Chromium contamination of the Ljubljansko Polje aquifer

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Abstract: Contamination of the Ljubljansko Polje aquifer with Cr^{+6} dating to 1986 is considered to be one of the best-investigated groundwater pollution in Slovenia. Contamination is a good tracer giving data and information on groundwater flow, hydrodynamics dispersion and leaching of pollution out of the aquifer.

Key words: contamination, chromium, measurement, hydrodynamic dispersion

Introduction

Groundwater contamination in Ljubljansko polje (Ljubljana Field) by way of hexavalent chromium was the first major contamination of the water source that called for extensive remedy measures and caused a temporary halt of water pumping from one of the wells of the Kleče pumping station. This has so far been the only instance of contamination that endangered the aquifer of Ljubljansko polje to an extent that interfered with its proper functioning. The contamination was identified at the beginning of 1986, research and reorganisation measures were carried out between 1986 and 1990.

Hexavalent chromium makes an almost ideal indicator for water movement, owing to the unchangeability of its characteristics. Additionally, underground it does not bind to the matrix or it is absorbed mostly at its surface. As a consequence of the contamination, chemical analyses of chromium levels in its oxidation form 6+ have become a necessary part of ground water monitoring and of the internal research of drinking water quality. Therefore, a large amount of data on chromium levels at different observation points for the period after 1986 has been made available.

Chromium is a polyvalent element, found naturally in the air, soil, water and lithosphere. Oxidation states ranging from 2+ to 6+ are characteristic of chromium, however only the oxidation states 3+ and 6+ represent the chromium form used practically. The oxidation potential for transforming the trivalent chromium into the hexavalent one is high, and the probability of transformation into a higher oxidation form is reduced. So far, the research

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has shown that the hexavalent is not the prevailing natural chromium form, with few exceptions. Despite the wide range of chromium in the soil and plants, it is rarely found in natural water above the concentration of the natural background, amounting to 1 μg/l. Higher concentrations are indicators of anthropogenic pollution.

Chromic chemicals are used in different industries. In leather industry for skin tannage in electroplating for coatings, in chemical industry for making pigments. Hexavalent chromium (Cr^{6+}) is far more mobile than the trivalent (Cr^{3+}) chromium. The trivalent chromium is immersed into poorly soluble substances that are inaccessible to organisms.

Contamination was identified at the end of 1985 while testing the neutralisation devices in the procedure of acquiring the occupancy permit in Iskra Mikroelektronika in the Stegne industrial zone. The wastewater sample contained 175 μg/l of Cr^{+6}. Since chromium was not used in the described technological procedure, an analysis of drinking water was made at the starting stage of the technological procedure. The analysis displayed a concentration of 150 μg/l, exceeding the permitted value (50 μg/l). Investigations into water quality in the vicinity of the Kleče reservoir (Fig. 1) showed chromium contamination (in μg/l) in well 12 (150), well 11 (100), well 10 (75), well 9 (50), well 8 (30) and well 7 (30).

The time period of groundwater pollution from the Vižmarje galvanization plant was not established. The contribution to groundwater pollution from other galvanization plants in the drainage area was also not established. Modern technological usage of chromium has been planned on closed systems, thereby avoiding outflow of wastewater containing chromium. Pollution sources today include soil saturation with chromium at the site of former galvanization plants and "wild" dumping sites.

