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# Current solutions for the treatment and deposit of dredged material in Hamburg

## Solutions courantes pour le traitement et le dépôt de matériaux dragués à Hambourg

K. Pröpping, H. Dansmann, H.-D. Detzner & A. Netzband – *Freie und Hansestadt Hamburg, Strom- und Hafenbau, Germany*

**ABSTRACT:** A comprehensive concept has been developed and implemented for the treatment and deposit of the approx. 2.5 million m<sup>3</sup> of dredged material that accumulates annually in the port of Hamburg. It includes the technical procedures for the processing (sorting and draining) as well as environmentally save storage of the polluted silt in landscaped hills. Moreover, large scale tests are currently being carried out for the installation of water-drained silt in harbour basins, production of bricks, transfer possibilities of less polluted sediments in the Elbe and optimisation of existing processing plants for new useful products. Since the toxicity of the dredged material is caused by the toxins in the Elbe, rehabilitation concepts in the Elbe area are required, which are obligatory for all residents in the area and which have the goal of toxin-free processing the sediments of the Elbe.

**RESUME:** Pour le traitement et le dépôt des résidus de dragage au port d' Hambourg - des travaux nécessaires d' entretien avec une quantité de matériau de 2,5 millions m<sup>3</sup> un projet vaste était développé et réalisé. Le projet contient le traitement d' une technique des procédés aussi bien que le dépôt de la vase contaminée, dans des collines construites une méthode sûre pour l' environnement. En plus, des grandes expériences sont effectuées pour l' installation de la vase déshydratée dans les darces, la fabrication des briques, les possibilités du changement de place des sédiments moins contaminés dans l' Elbe et un procédé d' optimum des usines de traitement existantes pour des nouveaux produits récupérables. Comme la concentration d' éléments polluants des résidus de dragage est causée par la pollution de l' Elbe, il est nécessaire d' avoir un plan pour assainir le bassin versant de l' Elbe. Enfin, le plan est obligatoire pour tous les riverains pareillement et il a pour but l' exploitation pas nocive des sédiments de l' Elbe.

### 1 INTRODUCTION

Due to its location at the upper part of the tidal inflow area of the Elbe as well as due to the segmentation into many smaller harbour areas, the port of Hamburg works as a big sediment pool for the sediments carried by the river before the river reaches the North Sea. Therefore the harbour must be dredged regularly to maintain the ship traffic; this causes yearly about 2 Million m<sup>3</sup> in dredged material. This material is utilized in Hamburg to the larger part on land.

Considering the sediment toxicity of the strongly polluted Elbe a direct utilization of the sediments on land or in the water was until now almost not possible.

At the beginning of the 80's Hamburg initiated a dredged material research program that had as a major result the start-up of the METHA (**ME**chanical **T**reatment of dredged **H**arbour sediments) to reduce the quantity and draining the dredged materials as well as the utilization of two landscaped hills as other essential results.

### 2 TREATMENT CONCEPT

Up until about 10 years the rinsing of the dredged material consisting of sand and silt occurred in unsealed rinse fields with a total area for processing and storage of almost 400 ha. Due to the large amount of water content of the dredged material and the insufficient sealing of the natural underground, the rinse fields would seep polluted water into the ground water.

Considering the recognised pollution it was required to develop an ecologically compatible and longer term concept for the handling of dredged material. For this the most important thing is always the rehabilitation of the inlets that cause the sediment toxicity; for this however at that time the outlook and possibilities were close to zero for the part of the Elbe located upriver from Hamburg.

Starting point for the treatment in Hamburg is the fact of the pollution material concentration in the fine grain fraction; the sand is mostly pollution free. The base

principle is the technical sorting of sand and silt with following draining of the silt and its environmentally save utilization on land; the sand is used for building purposes. The occurring sewage is cleaned before sending it back into the Elbe [7, 11].

The decision for land storage had the result that areas for the selected silt had to be found in the area around Hamburg. To avoid using new areas it was decided to accomplish the necessary new storage capacities on existing rinse fields. This, at the same time was done to minimise seepage of polluted water into the underground. The processing of the dredged material happens in Francop in the West of the harbour area. Here also one of two hill locations; the other one is located in Feldhofs to the East of the harbour.

The storage capacity is designed for a medium-term period in order to be able to make adaptations should anything develop differently.

### 3 DREDGED MATERIAL PROCESSING

#### 3.1 Sorting and draining in the METHA

The dredged material consists of about 40 - 50% of sand and coarser components ( $d > 63 \mu\text{m}$ ) and to about 50 - 60% of Silt with a grain diameter of  $< 63 \mu\text{m}$ . The treatment in a large-scale plant is done in order to win a useable pollutant poor sand fraction and to replace simultaneously the previously used space intensive and weather dependent procedures [3, 5, 6].

