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MONITORING OF GROUNDWATER WATER QUALITY IN ECO-INDUSTRIAL PARK BILA TSERKVA

Over the course of the last decade, the whole world including Ukraine has been experiencing a growing problem associated with the deterioration of the environment due to the impact of anthropogenic activity and urbanization. Industrial enterprises generate large amounts of waste, which may be detrimental to overall health. Numerous environmental problems that arose from industrial development prompted the creation of eco-industrial parks (EIP). Groundwater monitoring in EIP becomes a key factor in ensuring sustainable development and preserving environment.

At present, Ukraine is a part of the global program of eco-industrial parks (GPEIP) implemented by the United Nations Industrial Development Organization (UNIDO). The goal of GPEIP is to demonstrate the benefits EIP, which are to increase resource productivity and improve the economic, environmental and social performance of enterprises, as well as to promote inclusive and sustainable development [5]. In 2020, Bila Tserkva Cargo Aviation Complex (BCAC) became a member of GPEIP in Ukraine [6].

This research carried out in the frame of the project “Hydrogeological substantiation of the control system of the impact of eco-industrial parks on the environment” included examination of subsurface contamination with petroleum products and monitoring of groundwater quality in EIP Bila Tserkva.

Subsurface contamination with petroleum products was found at the studied area in the early 1990s. The source of contamination was the former Bila Tserkva Aircraft Repair Plant (BARP), next to which the State Arboretum Olexandria and the Ros River locate (Fig. 1).

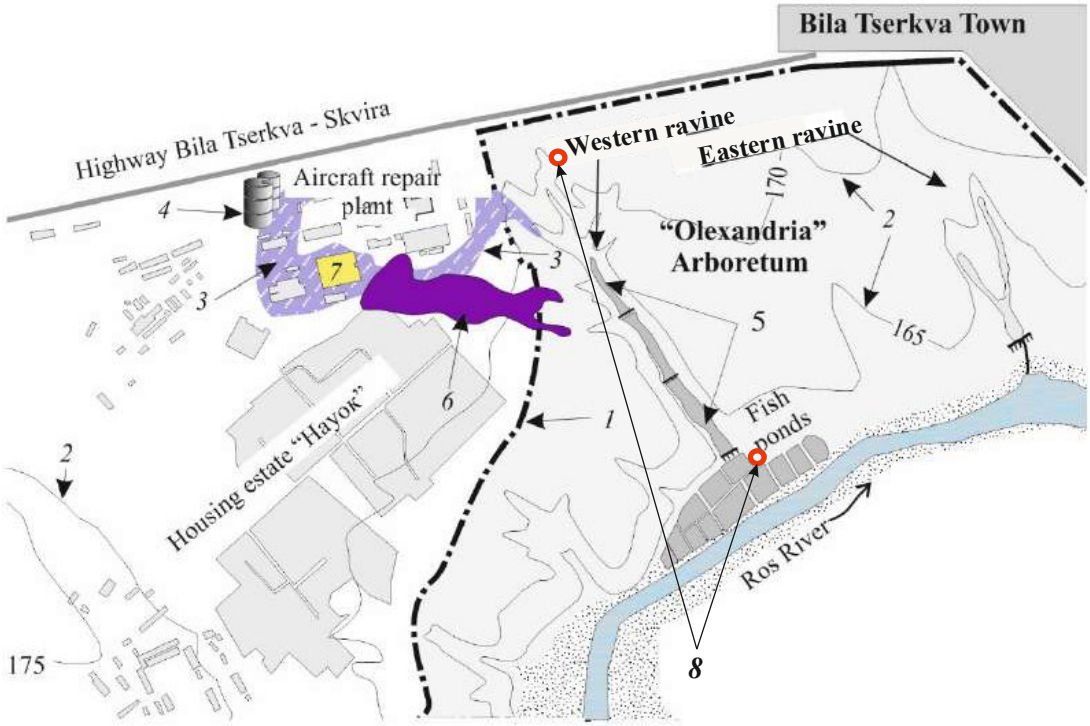

Fig. 1. The overview scheme of the research area: 1 – boundary of Olexandria arboretum; 2 – groundwater lines; 3 – subsurface contamination with petroleum products (by Pravoberezhna Geological Expedition, 1990); 4 – a fuel and lubricant warehouse; 5 – a cascade of artificial ponds (Poterchata, Rusalka and Vodyanik); 6 – a mobile petroleum products layer (by IGS, 2007); 7 – an aircraft repair workshop; 8 – wells recommended to the state groundwater monitoring system of Ukraine (by IGS, 2021)

In 1990, the appearance of petroleum products in surface water of ponds of the Western ravine in Olexandria arboretum was found. Petroleum product concentrations varied from 0.12 to 4.94 mg/l in the

Poterchata pond, from 0.07 to 4.40 mg/l in the Rusalka pond, and from 0.04 to 3.68 mg/l in the Vodyanik pond, which is tens and hundreds of times higher than maximum limited concentrations (0,01 mg/l) [8].

