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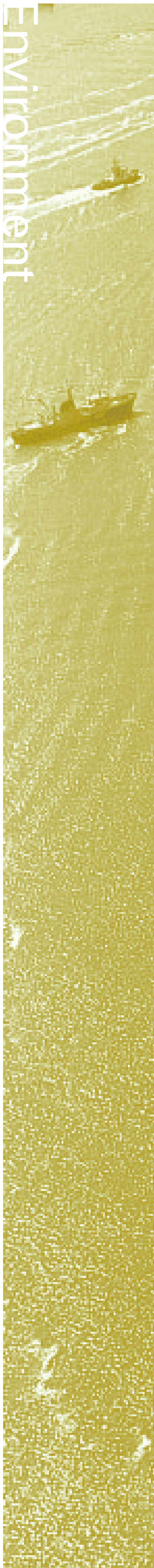
Environmental Monitoring of Dredging Operations in the Belgian Nearshore Zone



Abstract

The Waterways and Marine Affairs Administration of Flanders, Belgium initiated a research project, which aims at the environmental evaluation and monitoring of the dredging and relocation operations in the Belgian Coastal Harbours. The operations were required to meet the BATNEEC principle, that is, "Best Available Technique Not Entailing Excessive Costs".
In order to test the monitoring methods, a small dredging site at Nieuwpoort Harbour was selected. Three types of studies were conducted: physical, chemical and ecotoxicological.
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Introduction

Since 1995, the Waterways and Marine Affairs Administration of Flanders, Belgium has initiated the Mobag 2000-research project, which aims at the environmental evaluation and monitoring of the dredging and relocation operations in the Belgian Coastal Harbours. Since the relocation operations are subject to the directives of the London, Oslo and Paris Conventions on the pollution of the seas, these operations should meet the BATNEEC principle, meaning that for the execution of the works, the "Best Available Techniques Not Entailing Excessive Costs" should be selected.

The research project consists of two phases. During the first phase, a system for the continuous monitoring of the environmental impact of the dredging and relocation operations would be developed. The second phase includes the implementation of new technologies to reduce adverse environmental impacts identified during phase 1.

To be able to test methods for the monitoring, a rather small dredging site was selected: Nieuwpoort Harbour, where annually about 250 000 m^3 of material is removed by means of a cutter dredger. To be able to compare the effect of different dredging techniques on the behaviour of the material after relocation, during the test period some parts of the sediments were removed by means of the sweephead dredging technique.
The sediment relocation was observed from three points of view: physical (turbidity), chemical, and ecotoxicological.

The Dredging Site

Nieuwpoort is a small harbour at the Belgian coast, situated between the Port of Dunkerque and the Port of Zeebrugge. The main port activities include yachting and fishing (Figure 1).
Dredging operations are annually carried out in the entrance channel (the river Ijzer) and the marinas.

Table I summarises the main physical characteristics of the dredged material: muddy sand to sandy mud, depending on the location. Table II displays the main concentrations of chemical parameters present in the dredged sediment. Only relatively small amounts of contaminants – heavy metals, mineral oil, PCBs and

Table I. Overview of the physical characteristics of the dredged sediments. (Percentages by weight).

The Dredged Sediment Physical Characteristics				
Sample	> 63 µm	2 - 63 µm	< 2 µm	Dry solids
1	57	2	41	26
2	77	10	13	55
3	70	10	20	52
4	26	30	44	30

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Johan De Groote graduated in 1982 as an engineer specialised in hydrographic and land survey work. Since then, he has been responsible for several survey projects in Belgium and abroad. Currently, he heads the off-line survey department of the J.V. Northsea and Coast, where he is responsible for the processing and interpretation of hydrographic and environmental data collected by the survey teams.

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Dr. Janssen is a research co-ordinator and senior scientist at the Laboratory for Biological Research in Aquatic Pollution, University of Ghent (Belgium). For the past 15 years, he has been an active researcher in various fundamental and applied aspects of sediment and effluent toxicology; biochemical aspects of pollution-related environmental effects; terrestrial toxicology; and environmental risk assessment.