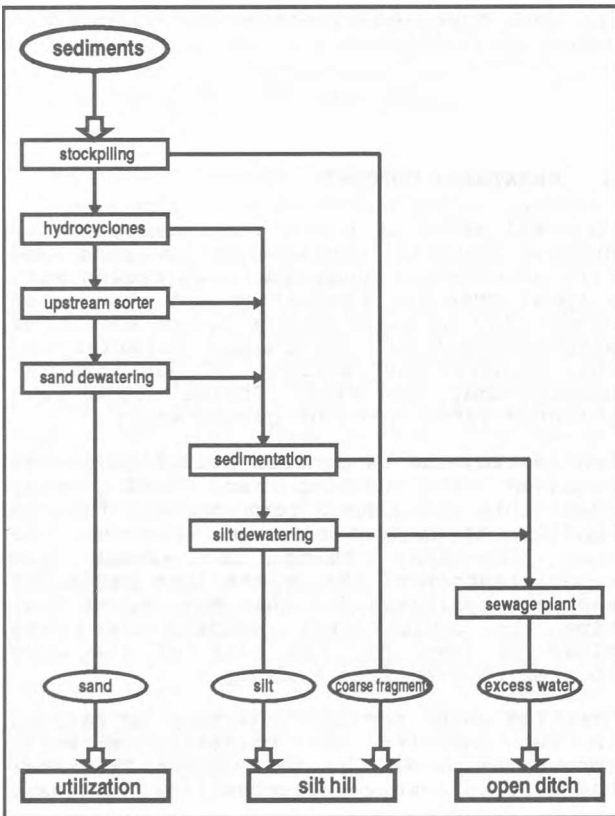


Figure 1: Procedure principle of the dredged material processing plant METHA

The plant METHA taken into operation in spring 1993 defines the state of the technology in the area of sediment processing. It was built with an investment expense of DM 137 millions DM and can process annually about 500000 - 600000 tons of dry mass.

The dredged material is delivered with shoots and is stored for the interim for reasons of time and qualitative comparisons in a basin with a total volume of about 300000 m<sup>3</sup>. Before the rinsing, coarse foreign matters ( $d > 60 \text{ mm}$ ) are sorted out. At the start of the technical process, all particles are separated that are larger than 10 mm by a rotary screen. In the hydro classification and following upstream sorting the fine particles ( $d < 63 \mu\text{m}$ ) with the pollutants are to the most part separated from the sand.

The unpolluted sand carried out of the sorting process is drained by means of a draining sieve to about 85% dry share and used as a building material.

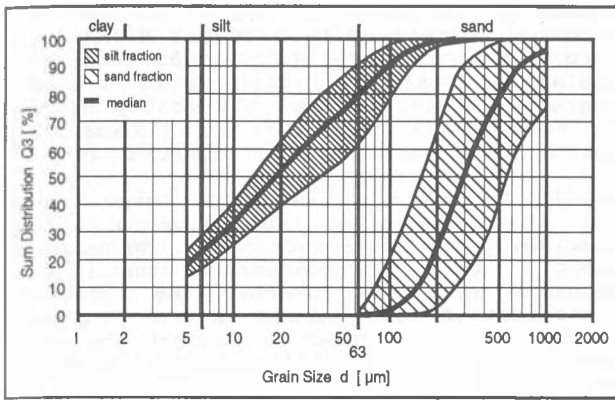
The fine silt suspensions of hydrocyclons- and upstream sorting overrun are thickened with the supplement of polyelectrolytes. The available process water will be reutilized to large parts. Goal of the draining is a product, that under ground mechanical viewpoint provides a sufficient stability ( $c_u > 20 \text{ kN/m}^2$ ) in order to be incorporated subsequently directly into the silt hill. The draining plant consists of filter belt presses and further high intensity filter presses. The total capacity amounts to 60 t dry substances per hour; a draining degree is reached by 55 weight-% dry substance share. The total flock particle related amount to the fixed material share is about 1000 - 1600 ppm. The occurring sewage is cleaned with state of the technology cleaners.

The METHA was expanded based on gathered experiences by an additional high class trial plant in the technical standards. This trial plant serves for the investigation of technical questions of the Storage of polluted silt fractions  $< 20 \mu\text{m}$  (fine silt) and to the utilization of the additionally won product of particles with 20 - 100  $\mu\text{m}$  (rough silt). This trial plant had an investment volume of 4 Mio. DM and has been in operation since December 1996. First results of possible utilization possibilities of the new products are expected middle 1997.

