Pilot remediation and thermic immobilization of sediments of New Merwede River

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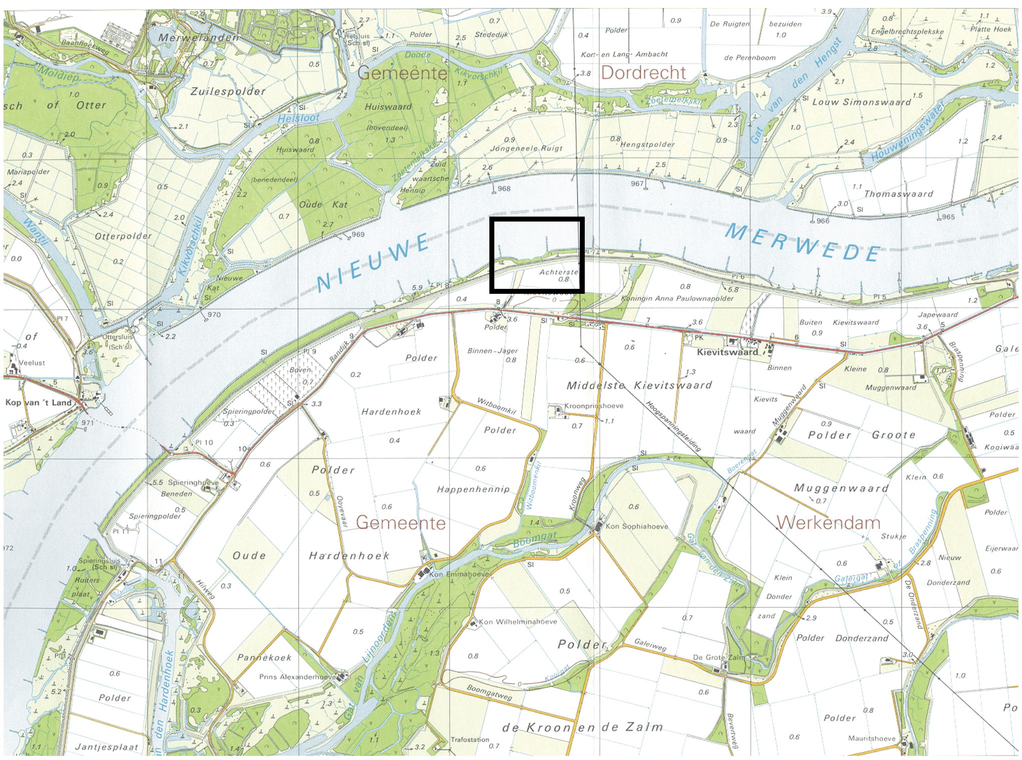
Introduction

On the bottoms of the large river systems in the Netherlands large amounts of sediments have settled in the more stagnant parts of the basins in the course of this century. The process was stimulated by the closing off of major water bodies, such as Haringvliet, and by the closing and poldering of the Zuiderzee. Because of discharges and river pollution these sediments got contaminated.
The Northern Delta Basin was also affected in this way. Large parts of the bottoms of rivers Rhine and Meuse, among which belong the Brabantse and Zuid-Hollandse Biesbosch and the New Merwede River are poluted by contaminated sediments. The concentrations of metals, PAH (polycyclical aromatic hydrocarbons) and PCB demand remediation of these waterbottoms.

A pilot projects was conducted by the Netherlands Directorate-General for Public Works and Water Management (*Rijkswaterstaat*) in preparation for the large-scale clean-up operation. This project involved a groyne section in the New Merwede River (*DHV*, ref. 2). Figure 1 contains a map of the area.

Figure 1 Map of New Merwede River. The rectangle marks the area of the pilot remediation.



The New Merwede River is a dug river with high-frequency shipping traffic. The dynamics of the river could disperse such pollutants through the surface waters. The clean-up of the specific groyne section, which covers a surface area of 40,000 m^2, was a test case for a possible future large-scale approach.

Need for remediation

The selected area is characteristic for large parts of the Dutch catchment areas:

- Deposits of contaminated sediment (classes 3 and 4), up to some metres in thickness, containing a mix of organic and anorganic pollutants
- A jagged bottom profile and heterogeneous geology, requiring many surveys and analyses to define the lower contours of the contamination
- Banks covered with reeds and trees, offering more footholds for contaminations
- Infiltration of river water to lower-lying polders, with the danger of long-term dispersal of contaminations
- Ecological risks through exposure of aquatic and terrestrial organisms to contamination
- Dispersal of polluted sediment at high-water flow rates or through nautical movements.

Remediations should therefore be targeted at removing the risks of contamination.

Objectives pilot remediation

The following general objectives were established:

- Estimating the physical, technical, logistical, financial and organizational possibilities of such a remediation
- Determining the effects upon the physical and biotic environment during and after the operation through monitoring
- Finding the best ways to coordinate and to cooperate in future clean-ups
- Determining the environmental benefits of the remediation, i.e. balancing the effort against the result.

