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OCCURRENCE AND DISTRIBUTION OF METALS IN THE AQUATIC ECOSYSTEMS OF THE DANUBE RIVER AND SELECTED TRIBUTARIES

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Introduction

The Danube River, the second-longest river in Europe (2,857 km), traverses ten countries and drains a catchment of approximately 817,000 km², making it the largest international river basin in the world.

Within Romanian territory, the Danube serves as an important source of raw water for drinking water production in numerous municipalities. Previous studies [1] have indicated well to very good water quality in the Danube under normal precipitation conditions. However, extreme conditions resulting from climate change may affect both the volume and the quality of the Danube's water. Consequently, continuous monitoring of its water quality is essential to ensure the safety of water resources, protect aquatic ecosystems, and support sustainable water management.

The aim of this study was to investigate the water quality of the Danube at specific points, from its entry into the country to Galati, before it enters the Danube Delta, during a period of extreme heat that affected Central and Eastern Europe.

Materials and methods

Surface water and sediment samples were collected during a sampling campaign conducted between 22 and 25 June 2026 at 16 monitoring sites, including 11 sites along the Danube River (Svinita, Eselnita, Drobeta Turnu-Severin, Bechet, Corabia, Turnu Magurele, Giurgiu, Oltenita, Borcea, Braila, Galati) and five sites located on its major Romanian tributaries (Jiu, Olt, Arges, Ialomita, and Siret), immediately upstream of their confluence with the Danube, respectively at Gighera, Islaz, Chirnogi, Giurgeni and Vaideni. Surface water and sediment samples were collected in accordance with standardized sampling procedures (ISO 5667 series).

For metal analysis, surface water samples were filtered and acidified with nitric acid (HNO_3) prior to analysis. Metal concentrations (dissolved fraction) were determined using ultrasonic nebulization inductively coupled plasma optical emission spectrometry (USN-ICP-OES) according to an analytical method accredited in accordance with EN ISO/IEC 17025:2018.

Sediment samples were freeze-dried to remove moisture, sieved to obtain the <63 µm fraction, and digested with aqua regia using a closed-vessel microwave digestion system. Metal concentrations were subsequently determined by inductively coupled plasma optical emission spectrometry (ICP-OES) following an analytical method accredited in accordance with EN ISO/IEC 17025:2018.

Results and conclusions

Surface water samples were analyzed for dissolved As, Al, Ba, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Sb, Se, and Zn. The measured concentrations were compared with the environmental quality standards for Class I surface waters specified in the Romanian surface water quality regulation [2].

The analytical results indicated that only samples S11 (Oltenita) and S12 (Giurgeni, Ialomita River) exceeded the Class I environmental quality standards for Zn and Ba, respectively, and were therefore classified as Class II surface waters under the Romanian surface water quality regulation [2]. The remaining samples showed either concentrations below the limit of quantification (As, Cd, Co, Cr, Cu, Mo, Ni, Pb, Sb, and Se) or concentrations below the Class I quality standards for Fe, Mn, Zn, and Ba.

Exceedances of the regulatory threshold values in sediments were identified in three samples collected from the Danube River. Sample S1 (Svinita) exceeded the guideline value for Ni, sample S3 (Drobeta-Turnu Severin) exceeded the corresponding limits for Cd, Cu, and Zn, and sample S11 (Oltenita) showed Cd concentrations above the regulatory threshold. In contrast, concentrations of As, Cd, Cr, Cu, Ni, Pb, and Zn in all other sediment samples, including those collected from the Danube and its tributaries, remained below the maximum permissible values specified by the in-force legislation [2].

The elevated concentrations of Ni, Cd, Cu, and Zn observed in several Danube sediment samples may reflect the cumulative influence of historical and ongoing anthropogenic activities within the upstream catchment, including industrial discharges, mining activities, urban wastewater inputs, and agricultural runoff. As sediments act as long-term sinks for trace metals, localized enrichment may occur in areas characterized by reduced flow velocity and enhanced fine-particle deposition. The accumulation of these elements in the <63 μm sediment fraction is consistent with the high affinity of trace metals for fine-grained particles and organic matter, which promote their retention in river sediments.

The spatial variability of metal concentrations in the sediments is likely associated with differences in sediment grain size, mineralogical composition, and hydrodynamic conditions, which control the transport, deposition, and accumulation of metal-bearing particles. Local anthropogenic inputs may further contribute to the observed enrichment at specific sampling sites.

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