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From coal mines and coal ash disposal sites to recreational lakes: tracing environmental impacts of coal and coal combustion by-products in streams and reclaimed mines in Bosnia and Herzegovina

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Coal has been one of the dominant energy sources over the last two centuries and currently provides ~38% of the world's electricity. Coal combustion produces nearly 1 billion tons of coal combustion residuals (CCR) annually, of which 40-50% are disposed of in surface impoundments and landfills. These materials are known to be enriched in toxic trace elements and pose a threat of leaking into the environment. In this study we investigate (1) the chemical and radiological characteristics of coals and CCRs from Southeast Europe, (2) the potential leaking of effluents from coals and CCRs into streams in the vicinity of three coal mines and thermal power plants in Bosnia and Herzegovina (BiH), and (3) trace elements concentrations in decades old recreational lakes built on the abandoned coal mine pits in Tuzla basin, BiH.

Based on major and trace elements concentrations, most analyzed CCRs belong to the high-calcium CCRs type, and are enriched in V, Cr, Ni, Nb, Pb, and U when compared to world CCR average values. Using geochemical and isotopic fingerprinting of $^{87}Sr/^{86}Sr$ and $\delta^{11}B$, we found evidence of coal and coal ash contamination of near-by streams. We found that streams near CCR disposal sites contain elevated trace elements abundant in CCRs (e.g. V, Ni, Sb, U, Mo) as well as $^{87}Sr/^{86}Sr$ and $\delta^{11}B$ values that are consistent with those of coals and CCRs and are distinctive from the upstream values. An exception was observed in a stream flowing through a coal mine, where concentration of Sr, U, and Se decreased after contact with the coal deposits.

Trace elements content in recreational lakes built on coal mine pits varied, but lakes already in use for recreation had generally lower trace elements content, compared to lakes not yet fully reclaimed. Overall, this work contributes to the understanding of environmental impact of coal mining and CCR disposal sites and provides new insights into sustainable land reclamation practices from legacy coal mining.

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