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Quality and mutagenicity of water and sediment of the streams impacted by the former uranium mine area Olší–Drahonín (Czech Republic)

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ABSTRACT

The water quality research performed in the years 2003–2010 demonstrated an impact of the mine water pumped from the closed Olší uranium mine and discharged from the mine water treatment plant (MWTP) and groundwater from springs in the area on the water quality of the Hadůvka stream. The water ecosystems of the lower part of the Hadůvka stream are impacted mainly by water originated from the springs located in the stream valley and drained syenit subsoil, naturally rich in uranium. Those inflows caused a very high concentration of uranium measured in the water of the stream, which exceeds the given limit value. No negative impact on the water ecosystems of the receiving Bobrůvka River was found. This reduction of impact is caused by five times higher average daily flow rate of the Bobrůvka River in comparison with the Hadůvka stream, which results in a sufficient dilution of pollution from the Hadůvka.

1. Introduction

1.1. History of uranium mining in the area of interest

Uranium mining activities started in the studied middle part of the Svratka River basin in late fifties of the last century. The largest development in uranium mining and modification of uranium ore from the fifties to the eighties of the 20th century caused devastation of the environment by accumulation of huge waste heaps, sludge settling lagoons and surface water and groundwater contamination. The Svratka River belongs to the main streams of the river network within the Morava River Basin, which is a part of the Danube River basin.

Contraction in the uranium industry started in the late 80s. Since 1990, uranium mining activities have been concentrated only in the mine Rožná. Though the mine was supposed to be closed by the end of the year 2005, it is currently the last operating mine in central Europe. Uranium mineralization is mainly represented by uraninite and coffinite (Zeman, 2002).

One of the closed mines is the Olší mine, which was flooded on January 8, 1996 and, at the same time, the mine water treatment plant Olší–Drahonín came into operation (location is shown in the map – Fig. 1). Decontamination works on these principles: precipitation of radium by barium chloride ($BaCl_2$) and sorption of the precipitate on the filters, sorption of uranium on ion exchange resins in sorption column, partial oxidation of iron (Fe) and manganese (Mn) in the mine waters (forced aeration). Further information about the Olší mining area including hydrogeological conditions is described in Rapantová et al. (2008).

Although worldwide attention has been given to the issue of environmental burden in the mining of uranium mines in last two decades (Van Dam et al., 2002; Meinrath et al., 2003; Carvalho et al., 2005, 2007), the lack of data on toxicity and mutagenicity of surface water and sediments, particularly from the mining of uranium and its compounds is still evident and studies of the topic are rare (Pereira et al., 2009). Tests of toxicity and genotoxicity represent the important role in the environmental pollution studies. And their results can become important bases for possible changes of the hazardous substances environmental limits in the future (Charles et al., 2002). Therefore, this study focused on monitoring the mutagenicity and toxicity of sediments from deposits Olší–Drahonín. For these purposes the procedures where the detection system are living organisms, affected by a real mixture of factors from a particular sample were used: Ames bacterial test (Kajtová and Soldán, 2001) designed to detect mutagenicity, the detection system are mutant strains of *S. typhimurium LT2*, and luminescent test with *Photobacterium phosphoreum* which belongs to bacterial toxicity tests. Biomonitoring results were complemented by

