallel to the river bank creates an incredibly complex surface structure. The particularities of the territory contribute to the transformation of surface runoff into groundwater and the entry into the groundwater of various kinds of substances, including oil products. The excess of the surface of the territory above the water edge in the river is at least 8.0 m.

The territory of the tank farm is built up with one- and two-story structures for various purposes, saturated with a large number of communications. A significant part of the territory is occupied by a tank farm for storing petroleum products. From 1985 to 1988, the company reduced its turnover by more than 18 times. In 1988, gasoline, diesel fuel, and fuel oil were wholly withdrawn from sales. Kerosene transshipment is completely stopped. Since 1996, the operation of the tank farm in its first direction has been completely stopped.

In the geological structure of the territory, to an exploratory depth of 25.7 m, sands and loams of the Quaternary age, covered by bulk soils, take part. Within the study area, in the thickness of alluvial sandy deposits, lake-bog loam and clay are developed. The thickness of the sandy deposits is 17.9-24.1 m, of loam and clay 1.5-3.1 m. The total thickness of the Quaternary deposits is 24.1 m.
Water-bearing horizons are confined to the sandy-clayey thickness of the Quaternary. Aquifers are formed on relatively water-resistant deposits, namely, loams and clays. Soil properties are confirmed during their sinking. Namely, the smell of petroleum products is felt. The smell indicates the infiltration of lost oil products through the thickness of these soils.

The horizon surface lies at a depth of 0.88–1.7 m, which corresponds to total marks 71.1-71.4 m. The thickness of the horizon is 2.2–3.4 m. The flow direction is towards the Volga River. Infiltration feed due to leaks from communications within areas with disordered surface runoff, as well as infiltration of leaks from the fire reservoir system. As a result, the regime of the water-bearing horizon is quite stable. You are unloading the horizon in the underlying stratum of sandy sediments. An oil products accumulation with a thickness of up to 0.01 m, it was noted on the horizon free surface.

The aquifer in alluvial deposits within the study area is ubiquitous, pressure-free. Pressure properties are due to the occurrence in the thickness of poorly permeable loams and clays. The filtration parameters of water-containing sands are characterized by values of the filtration coefficient from 12.7 to 22.3 m / day. The depth of the level during the period of work was 5.4–8.3 m, which corresponds to absolute elevations of 63.9–66.3 m. The thickness of the horizon is 13–18 m. The reddish-brown Perm clay of the Tatar layer serves as the lower confining layer. Horizon nutrition is infiltration, i.e., atmospheric nutrition, leaks from communications, overflow from the overlying horizon. Within the area with disordered surface runoff, increased infiltration nutrition is observed. Unloading is the Volga River. The horizon is heavily polluted within the entire territory of the tank farm, which is confirmed by previously completed work.

2. Materials and methods

The research methodology based on assessing the hydrogeological conditions in the area of discharge of the water-bearing horizon in the Quaternary sediments. To this end, 11 exploratory wells are drilled and equipped on the territory of the Sormovsk oil depot. Wells are located in the most unfavorable areas with disturbed surface runoff conditions. Within these areas, it was proposed to investigate existing pollution. It is assumed that pollution arose as a result of additional infiltration nutrition, the formation of a layer of liquid petroleum products on the surface of the water-bearing horizon in Quaternary sediments.

The need to minimize the volume of fieldwork led to the development of the next research strategy. The obtaining of areal characteristics and information about the regional structure, retrospective materials were used, both descriptive and mining.

3. Results and discussion

The distribution of the pollutants in the area is influenced by the sources' multiplicity and their action time extension. In this case, interference of the pollution fronts occurs. As a result, it is practically impossible to establish the role of each source reliably.

The present studies are focused directly on the industrial site of the tank farm, as an object directly adjacent to the Volga coast. It is within its limits that specific protective measures should be taken.

Currently, there is an accumulation of liquid petroleum products in all drilled and equipped wells, the thickness of which varies from the film on the surface of the water-bearing horizon to 0.4 m.

As can be seen from the obtained results, the accumulation of liquid petroleum products on the surface of the water-bearing horizon and their spreading and subsequent unloading in the area of the existing berth are observed within the discharge area of the aquifer. During the construction of the berth, the mud layer of the Volga river channel was destroyed. At the same time, favorable conditions have been created for unloading, including accumulated oil products.

According to laboratory studies, petroleum products accumulated on the surface of the aquifer are a mixture of kerosene and motor oil and can be classified as "stove fuel."

Corresponding calculations of the total possible volume and a recoverable fraction of liquid hydrocarbons can be performed only tentatively. Reasons are the lack of approved methods for assessing the oil saturation of soils in the aeration zone, the fractionation composition of oil products,
and many other indicators necessary to justify the assessment of the "reserves" of oil products within the limits of pollution spots.

The initial data in this case are:

- the total volume of oil-saturated soils within the limits of the spots of pollution, determined by the map of iso-capacities;
- the porosity of sandy loam soils (average 0.35%);
- effective porosity, determined by the Vetsinsky formula, and corresponding to a value of 0.17.

The volume of contaminated soils, defined as the product of the average between the capacities and the areas limited by them, gives a value of 3068 m$^3$. The product of this value by the porosity value (0.35) gives 1074 m$^3$. The data are overstated, as not all pore space is filled with liquid petroleum products. The product of the same volume by the effective porosity indicates the most probable volume of liquid hydrocarbons. Liquid hydrocarbons can move directly with the flow of groundwater under the action of gravity and are 521 m$^3$.

When calculating, the various density of oil products was taken into account. Estimates of possible tonnage are approximate. At a conditional density of 0.6, the weight of the gravitational reserves of liquid hydrocarbons is not more than 412 tons. Under the conditions of the gravitational regime, the recoverable reserves do not exceed 0.5. If this fact is taken into account, the volume of oil products for which extraction can be calculated is not exceeded 200-210 tons. Naturally, an approach to solving environmental problems based on self-sufficiency, in this case, is not possible.

4. Conclusions

An analysis of the geological and hydrogeological conditions of the site indicates the presence of a particular zone of unloading of the soil flow in the tank farm area. Up along the Volga valley, this zone is limited by the discharge channel of the thermal power station, which is the boundary of the first kind. Down the valley, the discharge front is rather conditionally limited by streamlines determined from the map.

Primary protective measures should be carried out in the allocated lane. It should be noted that, in principle, the contaminated areas within the large industrial zone can extend much further down the valley [2, 4].

Based on the previous, we can recommend the creation of a system of active engineering protection against pollution of the Volga by liquid petroleum products. The protection method is a penetration path cutting off a series of wells located along the banks of the Volga River. This penetration path should ensure the formation of a very elongated depression funnel on the surface of the groundwater, which prevents liquid petroleum products from entering the river.

References

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