

# Sediment Management in the Elbe from the Perspective of the Port of Hamburg

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## 1 Introduction

Continuous maintenance dredging is necessary in the Port of Hamburg to safeguard water depths for navigation. Since the 1990s the annual amount of dredged sediments has increased from about 2 million to about 6 million cubic meters today. The challenges for sediment management are manifold. Contamination of Elbe sediments decreased over the last decades; nevertheless, sediment quality still needs to be improved. Nature protection regulations and marine policy requirements demand management plans and limit placement of dredged sediments in open water. Although Hamburg safely disposes annually 1 million cubic meters of contaminated Elbe sediments on land, most dredged sediments have to be brought back to the aquatic system.

## 2 Sediment transport in the river and in the estuary

The Port of Hamburg is situated some 1,000 km downstream of the Elbe source and 100 km upstream of the Elbe mouth at the North Sea. Natural erosion processes lead to a fine-grained suspended matter load of more than 500,000 tons per year from the upstream region. The so called tidal pumping processes transport coarser material from the North Sea into the estuary. In the estuary these two fluxes mix.

In former times, many centuries ago, during flood events these sediments could settle in the low lying coastal plains, thus forming the fertile marsh lands. Due to embankment for flood protection this is not possible any more since centuries. Also river deepening and hydraulic engineering changed hydro-morphology and sediment transport patterns in the estuary. Today, the river and remaining inundation areas cover only a small percentage of the original area.

Sediments tend to settle where flow velocity decreases, both is true in shallow waters and in harbor basins. This is the reason why especially in the Port large volumes have to be dredged regularly to maintain safe water depths for navigation. But also shallow areas like side branches tend to silt up. If no counter-measures are taken the river will become more and more a canal, thus even accelerating the process by increasing the tidal pumping. Another effect is that natural habitats will become more and more uniform, and biodiversity will decrease.

Suspended matter, especially fine grained material, also functions as a carrier for contaminants. For decades prior to the fall of the "iron curtain" the Elbe had been the recipient of insufficiently treated wastewater. For example, the chemical complex at Bitterfeld used to release 200,000 m<sup>3</sup> of untreated industrial sewage into the Elbe each day. After the collapse of the communist regimes, the remaining and the newly built industries became generally equipped with modern pollution-control technologies. However, the concentrations of several contaminants in sediments are still not satisfying. Dredged material criteria are exceeded, fish consumption has to be restricted.

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### 3 Dredged material management in the Port of Hamburg

Recurring maintenance dredging is necessary in the Port of Hamburg as in most other ports world-wide. This activity is ongoing since centuries, although the equipment has certainly changed over times. In addition to the sediments dredged in Hamburg in the downstream part of the Elbe estuary the Federal Waterways administration has to dredge about another 15 million cubic meters per year. In other big estuaries in the North Sea region, like the Scheldt, the Rhine, or the Humber about the same overall amount has to be dredged.

In former times the dredged sediments were brought onto land in Hamburg. They were used for agricultural purposes, land reclamation, etc. Some 30 years ago the contamination of the sediments was detected. Research was undertaken to develop technologies to deal with large amounts of contaminated sediments. At the same time old disposal sites had to be remediated in order to minimize their ecological impacts.

As a result the Hamburg Dredged Material Management Concept was developed in the 1980s. It consists of mechanical treatment of the sediments and subsequent safe disposal of the contaminated fine sediments, following European and German technical landfill standards (Figure 1). These disposal facilities are in operation since then. Annually 1 million cubic meters of sediments is treated and disposed on land, annual expenditure is ca. 35 million Euros. With this treatment Hamburg is mitigating the contaminant load of the Elbe and subsequently the North Sea by some 30-50 %.



*Figure 1. METHA Treatment plant and Francop disposal site*

After German reunification in 1990 measures could be taken to control emissions at the source. As a result sediment contamination decreased. Therefore commonly used open water disposal was introduced in Hamburg. A management framework was agreed with the environmental administration to limit sediment contamination and to reduce ecological effects by introducing time restrictions for operation.

Today, most dredged sediments remain in the aquatic system. In the last four years some 2 or 3 million cubic meters were relocated into the river near Hamburg, while more than 1 million cubic meters were brought to the North Sea (Figure 2). This sediment removal based on a temporary permit by the federal state of Schleswig-Holstein should break the sediment loops which recently occurred caused by tidal

pumping: sediments were not sufficiently transported to the sea and accumulate in the upper part of the estuary. Due to this fact the German Federal Waterways Administration and the Hamburg Port Authority have developed a common river engineering and sediment management concept for the tidal Elbe (HPA / WSV 2008).



Figure 2: Elbe estuary with Wadden Sea. Tonne E3 is a temporary placement for dredged sediments from Hamburg in the North Sea.

## 4 Sediment Management Concept for the Tidal Elbe

The concept considers first the historical development of the tidal Elbe. Like any estuary the one of the Elbe is very dynamic by nature. At the same time human interventions, like the ones described above, have changed this environment. Any future development has to keep these dynamics in mind. Most parts of the estuary are designated Nature 2000 habitats, and environmental protection is a key issue.

