The risks of remobilization of historically polluted sediments in the Meuse

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Introduction: The banks of the river Meuse, especially in the upper (Walloon) region, contain many historically polluted sites, such as dumping sites and abandoned industrial grounds [1]. In many cases, the contamination is situated near the surface, which makes it susceptible to erosion during extreme high water events.
It is expected that climate change will lead to more frequent and extremer flooding of the Meuse [2]. The risks of erosion of contaminated sediment and subsequent transport to downstream parts of the Meuse, are therefore expected to increase in the future.
In this study, we have conducted preliminary model calculations in order to illustrate what the effects could be of a serious erosion event of a contaminated site in the upper part of the Meuse. We expressed the effects in height and duration of peak dissolved contaminant concentrations in the Dutch part of the Meuse. We also calculated the total transported contaminant load and the quality of the downstream deposited sediments.

Methods: We conducted the model calculations with the EXPOBASIN model, which was developed by Deltares as part of the EU-FP6 MODELKEY project. EXPOBASIN is an exposure model aiming at supporting risk assessments for chemicals, both hydrophilic and hydrophobic, on a basin-wide scale. The model establishes spatial relations between causes (pollution sources) and downstream impacts (ecological risk), taking into account the geometry, hydrology and fine sediment dynamics of European river basins. Bioavailability and bioaccumulation are included in the assessment. As a result, the exposure can be quantified not only in terms of aqueous concentrations, but also in terms of concentrations in sediment and biota.
For the illustrative purpose of this 'case study', we assumed that an extreme high water event would erode 1% (7000 m^3) of the contaminated soil at the Flémalle site just upstream of Liège. The Flémalle site is a former coke plant and its soil is contaminated with a cocktail of BTEX, PAH, mineral oil and heavy metals. We restricted our model calculations to benzene, fluoranthene and cadmium as representatives of the different contaminant groups. Information on the concentrations of these contaminants we derived from [3]. We used median concentrations in the calculations, which were 80, 460 and 2.7 $mg.kg^{-1}$ for benzene, fluoranthene and cadmium respectively. We forced the model with a hydrological period of one year encompassing the highest flood recorded in the last decades being the 1993 flood, which reached a peak discharge peak at Eijsden (B-NL border) of 3050 $m^3.s^{-1}$.

Results: The calculated eroded masses of benzene, fluoranthene and cadmium are 874, 5023 and 29 kg respectively, which equals 1.07, 8.71 and 0.01 times the average annual loads of these contaminants. During transport, retention of benzene is negligible whereas retention of fluoranthene and cadmium amounts to 66% between Flémalle and Keizersveer (NL delta). The calculated maximum dissolved concentrations at Eijsden are 3.3, 1.1 and 0.004 $\mu g.l^{-1}$ for benzene, fluoranthene and cadmium respectively. For fluoranthene this concentration exceeds the LC50 values for invertebrates (10x), fish (34x) and algae (1.6x) considerably. The fluoranthene concentrations in the downstream deposited sediments exceed the LC50 for sediment dwelling crustaceans 6 to 25x.

Discussion: The preliminary model calculations conducted in this study, show the potential hazards the contaminated sites along the upper Meuse present to the ecology in the downstream parts. They indicate that the eroded loads of (organic) contaminants from just one contaminated site can already lead to considerable mortality amongst fish, invertebrates and algae. In the light of the EU-WFD, it seems therefore unavoidable that measures are anticipated to prevent erosion of contaminated Meuse riverbanks during future extreme high water events.

References: [1] SPAQuE (2008). *Rapport Annuel 2008*; [2] Berlamont. J.E. (1995). *Extreme floods in the hearth of Europe: the case of the 1995 Meuse flood. U.S.-Italy Research Workshop on the Hydrometeorology, Impacts, and Management of Extreme Floods, Perugia (Italy), November 1995*; [3] Batlle Aguilar, J. (2008). *Groundwater flow and contaminant transport in an alluvial aquifer: in-situ investigation and modeling of a brownfield with strong groundwater – surface water interactions. PhD Thesis, Liège University, July 2008.*