PAHs – could be detected; the concentration of pesticides was below the detection limit.

For the comparative tests of dredging and relocation techniques, a location with comparable physical and chemical sediment composition was selected. The works were executed with the cutter suction dredger *Vlaanderen XV*, equipped with a traditional cutter crown (Figure 2). This was later replaced by the sweephead (Figure 3). The dredged material is discharged in the intertidal zone on the beach, where the sediment plume clearly can be observed (see Figures 1 and 4).

Physical Monitoring

The physical monitoring of the relocation operations was done by monitoring-frames placed on the beach, which measured current, turbidity, temperature and salinity. Because of the marine environment, temperature and salinity did not change too much during the measurements (April 1996); turbidity increased close to the outlet, but rapidly diluted up to background levels (see below).

Additional measurements were executed from the survey vessel *Oostende XI*, equipped with the continuous measurement system Navitracker, on which an OBS turbidity probe was mounted (Figure 5).
This configuration enabled the continuous profiling of the water column by undulating the probes during a "turbidity" survey, which resulted in the production of "suspended solids concentration maps", as shown in Figures 6 and 7.

The surveys resulting in these maps were done at high tide. The suspended solids concentrations were mapped every metre, starting 1 m above the bottom. The size of the maps does not allow displaying them all in these columns, but the maps shown here are representative for all levels.

These maps indicate that close to the discharge outlet the supended solids concentrations are very high (>12.500 mg/litre), but the concentration returns quite rapidly to background values (400 mg/l, at 400 m from the outlet). These maps also display a fundamental difference between the applied dredging technology:

– A cutter crown requires the addition of water to the sediment for the hydraulic transport of the removed material. This results in a rapid "dilution" – horizontally as well as vertically – of the relocated material. About 3 m above the outlet, hardly any increase of suspended solids could be observed. It was concluded that the use of a traditional cutter crown to remove the sediments results in a rapid return of the suspended solids concentrations to background values.

Figure 1. Aerial view of Nieuwpoort Harbour. At the left of the picture, a cloud of "black water"– generated by the relocation of harbour sediments on the beach – can be observed.

– The sweephead on the other hand, does not add any water to the sediment, which results in a larger "high density spot" of relocated dredged material close to the seabed. This "spot" is believed to move for a while along the bottom with the tidal currents, but there is no evidence of this yet.

Chemical Monitoring

The chemical monitoring of the relocation operations aimed at the comparison of the quality of the seawater during the dredging and relocation operations and in periods without any dredging activities.

Figure 2. View of a traditional cutter crown.

Table II. Summary of the chemical analysis of the dredged material.

The Dredged Sediment: Chemical Characteristics					
Parameter	Unit	Sample 1	Sample 2	Sample 3	Sample 4
As	mg/kg	16	7.3	7.4	16
Cd	mg/kg	0.48	0.2	0.21	0.48
Cr	mg/kg	70	25	25	63
Cu	mg/kg	21	7.2	7.7	22
Hg	mg/kg	0.33	0.1	0.1	0.33
Pb	mg/kg	62	25	25	58
Ni	mg/kg	56	22	22	52
Zn	mg/kg	180	50	62	130
Mineral oil	mg/kg	570	340	240	580
SUM PCB	mg/kg	0.36	0.27	0.32	0.51
Sum PAH's Borneff	mg/kg	6	1.5	1.4	2

Table III. Comparison of the seawater quality near the relocation area in periods without any dredging activities and during the works with cutter crown and sweephead.