The requirements of EU directives get increasingly important also for sediment management. The CIS-Document "Water Framework Directive (WFD) and Hydro-morphological pressures / Focus on hydropower, navigation and flood defence activities / Recommendations for better policy integration" (2006) states: "Given the impacts of sediment on water uses and/or aquatic habitats, supplementary measures dealing with sediment transport management could be part of the (sub) basin river management plans to support the achievement of the WFD objectives." In a letter the EU Commission stated that "... for dredging works in the tidally influenced part of the Elbe that have been designated as Natura 2000 sites the directive applies ... Regular dredging works as maintenance measures - not intending to deepen the shipping lane - can be included in the management plan for the respective Natura 2000 site and would in this case not be considered to be a plan or project according article 6 of the directive."

Therefore, the sediment management concept is aiming at win-win solutions, following the Working with Nature concept of PIANC (2008) with three main purposes.

(1) River engineering measures shall reverse the negative developments of tidal characteristics, which intensified the tidal pumping. These are long-term measures. The first will be implemented soon in Hamburg by creating a new tidal volume and a tidal habitat. A first so called silt trap has been built downstream of the port. Its purpose is to keep marine sediments from entering the port area, thus reducing the amounts to be dredged. It has been in operation for nearly two years now, but final results cannot be given yet. There are first ideas to construct artificial, near natural structures in the river mouth to dampen the tidal force. This would also lead to protect the estuary against storm surges.

(2) Modified dredging strategies aim to break sediment loops by transporting the dredged sediments to sites from where they do not return with the tide. Hence, fewer sediments should be dredged and less

sedimentation should occur in nearby shallow waters. The consequence are longer transport distances and higher costs for sediment disposal.

(3) River remediation as a long-term task for the whole Elbe community is a key element in remediation of sediment quality and to secure open water placement of dredged sediments. In this context land treatment of contaminated sediments in Hamburg plays an important role.

As many EU directives affecting sediment management came and will soon come into force, HPA commissioned a legal study to review the Sediment Management Concept for the Tidal Elbe on the background of EU legislation. The study came to the conclusion that the concept fulfils all these requirements in a holistic way and all measures have to be evaluated in this context (Breuer 2009).

## 5 Elbe River Basin Sediment Management

By the end of 2009 River Basin Management Plans were published in Europe as requested by the Water Framework Directive. Contamination was identified as an important issue in water-resources management in the Elbe catchment. Two research studies identified substances of concern for the Elbe catchment, based on existing data (Heise et al. 2008). The studies provide details about the so called risk areas where these substances originate. Sources of pollution are abandoned sites or legacies of the past "in or near the river". New emissions are not relevant.

In 2009 the German Elbe River Board published a background paper to identify supra-regional management objectives in respect to contamination (FGG Elbe 2009). In this context a supra-regional risk is given when concentration of a contaminant at a measuring station

- Can endanger the integrity of aquatic ecosystems,
- Can have adverse effects on human health,
- Can compromise the quality of land ecosystems,
- Affects efficient sediment management for navigation or flood control.

The paper identifies management targets for sub-catchments, given in percentage of contamination reduction of existing concentrations. These targets are derived from several specific uses or subjects of protection, reflected in concentrations.

The states belonging to the international river-basin district of the Elbe developed a common management plan consisting of two parts. Part A is being compiled under the umbrella of the International Commission for the Protection of the River Elbe. The Elbe management plan highlights sediments as an essential and integrated part of the river. Qualitative and quantitative aspects of the sediment regime are taken into account with regard to the assessment of the ecological status and to supra-regional management objectives. First measures for improving the sediment budget and the quality of sediments have been planned. Important statements of the first plan are:

- Measures for an improved bed load balance and sediment management are envisaged to reduce hydro-morphological stress. Principles of bed load and sediment management should be implemented at the river basin scale. Such a comprehensive approach has never been taken before.
- Significant contaminant loads belong to the most important supra-regional issues in water-resources management and are one of the major reasons of this dissatisfying situation. Accordingly, one of the main objectives is to establish a management concept for particle-bound contaminants at river-basin scale.
- Sediment quality was crucial for the definition of supra-regional environmental objectives regarding the contaminant issue.

## 6 Conclusions

Sediment management is of great importance both for quantity and for quality issues (SedNet2007). This is true in the estuary and for the Port of Hamburg and also in the entire river basin. Although contamination of sediments has improved significantly over the last decades, this trend has to continue. Sources are mainly in the upstream part of the catchment with an effect into the marine environment. Quantity issues, or hydro-morphological changes, are important in parts of the river, like the Middle Elbe or the estuary.

Nowadays tools exist to tackle this task. An overarching sediment management concept has been developed for the tidal Elbe and is being implemented step-by-step. Over-regional issues are being discussed in both national and international working groups under the umbrella of the national and international Elbe protection commissions and will lead to remediation of existing contamination sources in the whole catchment.

EU legislation, especially the WFD, together with other requirements have led to holistic reflection and action. This will help not only the environment, but also the Port, and the Port of Hamburg will play its role to support these common tasks.

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