

Sediment Ecotoxicity

Information sheet

The water quality of many European rivers and lakes has strongly increased in recent decades. However, polluted sediments serve as contaminant reservoirs that continue to affect the ecological condition of surface waters. Hence, the monitoring and assessment of sediment quality are of major significance.

Significance of sediments

Sediments are the habitat and spawning ground for numerous organisms. However, they also act as reservoirs and long-term sources for contaminants that adsorb to the sediment particles. Sediment-bound contaminants that are re-released into the water through sediment organisms, flooding or dredging may have a toxic effect on organisms. Organisms living in the sediment (benthic organisms) or immediately above (epibenthic organisms) are affected by the contaminants and - via the food chain - may also harm higher trophic levels. This is because some contaminants are accumulated by sediment-dwelling organisms (bioaccumulation) and may be taken up by higher organisms living on the contaminated organisms. As a result, poorly degradable substances increasingly accumulate in the food chain (biomagnification). Thus, fish, waterfowl, and mammals are also affected by contaminated sediments. Aquatic animals with a high fat content such as salmon and whales are often heavily contaminated with polychlorinated biphenyles.

Toxicity of sediments

Sediments store a wide range of contaminants such as metals, polycyclic aromatic hydrocarbons, pesticides (e.g. DDT, pyrethroids), polychlorinated biphenyles, naphthalenes, and Dibenzo-p-dioxins and furans. The sediment of the river Saane, for example, is partly contaminated with polychlorinated biphenyles and that of the river Rhine is contaminated with hexachlorobenzene, mercury, and cadmium. Such contamination can have a long-term effect on the water quality by increasing the mortality of aquatic organisms, affecting their endocrine or immune systems, changing their genetic material, or causing cancer.

Assessment of sediments

Since sediments play a very important role for the transport of contaminants and for water quality, they must be included in water quality management plans. The monitoring and assessment of the sediment quality are essential for national legislation and the implementation of the EU Water Framework Directive: for the first time, sediment quality monitoring is regulated in the European Union by a daughter directive of the Water Framework Directive. According to the Directive, Member States are required to monitor the concentration of 33 priority substances in sediments and organisms and prevent it from rising further. The Swiss Water Protection Ordinance stipulates that persistent contaminants must not accumulate in the sediments in order to protect aquatic organisms. However, it includes no requirements on sediment quality and no recommendations for the assessment of sediment quality. Ecotoxicological assays for the assessment of dredged material have long been mandatory, for example, in Germany, the Netherlands, and the USA.

Methods of sediment assessment

- **Chemical analysis**

Sediment quality is traditionally assessed by chemical analysis. However, the chemical analysis of all chemicals in an environmental sample is practically impossible because it is usually not known which substances are present in the sample. Moreover, chemical analysis does not provide any information on the bioavailability or biological effect of the substances and cannot assess the combined effect, mutual amplification, or reduction of the toxic effect of mixtures of substances. To obtain an idea of the biological effect of the measured chemicals, a comparison with sediment quality criteria is necessary. Such quality criteria for sediments have not been established in Switzerland to date.

- **Bioassays**

Bioassays can be used to determine the ecological effect of sediments without identifying the responsible substances or their sources. They very often include tests with bacteria and invertebrates (e.g. freshwater shrimp, chironomid larvae, or daphnids), *in vitro* test methods with yeast or cell cultures, and test methods using early life stages of fish or fish eggs. Many *in vitro* tests first require the extraction of the particle-bound contaminants into the aqueous phase. However, this extraction usually does not reflect bioavailability in the field. Therefore, sediment contact tests with various organisms (e.g. blackworms, chironomid larvae, or water milfoil) have been increasingly used in recent years. Several methods can be combined to bioassay batteries. The selection of the bioassays should consider different hierarchy levels of the organisms and different exposure paths.

- **Tiered assessment concepts**

Tiered assessment concepts are used in many countries to evaluate the quality of dredged sediments. It is decided at each tier whether a sediment is safe for a specific use or whether further investigation is required. Tiered proce-

dures are often used as a management strategy for sediment clean up or for the assessment of dredged material because these procedures take the cost factor into account and ensure a structured approach.

- **Integrated sediment assessment / weight-of-evidence approach**

The integrated sediment assessment or weight-of-evidence approach is a widely used approach to determine the risks of contaminated sediments by assessing the ecological effect of contaminants based on various lines of evidence through a combination of different measurements. Both chemical and biological data are incorporated. The **sediment assessment triad**, for example, combines sediment chemistry, sediment toxicity determined through assays, and the measurement of field effects on sediment biocoenoses (as in the macroinvertebrate index or in the oligochaeta index).

Links

Flück, R., Chèvre N., Campiche S. (2012) Quality monitoring of sediments in Switzerland. State of the art of available methods and recommendations (in German). Ecotox Centre Eawag-EPFL

www.oekotoxzentrum.ch/dokumentation/berichte/doc/Sedimente_final_DE.pdf

Sednet is a European Research Network with the goal of considering information on sediments in the strategies for environmental protection and developing new tools for sediment handling. Information on sediments from a European perspective.

www.sednet.org

Guidance document on chemical monitoring of sediment and biota under the Water Framework Directive

http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidance_monitoring/EN_1.0_&a=d

Documentation of the U.S. EPA on sediment handling

<http://water.epa.gov/polwaste/sediments/cs/index.cfm>

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