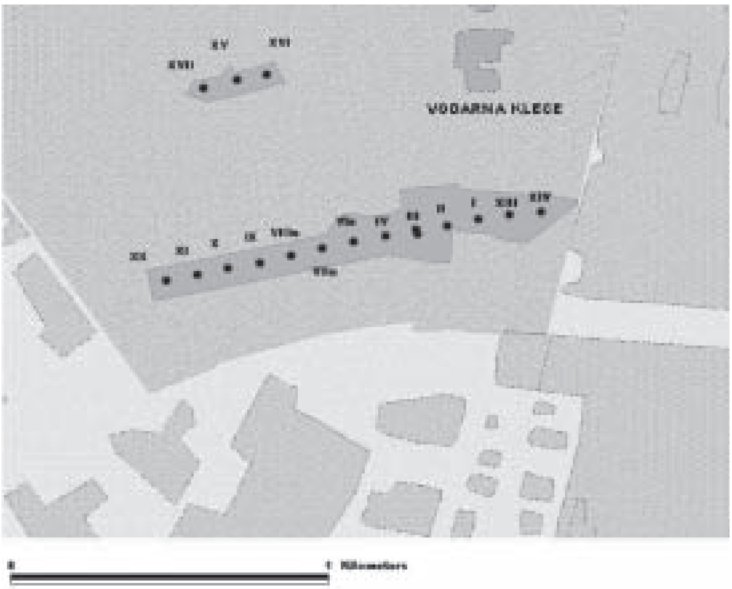

Figure 1.
The Kleče pumping station

Nevertheless, a detailed analysis of the emission potential of single pollutants has so far not been carried out. The primary sources of pollution are galvanization factories where aggressive sewage has damaged the sewer systems and caused its spillage into the underground. In industrial plants, warehouses and yards the grounds are saturated with chromium, and last but not least: in the past waste disposal was carried out unsupervised. In the areas of galvanisation plants and illegal dumping grounds in Ljubljansko Polje decontamination and systematic monitoring of polluted grounds have never been carried out. Consequently, now a lower degree of pollution is to be expected. Further monitoring of the contaminant phenomena will provide experience and valuable empirical data on the hydrodynamic features of Ljubljansko Polje.

Conclusion

The total concentration of chromium in any of the sampling sites in Ljubljansko Polje does not exceed the value of 50 mg/l, this being the permissible level according to the Regulations on health suitability of potable water (Official Gazette of the Republic of Slovenia: 46/97, 52/97, 54/98, 7/00). Temporary concentrations of the hexavalent chromium in the Kleče pumping station are gradually declining and it is expected that they will sink below the lower limit of detection in all wells of the reservoir.

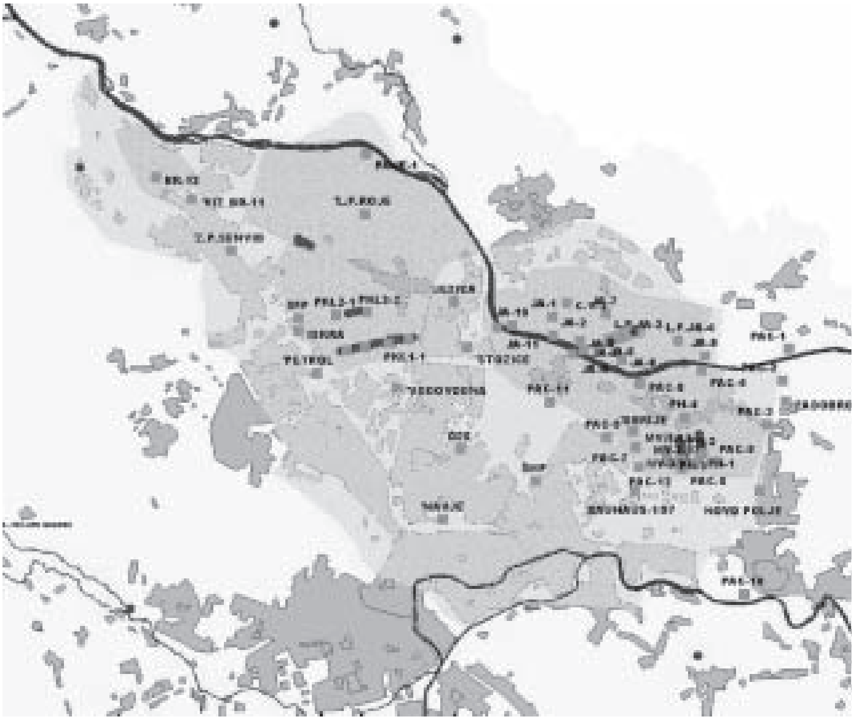

Figure 2. Area of Cr^{+6} contamination

Noticeably, the Hrastje pumping station exhibits a trend of mild increase in Cr+6 concentration, spreading from the south northwards. The most likely cause is the pollution cloud from the vicinity of the Hrastje pumping station, moving towards the Hrastje pumping station owing to pumping works and changes in the currents' courses - the groundwater level the Hrastje pumping station area having been raised. Namely, if groundwater levels are significantly higher then the streamlines from dense city areas are directed southwards towards the Sava River.

On-site and laboratory analyses of Cr^{+6} pollution have given valuable data and information on hydrodynamic features of geological formations of Ljubljansko Polje. These measurements have provided grounds for working out ground water models and will continue to do so in the future.

The groundwater regime at Ljubljansko Polje is highly specific and several phenomena, such as pollution trends and groundwater level movements, are being noticed not earlier than on the basis of several years' monitoring.

Proper and prompt actions and decision-making can put a stop to pollution in Ljubljansko Polje. Point-source pollution as a rule stays within the narrow boundaries of streamlines, luckily failing to spread along the entire water aquifer. The removal of the pollution source will obviously cause the pollution cleanup.

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