Fates of pollutants from uranium mining in floodplain of a meandering river (the Ploucnice, Czech Republic)

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The Ploucnice River (Czech Republic) received two groups of element pollutants. The first was Pb-Cu-Sb-Zn association with the onset early in 20th century; we attribute it to diffuse pollution at levels of the river watershed and/or mid European region with both atmospheric and fluvial transports. The second group was U-Zn-Ni-Co-Ba association related to uranium mining and mine-water processing during the 1970s and 1980s. Pollution hence allowed for identifying two chemostratigraphic units in 20th century floodplain fill, whose lower boundaries we interpret as isochronous at a given river reach. Historical and current maps and aerial photographs and current aerial lidar scanning allowed reconstructing the floodplain development. Electrical resistivity tomography (ERT) produced insight into the floodplain architecture.

Three geomorphic levels were identified in the studied river reach: active floodplain, abandoned floodplain (paleochannels there are now inundated at >Q50), and pre-Holocene or early Holocene terrace. Each level has its own pattern of pollution by Pb, U and polyaromatic hydrocarbons. The terrace and abandoned floodplain sediments together with deeper sediments from active floodplain allowed construction of background functions for pre-industrial concentrations of target elements and subsequent calculation of enrichment factors. That approach corrects for grain-size effects and thus coarser unsorted terrace sediments, finer silty sands of the abandoned floodplain, and the finest muds of the active floodplain were jointly processed. Such data processing was a pre-requisite for evaluation of weak diffuse pollution from early 20th century and recognition of post-depositional changes in pollutant concentrations.

The main portion of pollutants related to uranium mining got into the river system in 1970s with peak in 1981 during a summer flood with >Q50 discharge. The pollution impacted the entire river system (enhanced Ra-226 activities were detected at tens of km downstream of the mining area). Several hotspots were formed behind the end of the channelised river reach downstream from the mining area. The analyses of the pollution hotspots conducted by other researchers in 1990s and our novel results show that maximal pollutant gamma activity (mainly U and Ra-226) in these hotspots has been transported from a meander (channel) belt towards the distal floodplain. Downstream transport (secondary pollution) from the hotspots is demonstrated by considerable Zn, Ni and U enrichment in the deposits of 2013 summer flood (25 years after termination of the primary pollution) and by the fact, that enrichment factors of Zn, Ni and U in the floodplain sediments downstream of the hotspots has still not started to decline. The persistence of the pollution of the floodplain sediments is in contrast with the activity of the Ploučnice River water, which dropped down in 1989 and afterwards to the levels from the period before the start of the uranium mining.