In 2000-2001 and 2006-2007, the research carried out by Institute of Geological Sciences revealed that the main contamination sources were the facilities of BARP such as fuel and lubricant warehouses, an aircraft repair plant, engine repair and testing shops, and a petrol station. Three lenses of mobile petroleum products with a thickness up to 2.5 m located on the water table of the submarine water-glacial aquifer were found and deliniated. [2]. Groundwater contamination with dissolved petroleum products covered all three ravines of the arboretum (Western, Central and Eastern) and the ravine “Forester's House”. The maximum contents of petroleum products in groundwater (30 mg/l) and bottom sediments (5600 mg/kg) were found at the place of groundwater discharge in the upper Poterchata ravine [7]. As the waters of all ponds are discharged into the Ros River, the ecological situation in the arboretum also significantly affected on the state of the Ros river basin, which is the main source of drinking water for the residents of Bila Tserkva and other towns downstream. Long-term contamination negatively affected on the state of the woody and herbaceous vegetation in the arboretum, and the high toxicity of soluble hydrocarbons killed fish in the Western cascade of ponds [3].

In 2019, within the agreement on scientific cooperation between Institute of Geological Sciences and Olexandria State Arboretum we carried out the ecological and geological survey, which showed that petroleum contamination of the cascade of ponds in the Western ravine continued. The signs of dissolve petroleum product flow discharge into the mouth of the lateral trough crossing the western slope of the ravine (the Poterchata pond) were revealed (Fig. 2). This gives reason to believe that contaminant migration from the groundwater recharge area, where contamination sources locate, to the place of groundwater drainage in the Western ravine through moraine sediments occurs in high conductivity layers formed by fluvioglacial sand [1]. In order to confirm this assumption and solve the problem of groundwater and surface water protection, observation posts must be set up in places where petroleum products are expected to enter the ponds.

Fig. 2. Petroleum contamination of surface water of the Poterchata pond and petroleum product flow discharge on the surface (2019)

Since 2021 study of the contaminated area has been continued. Field works included sampling of soil, surface water and groundwater within the cascade of ponds in the Western ravine to identify the places of primary petroleum product entry, inspection of existing observation wells, drilling and installation of additional ones, and periodic measurements of water and petroleum product levels in observation wells (Fig. 3).

Fig. 3. Drilling of observation wells and measuring of water and petroleum product levels (2021)

Several observation wells drilled more than 30 years ago into the aquifer in the fractured zone of crystalline Precambrian rocks were deconserved. Since this aquifer lies first below the surface, it has undergone the main contamination. Testing of the wells revealed groundwater contamination with petroleum products [4]. Two of these wells have been recommended to be included in the State Groundwater Monitoring Network of Ukraine. According to the latest monitoring data in 2023, a mobile petroleum product layer (0.07-0.19 m) was found in all observation wells located on the western slope of the Poterchata pond (Table 1). Dissolved hydrocarbon concentrations in waters of the Poterchata pond vary from 0.36 to 1.33 mg/l (Table 2).

Table 1. The results of measurements of petroleum product and groundwater levels

No of well	Petroleum product level (m)	Groundwater level (m)	Petroleum product layer (m)	Petroleum product level (m)	Groundwater level (m)	Petroleum product layer (m)
	August 9, 2022			May 26, 2023		
1	10,02	10,23*	0,21	9,93	10,11	0,18
2	10,05	10,38	0,33	9,98	10,10	0,12
3	closed			9,76	9,84	0,08
4	10,19	10,40*	0,21	10,06	10,07	0,01
5	10,08	10,28*	0,2	10,01	10,19	0,18
6	9,85	10,19*	0,34	9,77	9,96	0,19
7	10,12	10,27	0,15	9,97	10,08	0,11
8	10,23	11,00*	0,77	10,13	10,20	0,07

*– bottomhole

Table 2. The results of determination of petroleum product concentrations in water

No p/p	Place of sampling	Petroleum product concentrations (mg/l)	Additional information
May 26, 2023			
1	Well 3m	1.68	Water is clear
2	Well 5m	2.90	Sediment is observed
3	Poterchata pond, 2nd ravine (3 m from the bank)	1.31	Water is clear
4	Vodyanik stream	0.44	Water is clear
5	Rusalka pond	0.03	Water is clear
6	Poterchata pond (draining through the dam)	0.36	Water is clear
7	Poterchata pond, 1st ravine near the bank	0.61	Sediment is observed
8	Poterchata pond, 1st ravine (3 m from the bank)	1.33	Water is clear
9	Pore solution	30.66	Water is clear

Thus, the results of this research indicate a negative impact of EIP Bila Tserkva on the environment. It is necessary to create a well network for monitoring groundwater quality, increase both environmental and economic efficiency of remediation measures, and promote the solution of current environmental problems related to soil and water contamination with petroleum products. Improvement of the ecological state of the contaminated area of Olexandria arboretum will contribute to the preservation of historical park compositions and valuable plant communities as well as the development of tourism.

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