Chemical Monitoring: Results Seawater Near Discharge					
		Background	Cutter	Sweephead	
As	µg/litre	100	100	110	100
Cd	µg/litre	< 1	< 1	< 1	< 1
Cr (total)	µg/litre	< 5	< 5	< 5	< 5
Cu	µg/litre	20	10	10	10
Hg	µg/litre	< 0.5	< 0.5	< 0.5	< 0.5
Pb	µg/litre	< 10	< 10	< 10	< 10
Ni	µg/litre	< 10	< 10	< 10	< 10
Zn	µg/litre	< 50	< 50	< 50	< 50
TOC	mg/litre	2.5	3.4	5.2	4.1
Mineral oil	mg/litre	0.3	< 0.2	< 0.2	< 0.2
EOX	µg/litre	< 10	< 10	< 10	< 10
Organo chlorine pesticides	mg/litre/component	< 0.2	< 0.2	< 0.2	< 0.2
SUM PCB	µg/litre	< 0.2	< 0.2	< 0.2	< 0.2

Figure 3. The dredger Vlaanderen XV equipped with the sweephead.

Figure 4. The discharge of the dredged material in the intertidal zone on the beach. The generated plume can clearly be observed.

Therefore, several seawater samples were taken in the discharge area and analysed on relevant parameters. The average values of the collected samples are displayed in Table III. This table shows that there is no change in the quality of the seawater owing to the relocation of dredged sediments in the nearshore zone near Nieuwpoort Harbour.

Toxicity Tests

To evaluate the ecotoxicological consequences of the dredging works, the following types of toxicity tests were executed by the University of Ghent, laboratory for the biological research of aquatic pollution.

- Porewater and elutriate tests:
  - 72 hr growth inhibition test with micro-algae
  - 24 hr lethality test with copepod

Figure 5. OBS turbidity monitors mounted on the towfish of the Navitracker system for the continuous monitoring of the suspended solids throughout the sediment column.

Figure 6. Map indicating the suspended solids in the relocation area 1 metre above the bottom, measured during the works executed with a traditional cutter crown.

- 26 hr lethality test with mysid
- 24 hr embryo development test with bivalve
- 14 day growth test with copepod

The results of these tests are displayed in Table IV.

- Sediment-contact tests:
  - 10 day lethality test with amphipod
  - 10 day lethality test with mysid
  - 28 day growth test with amphipod

The results of these tests are summarised in Table V.

These tests clearly indicate that there is no acute nor chronic toxicity on the dissolved/suspended fraction of the dredged material. There is also no acute or chronic toxicity on the "bulk" fraction of the dredged materials.

Legend for Figures 6 and 7:

blue	*= < 400 mg/litre*	*orange*	*= 1,000 - 5,000 mg/litre*
green	*= 400 - 700 mg/litre*	*red*	*= 5,000 - 12,500 mg/litre*
yellow	*= 700 - 1,000 mg/litre*	*dark red*	*= < 12,500 mg/litre*

Figure 7. Map indicating the suspended solids in the relocation area 1 metre above the bottom, measured during the works executed with the sweephead dredge.

Conclusion

The environmental monitoring of the dredging and relocation operations in Nieuwpoort Harbour provided the opportunity to develop and test methods within the framework of the Mobag 2000 project, initiated by the Flemish Government. This project aims at the environmental monitoring of all the dredging operations executed in the Belgian coastal harbours.
Mainly because of the quality of the removed sediment, it can be concluded that the maintenance dredging and relocation operations in Nieuwpoort Harbour only cause a visual effect near the relocation area, but have no adverse environmental effect and do not impact the local ecosystem as such.

Table IV. Results of the toxicity tests on the water phase.

Test	Harbour porewater	Harbour supernatans	Beach supernatans
algae	NO	NO	NO
bivalve	TOXICITY	TOXICITY	TOXICITY
copepod			
mysid			

No acute and chronic toxicity on the dissolved/suspended fraction of the dregded material

Table V. Results of the toxicity tests on the bulk sediments (harbour sediments and beach).

Test	Harbour bulk	Beach bulk
mysid - acute	NO	NO
amphipod - acute	TOXICITY	TOXICITY
amphipod - chronic		

No acute and chronic toxicity on the 'bulk' fraction of the dregded material