Sediment Risk Management and Communication

Synthesis of the SedNet Work Package 5 Outcomes

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1 Risk Management in Sediments

Sediment risk managers must address economic and societal, as well as environmental, risks. Acceptable levels of risk are determined by society, not only by science. Scientific risk assessment is an integral part of risk management; it is a tool that helps determine the probability and degree of risk and provides the scientific basis for decision making on management options. Such risk is generally defined as the product of the magnitude of a hazard and its probability. What risk management options are eventually selected, however, depend not only upon these scientific and technical issues, but also on legal, societal and economic considerations. These include societal perception of risk, which may be influenced by objective factors such as those above, but also subjective ones, including confidence in institutions, familiarity with issues, access to information and perceptions of control and potential personal impacts. Thus, early, frequent and transparent communication between all parties (including the public) throughout the decision process is an essential part of risk management. SedNet WG5 sought to address the various aspects of this process.

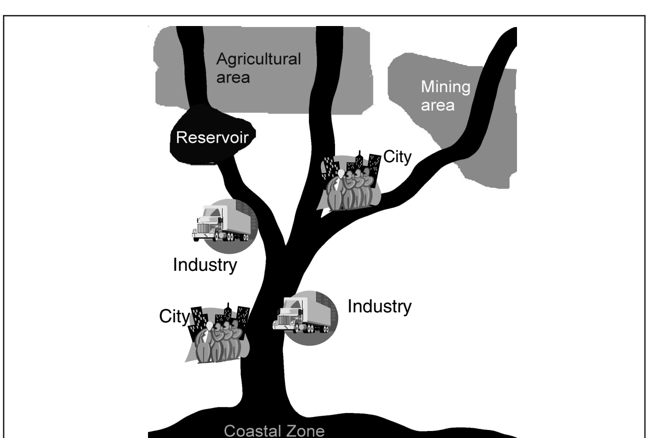

Fig. 1: Potential sources for contaminant emission to sediments

2 Functions and Uses of Rivers

As **Fig. 1** illustrates, many human activities within a river basin can have an effect upon the ecological and socioeconomic functioning of river basin system. If risks in connection with river basin sediment are to be addressed, the various environmental, economical and societal functions, interests and pressures that affect a typical river basin must be considered. These include:

- Industrial point sources of pollutants that may subsequently accumulate in sediment,
- Diffuse sediment and pollution sources from mining areas (heavy metals), agriculture (nutrients and pesticides) and other sources
- Cities bordering the river and its tributaries, potentially providing point and diffuse sources for municipal waste.
- Banks along the river used as recreational areas, or as erosional sources of previously deposited sediments (clean and/or contaminated).
- Parts of the river serving as fishing grounds.
- Harbours and channels along or at the mouth of the river, providing transport and possibly requiring dredging of clean and/or contaminated sediment to maintain navigation.

3 River Management

3.1 Objectives

Society manages river basins to meet a number of objectives, including:

– maintaining functions, uses and ecological quality status for the river basin and its sub-basins.
– finding a sustainable compromise which balances the functions, uses and quality criteria on a local scale and a river basin scale that can be agreed upon by all stakeholders involved (political, scientific, economic, environmental, private)

The ***sediment risk management objective***, as defined by SedNet Working Group 5, is "to reduce risk posed by contaminated sediments to humans and ecological receptors to a level deemed tolerable by society and to control and monitor sediment quality and ensure public communication with the final aim of complying with the EU WFD and Habitats Directive."

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3.2 Drivers

Activities and decisions in sediment management will be mainly motivated by the following drivers:

a) to organise and implement agreed objectives including changing functions and uses of the river.
b) to meet regulatory criteria of a number of regional, national, multilateral and European agreements and regulations. Even though sediments or dredged material are often not explicitly addressed in these agreements, it is necessary to consider them as an integral part of the aquatic ecosystem.
c) to maintain economic viability. This can be hampered by sediment if it decreases water depth to a critical level for navigation, if poor sediment quality or enhanced resuspension cause economic losses from e.g. fishery or tourism, or if the sediment dynamics result in flooding or undesirable erosion.
d) to ensure environmental quality and nature development. Sediment may be managed to reduce the risk of the deterioration of the ecological function of a river system, accompanied by the reduction of species and the destruction of habitats, degradation of water quality and the impairment of human health in direct (recreation activities) or indirect contact (fish and drinking water consumption) with the affected water body.
e) to secure the quality of human life. Sediment accumulation may facilitate flooding and endanger human safety, dredging activities or land disposal sites planned in the neighbourhood may alter the accustomed surroundings (and may trigger a NIMBY attitude[1]).

