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Magnetic tracing of coal slag and ash in a river basin

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Atmospheric distribution of pollutants by magnetic means has been extensively studied, but only little is known about pollution-related magnetic signatures for aquatic transport. The case of a textile factory in Croatia that released heavy-metal polluted and highly magnetic ash and slag material from coal burning into Mrežnica River for 110 years (1884-1994) represents an ideal target for studying principles of magnetic tracing through a river system. Samples from the riverside close to the factory show high concentrations of magnetite (mass-specific susceptibility χ $\sim$1-4 x10^{-5} m^3kg^{-1}) with low frequency dependence (χfd% <3%). However, quantitative detection of slag and ash transport in the downstream direction through the riverbed is hindered by extremely variable magnetic properties of the river sediments, presumably due to hydrodynamic sorting. Surface mapping of χ on riverbanks $\sim$3 km downstream of the factory reveals clear evidence for substantial distribution of slag and ash materials in the river basin due to flooding; the affected area reaches to >100 m from the riverside. The spatial pattern of shallow vertical sections of χ (surface to $\sim$0.5 m depth) shows different layers of coal burning residues which may even allow discriminating different flooding events (historical flooding). In order to assess the possible influence of fly ash from the factory, we studied vertical soil profiles at locations which cannot be reached by floods. These (red) soils, formed on limestones, are strongly magnetic (χ >10^{-6} m^3kg^{-1}). Despite this strong natural magnetic signals, the depth dependence of χfd% and characteristic chemical properties (sulfur content, Ni/Cu ratio) as well as the dependence of the vertical χ distribution with distance to the point source indicate a contribution of fly ash to soil contamination near the factory (within about one kilometer). The presently available results indicate that with a strong magnetic point source as in the case of the studied textile factory, magnetic tracing can contribute important information on the transport and mass balance of sediments in a river basin.