AMORAS – ANTWERP MECHANICAL DEWATERING, RECYCLING AND APPLICATION OF SEDIMENTS

AN INNOVATIVE AND SUSTAINABLE SEDIMENT DISPOSAL SOLUTION FOR THE PORT OF ANTWERP – Present situation

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Abstract:

In the Port of Antwerp an amount of approximately 600,000 tonnes dry matter of harbour Sediments need to be dredged every year. Until the present day the sediments have been disposed of on several containment sites on land or in underwater disposal cells. Since the present disposal capacity is insufficient and no expansion is possible due to the lack of space, the Flemish Government administration in association with the Port of Antwerp Authority have planned to construct an installation for mechanical dewatering of these sediments, using the dewatering technique with membrane filter presses.

History:

At the end of the nineties the port of Antwerp was thinking of conventional lagooning. The technique consists of filling dredged material into specially designed drying fields, also called lagoons, enabling the evacuation of water by both evaporation and drainage. The hydraulically disposed dredged material contains a large portion of water and only a small fraction of dry matter (DM), typically 15 – 20%. After a few months, the dredged material can be piled up in rows. Using this technique the dry matter content can be increased to 30 – 40 %. A system of drainpipes, built into the drainage layer of the drying field, collects the drainage water and sends it to a water treatment plant. The time needed for the total dewatering process strongly depends on the quality of the dredged material (density, sand fraction, % organic matter etc.) and of course, the weather conditions.

The decision concerning further treatment and disposal of dredged material has an important impact on budget lines, environment, and required land. Hence the port of Antwerp Authority was obliged to investigate if the lagooning technique was the most suitable long term solution. Another possible technique for the treatment and disposal of the dredged sludge was mechanical dewatering.

1. Prospection

Previous studies in the 80th and 90thies indicated that mechanical dewatering using chamber filter presses wasn't an ideal solution. The following problems concerning mechanical dewatering where identified: the big amount of sludge to process, the discontinuity of the process and the high cost of the system (see Directoraat-Generaal Rijkswaterstaat "Mechanische ontwatering van baggerspecie, inventarisatie van praktijkgegevens" POSW fase II 1992-1996).
During a large prospection program which started in 1999 the Antwerp Dredging Department witnessed in several industries the utilisation of very large chamber filter presses even up to a capacity of 16 m³. As a conclusion of the prospection the technique was considered as a serious option to dewater the maintenance sludge of the Port of Antwerp. After a preliminary feasibility study, Antwerp decided to perform a pilot test using chamber filter presses to dewater the dredged sludge.
Chamber filter presses are in use in municipal wastewater treatment plants and in various types of industries like the food-, pharmaceutical- and mine industry.

2. Pilot test

The following parameters were evaluated in the pilot test
- Degree of dewatering and characteristics of the dewatered sludge after conditioning of the incoming sludge with different conditioners.
- Mass balance in the different stages of the process.

- Consumption of energy.
- The time of one cycle of dewatering.
- The chemical quality of the dewatered sludge and the sand, compared to the quality of the crude sludge.
- The mechanical characteristics of the dewatered sludge in relation to the moisture content and the conditioner.
- The chemical quality of the filtrate water to determine the treatment of the filtrate water.

The pilot test presented the following results:.

- Amount of dredged material : 600,000 tons DM per annum
- Density of grains in dredged material : 2.64 ton/m³
- DM content of dredged material : 15 – 20 %
- Density of dredged material : 1.10 – 1.15 ton/m³
- Sand fraction of dredged material : 5 - 10 %
- DM content in recovered sand : 85%
- Density of grains in recovered sand : 2.60 ton/m³
- Soil mechanic results for the dewatered sludge :
    - Average content of dry matter 62%
    - Permeability k (determined in a flexible wall cell) 1.10-9 m/s
    - Cohesion c 20 kPa
    - Internal friction angle 25°
    - Undrained strength cu (after compaction in situ) 202 kPa

These results were important to make a reliable final comparison between lagooning and mechanical dewatering of the dredged material.

3. Comparison between lagooning and mechanical dewatering

Lagooning consists of 4 phases: the filling of the fields, the dewatering of the mixture, the emptying of the field and the replacement of the top drainage layer. The damaged and polluted top drainage layer has to be disposed with the dewatered dredged material.
As stated before, the time needed for the total dewatering process strongly depends on the quality of the dredged material and of course, the climate. Typically, in countries with a moderate climate, the dewatering process for lagooning takes a year to complete. It can be accelerated by pumping the dredged material into the drying fields with a high density. The dewatering time determines the needed surface.

From an economical and social point of view, lagooning requires a large surface area. For example, for a port like Antwerp, which dredges some 600,000 tons DM/year to maintain its waterways behind the lock complexes, lagooning activities would occupy an estimated 120 hectares (80 hectares if accelerated lagooning would be used). This poses quite a problem in densely populated and industrialised areas, where land is needed for new industrial activities and expansion of residential areas. For mechanical dewatering, only 20 ha would be required for the Port of Antwerp. Land is becoming a very precious resource, making it subject to delicate discussions. Further expansion of ports meets strong public opposition.

Other public acceptance criteria are noise, dust, odour and visual impact. Noise and visual impact of lagooning activities remain limited, but odour and dust may cause problems, as the dredged material is exposed to the open air over a long period of time. Turning it around further intensifies contact with the air. Visual impact, odour and dust problems are less probable in the case of mechanical dewatering.

Lagooning brings about some environmental risks, as it implies the construction of an isolation layer at the bottom of the drainage layer. Given the large surface area of the drying fields and the field activities (e.g. the use of cranes to remove the dewatered sludge or to repair the drainage layer) the possibility of penetration or damage of this environmental protection layer is not negligible, resulting in a risk of dispersion of contaminants. Emissions may occur as well.