A consideration of the objectives and drivers above for the sites within a specific river basin helps to define Basin Management Objectives (BMOs) – the socioeconomic and ecological objectives for a given river basin overall, and for sites within that river basin.

4 Risk management in rivers

Long-term risk reduction needs a basin-scale decision framework. Because of the dynamic, complex and interconnected nature of sediments, from sources and rivers to estuaries and the sea, effective and sustainable management strategies must focus on the entire sediment cycle, rather than on one unit of sediment at a time. Such an approach will help focus limited resources to maximise the achievement of management objectives, including basin-scale risk reduction. A basin-scale risk management framework should be comprised of two principal levels of decision making; the first being a basin-scale evaluation (**prioritisation** of sites for further evaluation and/or management) and the second being an assessment of specific sites for risks and management options (**site-specific risk ranking and management**).

4.1 Conceptual basin models

In dynamic river basin systems, contaminants and particles can partition, transfer and move through the ecosystem via various media, including air, sediments, soils, water and biota. Soil and sediment are present in various depositional areas, and, under the right hydrological conditions, they are amenable to mixing, erosion and further transport downstream. Furthermore, continuing agricultural and industrial practices, as well as catastrophic spills, accidents, and changes in erosional and depositional patterns due to climate change and anthropogenic activities continue to provide both point and diffuse sources of sediment, both contaminated and uncontaminated, into many river basins. Management of risk (whether to the environment or to our socioeconomic goals) in a river basin demands that sediment risk management should be closely linked with the assessment and management of these other media. To achieve this, the relationships between hydrodynamically connected sites, in terms of quality, quantity and energy, must be used to help define their relative risk, their (risk-based) priority in a risk management strategy, and how current or proposed management activities may affect one another. However, the understanding and communication of the dynamic interactions between sites and media is complex.

Just as a Conceptual Site Model (CSM) allows risk assessors to consider the flow of contaminants to target organisms in support of site-specific risk assessment, an understanding of the particle and contaminant flows and interactions within a river basin in support of basin-wide management and prioritisation, should inform basin-scale evaluation. This description and inventory, whether conceptual or quantitative, of the mass flow of contaminants and particles (and thus risk) within a river basin can be termed a Conceptual Basin Model (CBM), and is a critical part of effective risk assessment of a particular site, and of river basin management as a whole. The complexity of a CBM will differ from river basin to river basin, depending on the information available. It can be quite conceptual, or it can involve detailed chemical, sedimentological, hydrodynamic and modelling studies. Inasmuch as it describes how materials move and interact between sites, it leads to increased knowledge about the river basin system and also serves as an important communication tool about Cause (Drivers-Pressures-State)-Effect (Impact) relationships in a river basin. The more such relationships are understood and communicated the easier it will be able to manage the system (Response), with full participation of all stakeholders.

4.2 Site prioritisation

If by any process within the river basin (contaminated) sediment pose a risk to one or more of the basin objectives, reduction of that risk becomes a necessary item in a sediment management action plan. In most cases risk reduction is most effectively achieved if the whole river basin is addressed because of the dynamic, complex and interconnected nature of sediments. Various aspects of the CBM should provide screening-level information about how sediment and contaminant distribution and dynamics might possibly endanger the agreed-upon river basin objectives, as well as how these actions might be addressed. Data from the CBM, as well as a **site risk prioritisation** and a consideration of the socioeconomic and ecological basin objectives, when combined with other factors, will ultimately lead to a basin sediment management plan.

Site risk prioritisation should be done according to a number of criteria, preferably quantifiable at a screening level, including: the site's *location along the up- and downstream gradient* (e.g., how are downstream sites affected by contaminated sediment sources upstream?), *quantity of contaminated sediment* (e.g., is the volume large enough to present a risk?), *evaluation of sediment quality* (e.g., how contaminated is the sediment?), *sediment dynamics* (e.g., is (contaminated) sediment transported downstream?) and the *potential expected risks or benefits* of proposed management actions at a given site and for the river basin (to what extent can the risk to the site and the basin be reduced when the site is managed). In those cases in which sediment management decisions begin at the site-specific level, it is essential that the impacts of these actions upon adjacent sites, and basin-scale quality and objectives are considered.