Approach pilot remediation

The initial excavation would be conducted to 10 cm beneath the lower contour of the contaminated sediment, just reaching the clean sediment. This plan had to be abandoned. An old channel appeared to run in the groyne section, as a result of which the contaminations occurred as deep as 4 meters or more below the water surface. This channel had not been spotted in the surveys before and raised the estimated volume of sediment to be remediated from an original 23,000 m^3 to 95,000 m^3. Complete remediation was not covered by the budget and would seriously augment the danger of instability (Rijkswaterstaat, ref. 4)

The initial targets were therefore changed into:

- partial remediation of the top layer by excavating the groyne section to 1.5 m
- applying a clean layer on top of the contaminated sediment left behind
- at the request of other parties involved, no remediation of the sediment below the fringe of reeds bordering the groyne section (which afterwards proved not to require remediation anyway).

This approach minimizes ecological risks. The top layer of the contaminated sediment was replaced by a layer of non-contaminated sediment. This would drastically reduce the danger of exposure and ecological detriment and stop the dispersal of pollutants through the surface water.
It was more difficult to assess the effects with regard to infiltrating river water. Calculations (RIZA, ref. 6) demonstrated that, without a clean-up, the groundwater could in the long run be contaminated by mobile substances or their waste products, such as naphthalene and dichlorobenzene. The levels of these long-term concentrations, however, do not warrant remediation.

Implementation of the civil engineering works

The activities were conducted with a dredge and a crane. Table 1 summarizes the results of the pilot (ref. 2):

Table 1. Results of the civil engineering works

Total of excavated volume	51,415 m^3			
Total of supplemented volume	14,170 m^3			
	Dredge, surface = 25,615 m^2		Crane, surface = 7,350 m^2	
	Volume (m^3)	Mean (m^3/m^2)	Volume (m^3)	Mean (m^3/m^2)
Excess volume dug	83	0.003	111	0.015
Insufficient volume dug	235	0.009	101	0.014
Excess volume supplemented	530	0.021	91	0.012
Insufficient volume supplemented	59	0.002	7	0.001

The pilot remediation yielded profiles more or less within the tolerances of the specifications. The bucket dredger proved more reliable than the crane in the groyne section, probably because the dredge was deployed in a flatter area than the crane.

Thermic immobilization of dredging sludge

A small part of the material from the groyne section, 984 m^3 (equalling 1439 tonnes of wet sludge or 689 tonnes of dry matter), was offered for processing. The processing consisted of the separation of sand, and dewatering, drying and thermic immobilization of the silt fraction. The objective was:

- to test the method in a full remedial chain
- to gain insight into the relevant technical, environmental and financial-economic aspects of the process applied
- to gain insight into the recycling aspects and applicability of the construction materials thus produced.

The objective of the thermic immobilization was to make material that could be used in civil works. This was done by separation the spoil into a sand and a sludge fraction. The sand fraction could be used as foundation in the road building. The sludge fraction had further been processed:

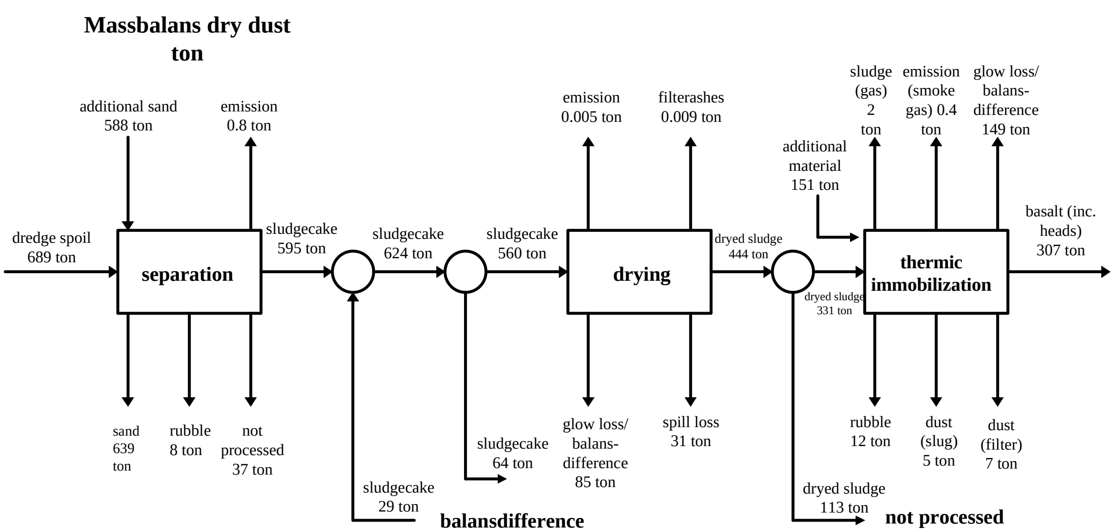
- dewatering and drying the material to about 95% dry solid
- melting the dried sludge and adding of materials to lower the melting point (about 1.400 °C). After cooling down basalt had been formed.

In this way about 95% of the material could be reused as sand or basalt.

