
OIL CONTAMINATION OF THE “RATNO OSTRVO” AREA IN NOVI SAD

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Water supplies of the city of Novi Sad relies to a great extent (about 50%) upon the water resource “Ratno Ostrvo”. It is situated on the left Danube bank, downstream to the city, sewerage discharge, and the inflow of the canal Danube-Tisa-Danube to the Danube. The complex of NIS Oil Industry is located in its hinterland, as well as TE-TO thermoelectric power plant, transition sewerage pipelines, heat pipelines, settlement Sangaj, and agricultural soil. Despite of all these activities that are taking place in the hinterland of the water wells, up to recently, the quality of the groundwater has been successfully preserved. However, a great danger to the water quality ensued after the NATO bombing of the Oil Refinery “Novi Sad”, threatening by water shortage to the city of Novi Sad.

During the NATO aggression, the Institute of Chemistry of the Faculty of Sciences Novi Sad and the local headquarters of civil defense organized the monitoring of the groundwater from the “Ratno Ostrvo” wells and the Danube. After the aggression the Communal Service Company “Waterworks and Sewerage” Novi Sad carried out the emergency monitoring of the water source in the period from August 1, 1999 to December 15, 1999, in the frame of which the Institute of Chemistry carried out analyses of the quality of the groundwaters, the Danube and the surrounding soil. During the year 2000 (to November) the waterworks laboratory continued on the monitoring of the groundwater from the water wells.

The Oil Refinery Novi Sad was struck 12 times with about 270 missiles. The destruction of installations and storage capacities caused a loss of 73 569 t of crude oil, 90% of burned out, about 5600 t reached the Danube, and the rest was spilt over the soil within the Refinery. No soil analyses were carried out in the course of bombing. After that all the sites of oil spill were identified, including the data about the kind of pollutants, their amount, and surface area of the contaminated soil.

The work presents the data collected within the monitoring program. Samples of soil, groundwaters from shallow and deep piezometers, the Danube water and Danube sediment, were analyzed on contents of mineral oils and especially of the carcinogenic polycyclic aromatic hydrocarbons (PAHs).

Total area of the contaminated soil was 85 524 m², the amount of spilt oil derivatives 5602 t, and total volume of contaminated soil about 40 000 m³. In the soil above the groundwater table, free oil derivatives were found in the amount of 56 ml/l of the pumped out water. In the soil on these locations the amount of crude oil and oil derivatives was 67 g/kg.

Content of mineral oil in the Danube water ranged from about 100 µg/l during May 1999 to 11 µg/l in October of the same year.

At the same time it was found that the Danube sediment contained also high levels oil and oil derivatives, which during the bombing campaign amounted to 219-293 mg/kg, to fall down to 15-31 mg/kg in June of 2000. It was shown that the sediment contained PAHs in the range from 0.266 to 123.5 mg/kg in the period May-October 1999, and in June of 2000 these values were lower up to 1000 times. The maximal allowed concentrations (MAC) are:

Harmful matter	MAC according to The Regulations on Harmful Matter in Waters (Official Papers of SRS, 1982) (µg/l)		MAC according to The Regulations on Hygienic Suitability of Drinking Water (Official Gazette of SRJ 42/98-4) (µg/l)
	Class I and II	Class III and IV	
Benzene	500	500	1
Crude oil	50	300	10
PAH, total	0.2	-	0.2
Xylene	50	100	50
Toluene	500	25 000	700
Phenol	10	300	1

The possible directions of spreading of the effect of the oil pollution are presented in Figure 1.

