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Heavy metal contaminants on the Elbe River floodplains - chances and limits to prediction of topsoil qualities

F. Krüger and B. Urban

LEUPHANA University Lüneburg, Water, Soil and Resources Engineering, Faculty of Environmental Sciences and Engineering, Suderburg, Germany (brigitte-urban@t-online.de, +49 5826 8661)

For decades to centuries the Elbe river lands have been highly polluted by heavy metals and organic micro pollutants due to uncontrolled and unlimited sewage disposal from settlements, industries, agriculture and contaminated sites.
During high flood events polluted sediments are transported downstream and spread over the floodplains where they have caused severe large scale contamination. Recent sustainable agriculture on Elbe river grasslands requires site specific management, adapted to the degree of contamination. Due to different sedimentation rates and different historical contamination loads of pollutants, the status of soil contamination varies over time and between sites.

As part of the RAMWASS project (Risk Assessment and Management of the Water-Sediment-Soil System, 6th EU research frame programme), a topsoil monitoring strategy was applied to the Lower-Saxony section of the Elbe River (Germany) which incorporates different flooding situations. In 2007, 66 topsoils were sampled along 21 cross sections within 11 meander loops. Up- and downstream, bankside and distant flooding environments were considered as well as different flooding frequences of sites. Measured soil parameters were heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn) arsenic, organic carbon, nitrogen, pH and grain size. Measured site parameters were elevation (flooding frequency) and distance to the Elbe from pollution source. Findings included arsenic values ranging from 17-165 mg/kg; cadmium, 0,5-11 mg/kg; and mercury, 0,1-20 mg/kg. More than 90 % of all investigated sites exceed legally allowed "threshold values" for mercury of 2 mg/kg for grassland use.

The described monitoring strategy enables an assessment of large scale pollution. Multi-regression analyses were performed with selected parameters correlated to sedimentation processes to predict contamination status without heavy metal analysis, but with the help of easy assignable parameters as elevation, distance to the river from pollution source, pH, Carbon, C/N and grainsize. The results are e. g. for mercury equations:
Hgcalculated = -10,9 + (-0,87*ELEVATION [m] + 0,001*DISTANCE [m] + 0,15*PH + 1,43*CARBON [%] + 0,529*C/N + 0,08*GRAINSIZE [$<$20 μm, %]). The standard error of this formula is 2,3 mg/kg for Hg. The validation of multi-regression calculations was performed with the help of 22 additional soil samples (gathered in 2008), equally distributed within one meander loop/test site called "Wehningen".
The multi regression approach distinguishes reliably higher and lower contaminated sites. The organic carbon content of topsoils is the most important factor determining the contamination status. Problems occur for sites with relatively low organic carbon contents, where negative results might be calculated but the underestimation is still within the standard error of e.g. 2.3 mg/kg for mercury. However, it is clear that multi-regression or single regression approaches cannot replace measurements if a judicial resilient assessment is required. It can be summarized, that the multi-regression approach is a robust tool for prediction of contamination status based on a set of parameters.
Due to the fact that, in general, soil quality is affected by recent sedimentation, further 21 high flood sediment samples were collected during floods in 2007 and 2008. Sediments were collected with the help of artificial lawn sediment traps along the Lower-Saxony river section at different sites. Sedimentation rates of 50-2700 g/m^2 were determined.
Summarizing these findings it can be stated that recent sediment accumulation rates are so low that soil quality is hardly effected, within an investigated soil column of 10 cm. Accepting a mean topsoil density of $\sim$1 g/cm^3, a

sediment load of 10,000 g/m^2 is required to produce a sediment accumulation rate of 1 cm. Consequently, recently assessed soil quality results of the area under investigation will have a long lasting validity.