Figure 2. Basalt made out of dredging spoil

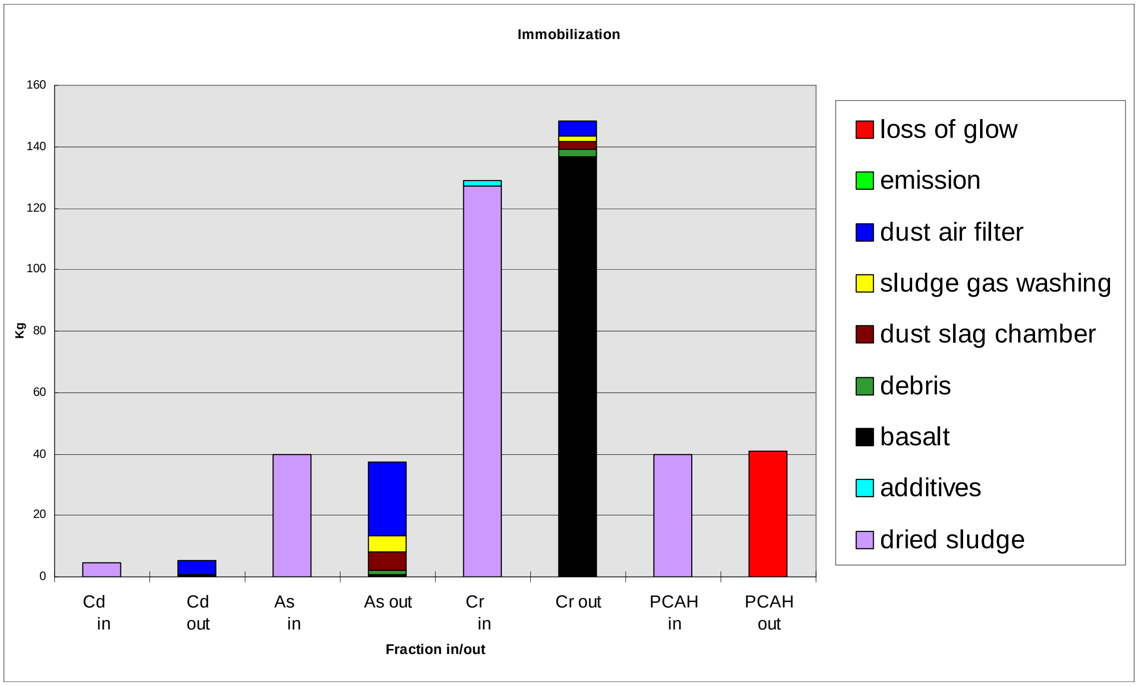
Figure 2 shows the processing route and mass balance of the dry material of the dredging spoil.

Figure 2. Processing route and mass balance of the dry material in the dredging spoil.



After sand separation and drying, 304 tonnes of immobilization product was extracted from 274 tonnes of dried silt and 125 tonnes of additives. Calcining caused the loss of 75 to 100 tonnes, 75% of which originated from the sludge (DHV, December 1996, ref. 2).
The contaminations appeared to take different routes. This is shown in figure 3 for cadmium (Cd), arsenium (As), chromium (Cr) and polycyclic aromatic hydrocarbons (PCAH).

Figure 3. Routes of contaminants during the process of thermic immobilization.



More than 95% of the relatively volatile compounds, such as cadmium, lead, zinc and arsenic, evaporated and ended up as deposits in air ducts, filter residues of the air purification system and silts of the wet gas scrubbing. PAH almost completely disappeared as a result of scorching. Only chromium and copper were found to have remained, practically intact, in the final products. Table 2 (ref. 1) gives a summary of the results of the materials analysis and leaching tests.

Table 2. Composition (C) and leachability (L) at a liquid/solid ratio of 10 of source material, intermediate products and final product. All figures in mg/kg d.m.

	Dredging sludge		Sludge cake		Dried silt		Basalt	
	C	L	C	L	C	L	C	L
Arsenic	140	0.82	170	0.15	133	2.34	<5	0.09
Cadmium	15	< 0.002	18	0.10	13	0.004	<0.2	<0.001
Chromium	350	0.21	410	0.17	288	0.45	140	0.22
Copper	240	0.07	320	0.16	313	2.84	95	0.26
Mercury	15.5	<0.0003	12.5	<0.0003	7	<0.0003	<0.1	<0.003
Lead	410	<0.08	500	0.13	390	<0.05	24	0.094
Zinc	1800	0.94	2000	24.4	1500	0.17	270	0.56
PCAH	72	0.012	77	<0.0003	81	0.0001	<0.25	<0.0003

The basalt produced meets the requirements of the Interim Policy set by the Association of the Provinces of the Netherlands. Compared to the original sludge, the rate of leaching did not appear to have been reduced significantly, despite the fact that various contaminants were now concentrated in the generated residual fractions rather than in the end product of basalt.
It can be concluded that the production of basalt from seriously contaminated sludge is a feasible proposition. The term 'immobilization' does not, however, appear to be entirely justified, as the

process concerns both purification - to retain volatile metals in residual substances, and immobilization - to retain contaminants in a solidified end product.

Amersfoort, April 13th 1999

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