#### 3.2 Operating Results of the METHA

In figure 2, the grain size distribution of the sand and of the silt produced in the METHA in 1994 is represented.

Table 1 Contains pollutant data of the produced METHA-Silt. The values lie in the area of that after LAGA utilized remainder materials [8] or somewhat above that, i.e. in a land storage area in contact with the technical instructions for deposits. The Hamburg silt hill corresponds to these regulations.



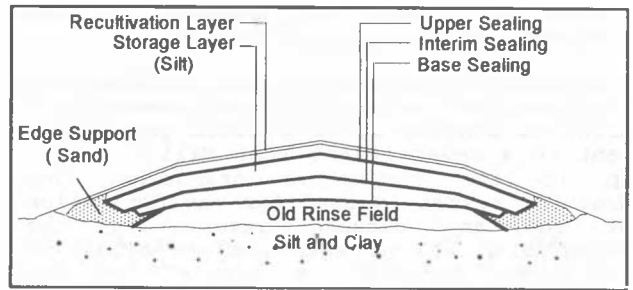
**Figure 2:** Grain size distribution of the sand and silt produced in the METHA in 1994

**Table 1:** Classified METHA-Silt of the years 1993 until 1995. All statements in [mg / kg dry substance], Dioxin in [ng I-TEQ / kg TS (NATO)]. For the sum development, the conditions "<" with the determination limits were considered.

Parameter	METHA 1993-1995	
	Total fraction	Fraction < 20 µm
Arsenic	17 - 46	37 - 90
Lead	57 - 210	130 - 370
Cadmium	1,9 - 5,1	3.6 - 9.1
Chromium	61 - 120	140 - 200
Copper	70 - 190	140 - 270
Nickel	28 - 52	72 - 110
Mercury	1.6 - 7	4.8 - 12
Zinc	370 - 890	1100 - 1700
Mineral oil	100 - 1200	
ΣPCB (6)	0.06 - 0.18	
ΣHCH a-g	<0.03	
ΣPAH after EPA	0.83 - 37.89	
Dioxin	33.5 - 117	
Sediment composition	6.7-11% Ignition loss	34-64% <20 µm

#### 4 CONSTRUCTION OF THE SILT HILL

The classified and water-drained Elbe silts out of the port of Hamburg should be deposited at the locations Francop and Feldhofe in hills with a silt capacity of respectively at least 6 Mio m<sup>3</sup>. An important criterion for the decision to this solution was, that with the erection of the hills on available rinse fields the total requirement for deposit areas and the landscape consumption in the area of Hamburg is minimized and the effects on the environment after the principles of the emission minimization and emission avoidance become limited. The extensively emission neutral deposit in land by encapsulating of polluted materials in sealing layers presents, after existing expert opinions, the most favourable reclamation type. The hills are developed landscape architecturally that they can be made available to the public after mixed recultivation and trail networks.



**Figure 3:** System sketch of the silt hill Francop

The development and plan of the silt hill result in close collaboration between technical planners, landscape planners, geologists, biologists, hydrogeologists, meteorologists and chemical scientists from universities and planning offices. In this way it was achieved that early viewpoints of the environmental compatibility could be taken into consideration for the plan. The building plan concept and building regulations were finalized since 1991 for the hill in Francop, about which is written here, so that the reported hill building can take place. The regulatory steps for the silt hill Feldhofe is being initiated at this time.

In Francop, the silt construction is done in layers inclined outward by 1.5 m in changing layers with 0.3 m of thick sand drain layers. The storage area is partially surrounded by edge support of sand, permitting that the hill is as high as 38 m. The multi barrier system for the minimization of the emissions consists of a sealing base, that also has as a double sealing base an additional PEHD-layer and a surface sealing made of especially sealing silt that encapsulates the storage layers. The arrangement of silt interim layers for sealing within the storage layers should enlarge the supervision possibilities. The sealing layers are tilted so that the drainage water can run off easily. As sealing material, classified silt is used, that follows the regulations of the technical rules for porosity. Water-drained silt proves to be, in spite of the pollutants contained in it, a good and ecologically acceptable sealing material. The sealing system of the hill forms at the same time the cover and back-up of the old rinse field. A comparing ecological investigation regarding the extent of the total old rinse field brought a more unfavourable result in contrast to an upper end sealing process. (See system figure 3)

At the upper part of the sealing are drainage areas that catch and control the drainage water. All polluted water is gathered in a piping system and is led to the sewage system. The drainage water of the upper sealing layer is taken away separately in order to be able to carry out a direct line into the primary flood gate if the amount of water makes this possible.