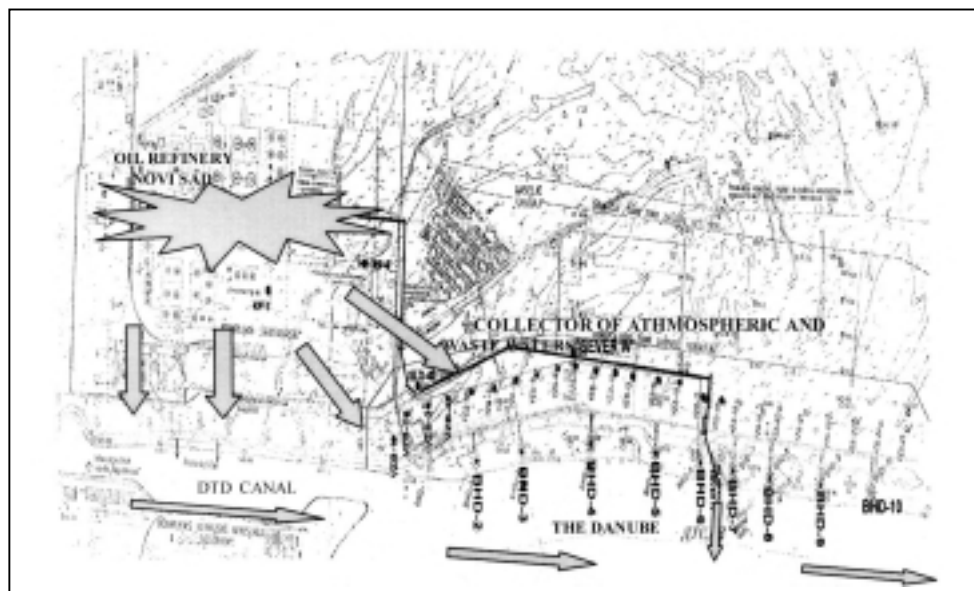


Figure 1. Possible effects of oil and oil derivatives on the water wells

Directions of spreading of oil derivatives from the Refinery in groundwater and from the collector "Sever IV" to the Danube

Ranney Wells: BHD-2; BHD-3; BHD-4; BHD-5; BHD-6; BHD-7; BHD-8 and BHD-9 the well under construction BHD-10 (Black spots around the collector represent piezometers)

In the course of monitoring it was possible to establish the most endangered locations on the Danube bank and at the borderline of the Refinery and water supply wells and on the site of the wells themselves (by the collector of oiled waters). The monitoring showed that the quality of groundwater on the location of the wells is worsening. In the space between the boundary of the Refinery complex and the water wells it was registered worsening of the aquifer water and the estimations showed the possible penetration of the pollutants (the result of the hydrological analysis) in the course of 40 months.

The results obtained by analyzing samples of the Danube water and sediment indicate a decrease of the concentration of oil and oil derivatives in the Danube water after the bombing campaign.

The analysis of sediment samples showed a decrease in the level of mineral oil and extremely toxic PAHs in the period after the bombing campaign, which can be explained by the sediment spreading downstream along the left Danube bank.

Hence, according to these results, it would be necessary to carry out monitoring of the endangered locations in the course of a longer period of time, having in mind the negative consequences of oil pollution that could be expected.

The results of the monitoring and the local hydrological conditions indicate the need of urgent protection of the water wells by constructing a hydraulic barrier, to remediate the state of affairs within the Refinery (reconstruction of the system of environmental protection) with the aim of preventing further degradation of the groundwater quality.

Continuous long-term (over several years) monitoring of the whole area should encompass:

- ☞ the hinterland and the rims of the wells,
- ☞ the boundary belt with the Refinery,
- ☞ the area of the wells themselves (especially around the collector and its discharge to the Danube), analysis of the wells water and samples of the water for treatment,
- ☞ the quality of the Danube sediment in the area of Ratno Ostrvo and also upstream and downstream to it,
- ☞ the Canal Danube-Tisa-Danube at the southern part of the Refinery zone and its discharge to the Danube at the close vicinity of the Ranney wells.

Estimation of the necessary capital costs of the proposed protective measures:

Protective Measure	Estimated Capital Costs (USD)
Hydraulic Barrier	652 174
System of Environ. Protection in the Refinery	900 000
Monitoring Projects	178 826

In addition to general chemical analyses, the samples taken on these locations should be analyzed on contents of mineral oils, PAHs, volatile organic components, aromatic hydrocarbons (BTEX). These analyses should quantify the consequences of the oil pollution. In view of its complexity and the difficulties in the analysis that are encountered in such undertakings (primarily caused by physico-chemical and microbiological transformations of the pollutants) we are of the opinion that the analysis of organic profile (GC/MS SCAN) of the samples would also be very useful in the assessment of the degree and nature of pollution. In this way, it would be possible to obtain a quantitative picture of the state of the whole area and of the effects of all the subjects living and acting on the location of Ratno Ostrvo, which would be especially important not only from the aspect of planning and realizing protection of the water wells but also from the aspect of modernization of the system for preparation of drinking water.