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Pollution of the stream waters and sediments associated with the Crucea uranium mine (East Carpathians, Romania)

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Uranium and thorium are omnipresent in our environment. Various anthropogenic activities involving the processing or use of materials rich in uranium may modify the natural abundance of uranium in water.

The study is related to uranium mineralization located within Crucea ore deposit, in the East Carpathians, Romania. The Crucea uranium ore deposit is located in the eastern part of the Bistrita Mountains (40 Km southeast of the town of Vatra Dornei) in the headwaters of Crucea, Lesu and Livezi valleys. At present, this is the largest uranium mine in the country. In the past, the mining area covered 18 km^2, but was gradually overtaken by logging activities.

The exploration and mining facilities include thirty-two galleries, situated between 780 and 1040 m above sea level. Radioactive waste resulted from mining are disposed next to the mining facilities. The waste rock was disposed in piles of variable size that are spread over an area of 364,000 m^2. Older dumps (18) have been already naturally reclaimed by forest vegetation. The vegetation cover played an important role in stabilizing the waste dump cover and in slowing down the uranium migration processes.

A number of 46 water samples were taken in order to evaluate the impact of ore deposit (including its exploitation process) on the chemical composition of waters down to the exploitation galleries. The sediment samples were collected at 16 sampling points from the bottom of the studied stream waters. ICP-OES, XRF and IC methods was used to evaluate the impact of uranium mine dumps on the surface waters from Crucea region.

According to the analytical data the stream waters showed a Ca – carbonate character. In relation to salinity, the pH and the anion NO_3^-, CO_3^{2-} and SO_4^{2-} contents display generally non-linear relationships with chloride.

Uranium is the most significant trace element in the river waters nearby the waste rock dumps, sometimes reaching levels up to 1-mg·L^{-1}, well in excess of the Romanian standards limits. The uranium concentration ranged from a value of 0.016-mg•L^{-1} to 1.43-mg•L^{-1}, with a mean of 0.365-mg•L^{-1}. A remarkably good correlation exists between dissolved U and the total anion concentrations, indicating that uranium in these stream waters derived mainly from oxidation of uraniferous bitumen and/or dissolution of carbonates. Based on the correlation dependence (r= 0.69) between U and the sum of Ca + Mg + K + Na major cations and the linear correlation (r= 0.70) between U and silica, we find silicate weathering as an additional source of soluble uranium. The concentrations of dissolved Th are quite low, with median values of 0.015- mg•L^{-1}. The linear variation of dissolved thorium concentration with carbonate alkalinity (r = 0.86) strongly suggests that these concentrations are due to the increase alkalinity. The metals released (U, Th and Pb) are amplified by mining activities.

The pollution degree of the sediments was classified using the index of geo-accumulation (I_{geo}). The I_{geo} of U, Th and Pb presents medium and punctual high values that represent sediments with strongly to extremely polluted classification ($I_{geo} > 6$), while the rest of the elements presents concentration close to the background values or lowers to them. 71% of uranium from bottom sediments is present as primary fractions and 21% is associated to carbonates. Thorium resulted even more insoluble (94% in primary fractions). In view of the substantial mobility and bioavailability of the fractions, this is not an alarming feature. Although neither U nor Th has an appreciable "exchangeable" fraction, the isolation of specific U- and Th-rich sediment fractions helped to identify connections between bioavailability and genesis of sediments, which control ecosystem cycling of U and Th.

The measurements carried out in the surroundings of a local uranium mine show that the impact of Crucea mine on water quality downstream of mining area is insignificant.