The protection layer should protect the sealing elements and enable landscaping. The upper area waters occurring on the protection layer are turned into additional

inflow gates which are necessary in the time when the landscaping is done.

The occurring pores and drainage water from the inner part of the hill are taken up and prior to sending it to a flood gate it is sent to a sewage plant that will clean it up to the respective standards. The draining system is used for the derivation of the any escaped gases. For the supervision of the emissions an extensive measurement program is carried out the results of which are presented in form of an annual environmental report. First measurements show that the emissions in this area are within the frameworks designed by the officials.

The hill in Feldhofe is planned fundamentally after the same principles as the hill in Francop. Deviations arise especially through the conformity to the geometric deviations in area size and as well of the construction specific experiences and geotechnical supervision results in the landscaped hills in Francop, the only landscaped hills without edge support out of sand that are left. This sealing system out of base and upper sealing layers is run up to the hill's edge. For the back-up of the old rinse field an additional one is required on the basis of the pitch of the interior that is inclined in a way to seal the old rinse field and to drain to a central water drainage area.

The protection of the ground water is very important to keep in mind when the hills are built and this is controlled by installing a ground water control well. Anything that interferes with it be it nature or the landscape during building of the hill there will be extensive replacement measures.

## 5 TECHNICAL ALTERNATIVES

Since the beginning of the dredged material research programs capable technical alternatives to the storage were searched and implemented to create the most different proposals. A 1995 study covers the national and international possibilities of a technical treatment of polluted sediments both in the port of Hamburg as well as in *Hot Spots* in the upper Elbe area [9]. It showed that there was for the Hamburg dredged material mass, no short or medium-term alternatives to the previous concept.

Besides this, the industry developed attempts toward implementation, whose main component is a thermal treatment for the manufacture of a high-value brick product.

This procedure uses also the treatment technic and draining in METHA. For inspection of the implementation outlooks with a medium size Hamburg firm, a contract with a multiyear run time was terminated by which means the technical and ecological exogenous factors of the brick processing by sediments are examined in a large test plant. In the newly erected brick plant for the manufacture of ceramic products such as clay and secondary raw materials, sediments are also important. In this plant,

presently annually 5 million bricks are produced whereby up to 30.000 t METHA-Silt with a dry substance share of 55 weights-% replace natural clays with up to a total share of 75%. The sale will mostly happen to industry clients and commercial buildings as well as public construction.

In the framework of landscape large tests the installation of the Elbe silt is examined during construction on the harbour basin. The accompanying measurement programs will show whether the expected consolidation will happen in the proposed time and size in order to connect the land sufficiently for building in the harbour area. The installation procedures proved to be feasible. The first measurements confirm tendencies for these expectations.

## 6 STATUS AND OUTLOOK

The Hamburg dredged material concept is a transition solution until the Elbe sediments can be regarded again as clean. In addition since the political turning point in 1989, certain prerequisites exist. Among other things, co-ordinated by the International Elbeschutzkommission (IKSE) in 1990, rehabilitation measures for sewage inflow into the greater Elbe area have started and have led next to introduction of a stop of certain enterprises also to a clear improvement of the water quality of the Elbe.

Besides further introductory rehabilitation, if necessary, highly polluted sediments in the upper part of the river close to Hamburg must be taken out. The goal must be to reach a quality of the sediment that makes it possible to transfer dredged material in an ecologically safe way into other bodies of water.

This is already today possible with dredged material from the western area of the Hamburg harbour. As a result of the mixing with marine sediments, the pollutant load there in comparison with the criteria of the work team that is necessary to keep the Elbe clean results in reshifting certain parts. Previously carried out large scale tests show that this type of procedure that is used in other areas as well can be practised in an ecologically compatible manner.

The country governments of Schleswig-Holstein and Niedersachsen accepted already at the beginning of the 80's the removal of respectively one-third of the mass. In Schleswig-Holstein, the search for an appropriate area for a hill site resulted in the choice of an area at the North-Baltic Sea-Channel in the vicinity of Rendsburg.

In Niedersachsen presently the prerequisites are examined for this, in order to fill Elbe-close available salt caverns with METHA-Silt. These caverns have a large size and make it possible, after the technical problems are solved, to carry out the removal of a large part of the mass. A decision for this conversion will be made in 1997.

With the described options, it is possible

to utilize the dredged material used on land until the year 2010 or longer. It is to be considered that at the same time in Hamburg comparatively large quantities of sediment with a relatively slight load of pollutants will occur. For the treatment, the Hansestadt uses annually around DM 60 millions. This is economically not sustainable. The goal of the North Sea protection through reduction of the pollutants both in the solved phase and also in the sediment toxicity are a task that all Elbe residents should consider alike.

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