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The relevance of a sound long-term monitoring of sediment quality for the objectives of the EU Water Framework Directive

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Introduction The European Water Framework Directive (WFD) aims at achieving a good ecological and chemical status of the surface waters in the European river basins until 2015. The central idea of the Treaty is that the environment should be protected to a high level in its entirety. The central operational instrument of the WFD to control and reduce pollution is the combined approach using emission standards on the source side and quality standards on the effects side. Adequate monitoring concepts are required to establish a coherent and comprehensive overview of water status within each river basin district.

Environmental Quality Standards (EQS)

The WFD requires that quality standards are established. Compliance checking with these standards will be one of the major elements of a comprehensive strategy against water pollution. According to the WFD quality standards are to be set for water, sediment or biota. Currently, EQS derived from (aquatic) NOEC data are proposed for the water phase (AMPS 2004). In cases where EQS have been violated, one of the sources of pollution might have been the release of contaminants from contaminated sediments to surface waters. This demonstrates the connectivity between both phases. However, compliance monitoring of sediment quality is not yet feasible because of the lack of valid Sediment Quality Standards.

Sediment monitoring

Sediments have an impact on ecological quality because of their quality, or their quantity, or both. They are subject to transport, deposition and erosion, thus forming a dynamic part of the hydrological system. At the same time they have specific significance as habitats of different biocoenoses and as the place where manifold transformation processes occur. Because of their high potential for accumulation of non-polar, persistent, and toxic compounds, sediments are particularly sensitive to anthropogenic impacts, which may disturb the natural state of waters. Therefore, sediment monitoring should include quantitative as well as qualitative and ecological aspects.

Qualitative sediment monitoring programs should address the *risk* coming from contaminated sediments and the temporal and spatial changes in sediment quality. The presence of contaminated sediments might be one of the obstacles to achieving "good ecological status" for a waterbody, even if point source emissions have been dramatically reduced. One widely accepted way of obtaining an initial information of the likely causes of a poor ecological status is the sediment quality Triad (Chapman 1996). The assessment of *in situ risks* at sites where sediment quality is to be considered is part of monitoring programs (den Besten et al. 2003). *Trend monitoring* will provide an indication of temporal changes in sediment quality over a prolonged period, and facilitate to assess compliance with the no deterioration objective of the WFD. Before starting a trend monitoring programme it is essential to establish the quantitative objectives. It is the duty of the program manager to specify the size of the changes the monitoring program is expected to identify. Sediment samples should be collected taking into account the sedimentation rate and hydrological conditions. For inland reaches of large rivers like the Elbe, a typical sampling frequency would be once every year. The locations for sediment trend monitoring should be representative of a waterbody or a cluster of waterbodies. They should represent non-erosion areas, to obtain sediment with a relatively high content of clay and silt that will probably contain measurable levels of contaminants and reduce normalisation problems. For dynamic systems, as tidal estuaries, it might be useful to collect suspended matter for monitoring purposes. *Spatial monitoring* will provide an indication of the horizontal spread of a contaminant over a river basin, and possibly to locate its source. It will provide basic information for appropriate sediment management. Historic contamination at hot spots is often reflected in the deeper sediment layers. Besides chemical and eco-toxicological sediment monitoring, biological monitoring of sediments provides an adequate method to determine if a watercourse has been influenced by pollutants. Benthic macroinvertebrates are common inhabitants of sediments. Their presence and abundance is strongly depending on the quality of their habitats, thus they can indicate pollution impacts from various, cumulative or multiple sources. Moreover, due to their long presence they can indicate problems, that may stay undetected by conventional chemical surveys.

1 Results of long-term sediment quality studies on the river Elbe

Results of long-term studies in the Upper and Middle Elbe River between 1991 and 2004 are presented and the temporal and spatial trends in sediment contamination and toxicity are studied (Heininger et al. 1998, 2003; Ackermann 1998). Principally, two categories of sampling stations were used. Monitoring sites are unaffected by direct anthropogenic influences and should provide information about long-term and short-term changes in the recent background conditions. Heavily polluted reaches ("hot spots") are taken as the worst case scenario. The most striking observation was the significant reduction of pollution by heavy metals. Despite these positive trends it must be pointed out, that the situation for most of the metals is far from being clean. Compared with local background data of sediments in the Middle Elbe, only the concentrations of nickel and chromium have already reached these levels. The other element loads still contain significant anthropogenic portions of up to 90 % and more (zinc, mercury, cadmium). Regarding organic priority pollutants, the picture has both similar as well as completely different features. For some organic pollutants reduction rates as for the metals could be noted. But, caused by inputs via the small tributary Bilina on the Czech side, with respect to p,p'-DDT and HCB the situation in Elbe sediments in general is in 2001 not better or even worse than at the beginning of the 1990s. Non-point sources dominate the PAH inputs into the Elbe and their level follows the run-off pattern. In the mid - 1990s, with high streamflow, the PAH concentrations reached a maximum.

From the results of the aquatic bioassays and whole-sediment tests with the nematode *Caenorhabditis elegans* one can conclude that Elbe sediments have a permanent measurable toxicity. Outside hot spots, the toxic effects as observed in the aquatic tests usually are low, and normally they disappear rather rapidly with dilution. But there are intervals of stronger toxicity over the whole monitoring period. In this way, obviously there is not a trend towards lowering sediment toxicity. The observed adverse effects to algae and nematodes must not be neglected when conclusions about the ecological status are drawn. Particularly chronic effects should be taken into account in future monitoring programmes.

There is quiet a lot of correspondence between priority chemical pollutants pattern and ecotoxicity, but deviating findings occur as well. Both elements are necessary for a representative sediment quality monitoring.

1.1 References

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