[1] NIMBY – 'not in my backyard'

4.3 Site-specific risk ranking and management

If a site is identified as high priority during site prioritisation, then it will be subject to a management process, which includes site-specific risk ranking. A site-specific risk ranking is needed in order to determine, in greater detail, what the risks at a given site are. A tiered assessment is recommended that comprises at different levels the use of chemical, ecotoxicological and sediment community data in order to assess the in situ risks and predict those that are connected with management activities. Such an approach requires the development of explicit measures of exposure, related to ecological processes, which must be selected based upon site-specific conditions and management options (or scenarios). Ultimately, basin-scale risk management will require the harmonisation of risk assessment and ranking approaches. The selection of risk management or disposal approaches requires a comparative risk assessment that identifies (and possibly compares) the risks to the environment due to management options, e.g. dredging. Post-remedial monitoring, to confirm risk reduction, flag continuing problems, and to update and refine CBMs is recommended as well.

5 Sediment Management and Communication

For effective and successful sediment management it is essential that the relevant stakeholders participate in the entire process, on both the local and basin scales, during assessment, development and implementation, of sediment management plans.

To this end, measurable risk indicators may be defined for certain objectives such as

– 'contaminant concentrations in fish are below limit values' for the objective 'quality of human life', or
– 'navigation in marina X is possible' as indicator for 'economic viability'.

Such risk indicators will support the communication process by simplifying complex information and making decision processes transparent, making it easier to understand the frames and aims of the other parties and helping to avoid misunderstanding or ineffective communication. Such a clear identification of the links between risks and objectives, combined with the CSM as a communication tool, may illustrate how 'problems' at one site may be better addressed with 'solutions' elsewhere in the basin system.

There have been a number of positive examples in which resources were more effectively invested by shutting down contaminant sources upstream than by dredging downstream contaminated sediments for years or decades. One example is the financial support that Hamburg, Germany, gave to a Czech chemical company that emitted large quantities of mercury into the Elbe River. By spending 150.000 € upstream for the construction of two settling basins, the annual mercury load in Hamburg, 600 km downstream, was reduced by 50%.

In another example, initiatives like the Rhine Action programm in 1987 were started by institutions like the ICPR[2] and included agreements between the City of Rotterdam and upstream dischargers of contaminants which consequently led to a decrease in point sources of pollution and to a significant improvement of the water and sediment quality of the Rhine.

[2] International Commission for the protection of the Rhine

Finally, the 'Elbschlick-Forum' in Northern Germany in the 90s is an example of successful involvement of the public in sediment management decision-making. The Federal States of Lower Saxony and Schleswig-Holstein bordering on the Lower Elbe had committed themselves to support the Federal State of Hamburg by depositing within their own borders one third of their dredged material over a period of 10 years. The disclosure of the initially non-public search for a disposal site of contaminated dredged material in Lower Saxony caused a public uproar. This, however, led to the initiation of an open forum, to which all stakeholders, namely citizens, civic action groups, various institutions, NGOs, associations, and representatives from industry and agriculture, were invited. The aim of the 'Elbschlick-Forum' was to discuss publicly the problems of dredged material management and to come up with recommendations for strategies to prevent, reduce and use dredged material in that area and, if necessary, for its disposal. One year later, the Forum was able to present political recommendations to the government of Lower Saxony.

6 Summary and Recommendations

Acceptance and implementation of a basin-scale approach will require significant work, both technical and political. However, successful development of a basin-scale risk management framework should provide the basis for parties with very different goals for sediment to come together in support of sustainable sediment management.

We recommend that effective and sustainable management strategies focus on the entire sediment cycle, including suspension-sedimentation processes along the whole river basin. A Conceptual Basin Model (CBM), describing the dynamic processes (soil-sediment-water-contaminant) within the catchment, should be set up and the basin-scale management objectives (BMOs) should be identified in order to develop a Basin Management Plan. This Basin Management Plan should define/list the goals for both the river basin and individual sites.

A comprehensive Basin Scale/Site specific risk management approach is recommended that includes the following steps:

1) The communication between managers and the public, throughout the decision process,
2) The identification of management objectives,
3) The determination of appropriate risk indicators,
4) the usage of risk indicators to prioritise sites on a river basin scale and to rank risks on site-specific scale,
5) the decision making process in which potential effects on the river basin and on the site-specific scale are weighed against each other, taking into account the economic, societal and environmental risk, and finally
6) the selection, implementation and monitoring of the final management option(s).

A prerequisite for sediment management on river basin scale is the harmonization of site prioritisation (basin scale) and site-specific assessment (risk ranking) schemes

A DPSIR ('Driver-Pressure-State-Impact-Response') approach, along with the use of CBMs to quantify and communicate basin dynamics, should be used to facilitate communication between stakeholders (including the public). We applied these to describe the relationships between social and societal forces, the objectives of risk management and the potential management options, and the prevailing interests.