Spatial and Temporal Variations in the Distribution of Multiple Elements in Sediments within the Iron Gate I Reservoir along the Danube River

Trtić-Petrović T.[1], Culicov O.[2,3], Šaraba V.[1], Lazarević D.[1], Jovanović J.[1]

[1]Laboratory of Physics, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia
[2]Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, IIO, Dubna
[3]National Institute for R&D in Electrical Engineering ICPE-CA, Bucharest, Romania

Iron Gate I, situated in the Đerdap Gorge and extending over 117 km, stands as the largest hydropower dam and reservoir system along the Danube River. The environmental impact of this dam encompasses alterations to the hydrological regime of both surface and groundwater, as well as changes to sediment patterns. Notably, the sedimentation rate within the Iron Gate I Reservoir is remarkably high, estimated at approximately 23.3 cm per year, suggesting a significant potential for accumulation and, consequently, the preservation of pollutants. Monitoring efforts have been focused on evaluating pollution levels in the River Danube, with particular attention given to emerging contaminants such as metals and metalloids (Hg, As, Ni, Zn, Cu, Cr, Pb, and Cd). This study aims to determine major and trace elements in Danube River sediment using instrumental neutron activation analysis (INAA) and to identify possible contamination.

The concentrations of 40 major and minor elements were measured at 8 locations along the Danube River, spanning from 1141 to 864 km, to monitor the spatial and temporal quality of sediment. Sediments were collected from the surface of the river bottom at the central and the deepest part using an Ekman grab sampler in April and September 2016, April 2017, April and July 2018. All samples are analyzed applying the INAA. The major elements (Al, Ca, Fe, K, Na, Ti, Mg, and Mn), trace elements (Ba, Zn, Cr, Sr, V, Rb, Ni, Cu, Co, As, Sc, Th, Cs, Hf, Sb, U, W, Ta), and lanthanides (La, Ce, Nd, Sm, Eu, Gd, Tb, Dy, Tm, Yb) were quantified. Irradiations of the samples were performed at the pulsed reactor IBR 2 (Frank Laboratory of Neutron Physics - FLNP, Joint Institute of Nuclear research—JINR, Dubna, Russian Federation) using thermal or epithermal neutrons.

The concentrations of the investigated elements varied significantly among the sample locations, with relative standard deviations ranging from 18 to 90%. The contamination factor (CF) was calculated by comparing the concentration of the target element in sediment from the sampled location to values from a reference sample, denoted as background. A sediment sample collected from the depths of the River Danube, specifically at a depth of 7 meters, and displaying the lowest concentrations of nearly all elements, served as the reference sample.

We found a contamination factor (CF) exceeding 6, signaling exceptionally high levels of contamination for Zn, As, and Sb in the sample gathered from location Smederevo. CF values for Zn, As, and Sb varied between 1 and 6, indicating low to moderate contamination levels across all examined samples. The sediment sample from the River Danube in Smederevo serves as a focal point for contamination with Zn, As, and Sb, likely stemming from anthropogenic sources, possibly linked to a nearby steel processing plant in the vicinity of Smederevo.