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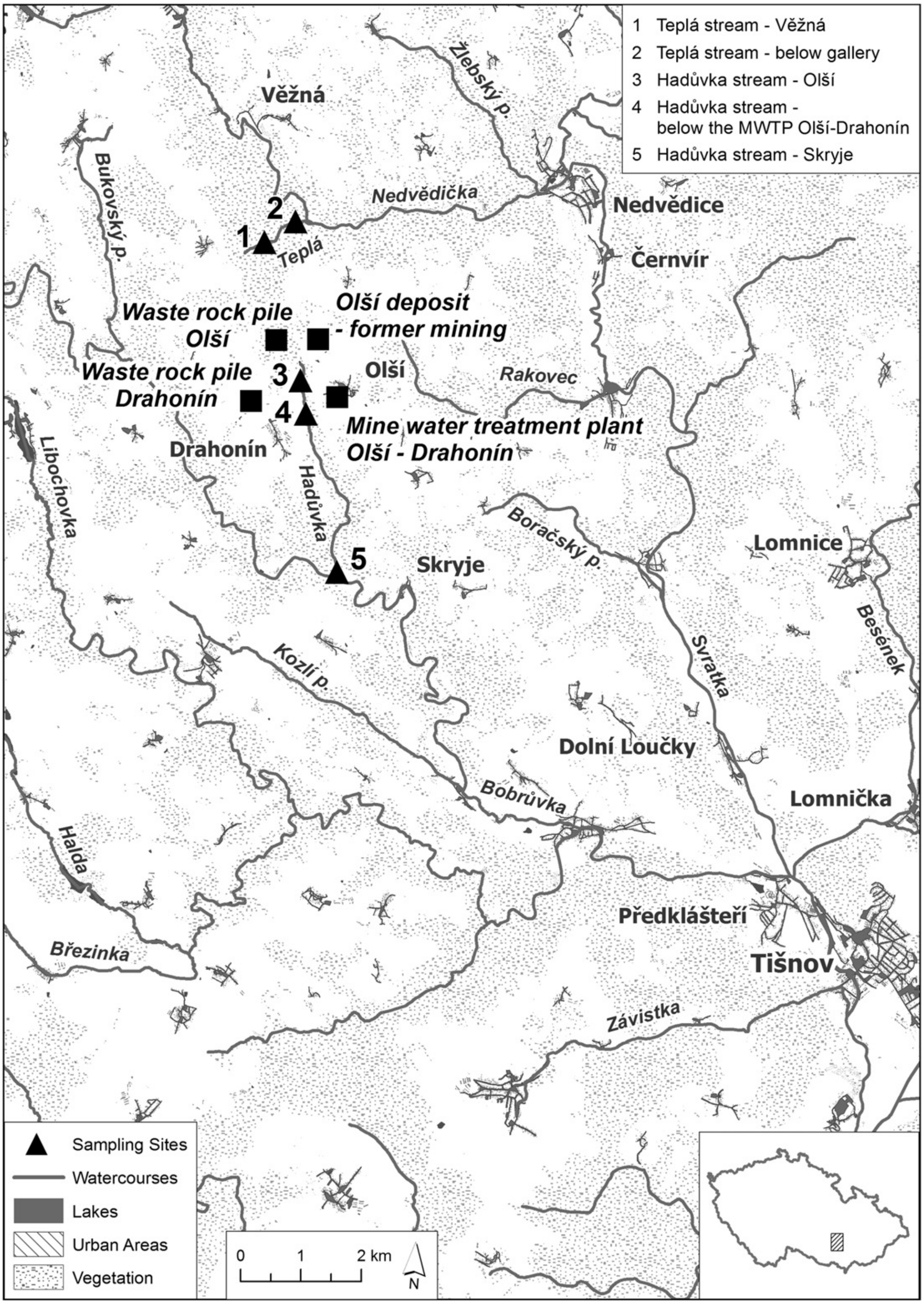

Fig. 1. Map of the area of interest with the marking of the studied water bodies and sampling sites.

chemical analyses of selected heavy metals and radionuclides. Evseeva et al. (2003, 2005) in their studies focused on the examining of genotoxic effects of the water samples from areas contaminated by radionuclides and heavy metals concluded that combined exposure to metals and radionuclides in doses below the permissible exposure limits for humans, can have significant biological effects on organisms. This effect is caused by the synergistic reactions of metals and radionuclides.

1.2. Hydromorphological conditions

The deposit is drained by the adit with free surface in the altitude of 451.3 m (while drawdown is technologically possible) – Michálek et al. (2008). All mine water pumped from the deposit (6–6.5 L s^{-1}) is treated before discharge. Waste water drained from two spoil heaps is also discharged to the mine water. The total volume of discharged decontaminated mine water was 2,774,442 m^3 from 1996 to 2007.