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The combined use of ^{210}Pb, ^{137}Cs and heavy metal concentrations for

determination of deposition rates on the floodplain under anthropogenic impact

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The study area is the Warta River floodplain in the gorge through the Cracow Upland (southern Poland) built of Upper Jurassic limestones. Over a length of 0.8 km, the Warta River undercuts the left, rocky side of the valley. The opposite side of the channel is accompanied by natural levee, which separates an elongated backswamp consisting of several smaller, irregular basins. The alluvial plain is 150 – 180 m wide.

Human impact on the Warta catchment intensified in the last 200 years. A considerable deforestation of this area occurred at this time, as well as the development of large-scale mining of iron ore. Numerous mine waste dumps became one of the most important source of fine-grained alluvia into the surface water network. Recent pollution sources can be identified as related to functioning of iron smelter and to discharge of municipal wastewater from the city of Częstochowa in late 1950s. Loads of pollutants to the river decreased after sewage treatment plant started to operate in 1960.

Seven sediment cores were collected from the floodplain. Two profiles were taken in a natural levee and five profiles in crevasse splays and backswamps. 50-74 cm long profiles of unsaturated floodplain deposits were sectioned into 2-5 cm thick layers. Total ^{210}Pb, ^{137}Cs, $<$0,063 mm fraction, loss on ignition (LOI) and selected heavy metal contents (in the $<$0,063 mm fraction) were analysed for each subsample.

The principal component analysis (PCA) was applied in order to find relationships between the sediment characteristics and to explain distinct patterns in their depth profiles. PCA allowed to group sediment characteristics for all but one profile into two factors: one of them reflects vertical variability of $<$0,063 mm fraction and LOI, the other factor is loaded by most analyzed metals, particularly Ni, Pb and Zn. The first factor is loaded also by total ^{210}Pb and, to a lesser extent, by ^{137}Cs.

Control of radionuclide activities in the profiles by fine and organic material contents could undermine their usefulness as geochronological tools. We show, however, that the strong increase of total ^{210}Pb in the uppermost parts of the profiles is due to high contribution of supported ^{210}Pb as confirmed by ^{226}Ra analyses. The relationship between ^{137}Cs and fine and organic material does not weaken geochronological applicability of this radionuclide because it is used as a marker of events related to its releases into the environment. From this viewpoint it is less important which fractions of the sediment contain ^{137}Cs.

The PCA showed that the vertical variability of metal concentrations is not controlled solely by their adsorption to fine particles what suggests that metal concentration profiles reflect variable delivery of these metals to the river. The characteristic strata in metal concentration profiles can be thus dated by relating them to abrupt changes in pollution loads related to intensification of metallurgical production and opening of wastewater treatment plant in Częstochowa.

Deposition rates derived from ^{210}Pb, ^{137}Cs and heavy metals are consistent and range from 0.2 cm/year in the backswamp to 1 cm/year. Good agreement between values averaged over different periods (around 100 years for ^{210}Pb, around 50 years for ^{137}Cs and heavy metals) proves that the deposition rates have not changed during the 20^{th} century on the studied floodplain.

The PCA identified also a profile from the natural levee for which the relationships between profile characteristics was different than for other profiles. This profile appeared to be useless for deposition rate determination because its formation occurred in irregular conditions.

The combined use of several tracers and application of the principal component analysis allowed for a reliable and geomorphologically consistent reconstruction of deposition rates in different zones of a floodplain under strong anthropogenic pollution.

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