Furthermore, the breeding season of bird colonies is an important ecological factor that has to be taken into account during the operation of lagooning fields. The ecological risks for an installation for mechanical dewatering are more limited.

Lagooning is a largely uncontrolled process. First of all, it is sensitive to weather conditions, as wet periods have an important effect on the total dewatering time. Mechanical dewatering on the other hand is insensitive to weather conditions during the entire process.
Lagooning offers limited possibilities to influence the quality of the end product, such as soil mechanical properties and processing ability. These are important issues in view of the final disposal as well as the beneficial use of the dewatered material. In fact, the quality of the end product of lagooning is rather poor, which limits the range of applications. Mechanical dewatering is a polyvalent controlled process: by changing additives, cycle time, pressure etc…. the properties of the end product can be controlled which offers more opportunities for re-use. Due to the possible use of a large range of conditioners (polyelectrolyte, lime, gypsum, fillers, cements…) it is possible to change the specific physical characteristics of the dewatered mixture. The dosing of the additives can influence the quality of the desired end product or basic material for re-use. Process control is much higher and more polyvalent using mechanical dewatering compared to lagooning.

Furthermore, mechanical dewatering using chamber filter presses has been a very well-known technique for many years. The present chamber filter presses are full automatic and are able to treat dredged sludge which is difficult to dewater. Even dredged material containing a high content of mineral oil can be treated.

Today presses even have several technical options. They can be equipped with heating systems (steam) and rinse or washing systems for filter cakes. These options give possibilities to decontaminate problematic or heavily contaminated material.

Furthermore, mechanical dewatering of dredged material has the following advantages:

- very high contents of dry matter can be reached;
- maintenance and energy consumption is limited due to the robustness and limited amount of moving parts;
- automatic transport systems can be installed;
- capacity of the installation can be easily enlarged
- prior sand separation or decontamination of the dredged material is easily added
- easier categorising of the dewatered mixture
- continuous process is possible by treating dredged material in different filter presses.

For lagooning as well as mechanical dewatering of dredged material a comparison is made regarding the costs related to both techniques.
Both investment (write-down over a period of 15 years) and operational costs are lined up and include the following topics:

- Necessary buildings and infrastructure (including roads, parking lots, water treatment plant,...)
- Equipment
- Transportation to storage depot
- Automation, electricity and instrumentation
- Personnel
- Maintenance of the installations
- Maintenance of the buildings
- Energy consumption
- Consumption of additives
- General costs
- Land concessions
- Water treatment of the filtrate water

For lagooning, different scenarios are checked: variation of the duration of the total dewatering process (due to manipulation of the sludge) and different lay-outs of the lagoon fields themselves.
For the mechanical dewatering the option with or without sand separation is checked.

Taking into account these parameters, the costs were estimated in June 2001 as follows:

- Lagooning : between 32.50 and 49 EURO/ton dry matter
- Mechanical dewatering: between 28 and 31.50 EURO/ton dry matter.

4. Conclusion:

It turns out that mechanical dewatering using chamber filter presses is not only an economically viable alternative for lagooning, it also enables, for the first time, proper control of the dewatering process. Hence it yields an end product of superior quality, and it opens up new applications for re-use. In addition a mechanical dewatering plant for dredged material has a smaller environmental impact as well as a much smaller footprint. In short, it is a much more sustainable solution for the treatment of dredged material.

In the following table an overview is given of the advantages and disadvantages for the lagooning technique as well as the mechanical dewatering.

Parameter	Lagooning	Mechanical dewatering
Surface area	120 hectares (80 ha for accelerated lagooning)	20 hectares
Total Cost (including land)	32.50 to 49 Euro/ton dry matter	28 to 31.50 Euro/ton dry matter
Process	Discontinuous, depends strongly on weather conditions	Continuity guaranteed not depend on weather conditions
Additional steps in process	Prior cleaning or sand removal steps are difficult	Prior cleaning and sand removal steps possible

Expansion possibilities	Difficult to expand due to large surface area needed	Expanding capacity is possible
Location	Few options (only 1 in the Harbour of Antwerp) due to large surface area needed	Can be located strategically
Transportation system	No automation possible; requires much internal logistics	Automatic transportation system is possible
End product & processing	Poor quality; processing not easy	Stable quality; very good process ability
Ecology	Higher risks	Limited risks
Beneficial use	Less applications	Good end product; more opportunities for re-use
Potential social impact	Strong opposition expected because of large surface area	No or limited opposition expected

In July 2006 the Flemish government agreed on the realisation of the AMORAS-project.
The government authorised the Minister of public works within the framework of the European rules to start the candidate selection procedure and ask them for an offer.

Taking into account the budgetary possibilities of the Flemish region a partial PPP was opted for. This means that part of the construction work is borne by the contractor (ca. 25 million of 65 million euro) and paid back during the operating phase (15 years) by means of a monthly payment.
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In early November 2006, a (European) call for candidates was launched. Five temporary trading associations presented themselves. On 26 September the competent Flemish minister approved the 4 selected candidates and the suggested tender file. Then the candidates were invited to submit their tenders.

The candidates' tenders have been opened on 5 March 2008. The submission for approval by the Flemish Government of the proposal of part together with the proposal of agreement with the Antwerp Port Authority was proposed to the Flemish minister of public works at the end of June 2008. The intention is for the approval and the assignment to take place before the end of 2008.

If construction work is started at the end of 2008, the installation will be ready for operation after 24 months. For the start of the operations, a term of 6 calendar months is envisaged. The first dewatered filter cakes are expected to roll off the conveyer belt at the beginning of 2010. It is reasonable to expect that in the second half of 2011 the AMORAS-project will be ready for full operation. According to the specifications of the tender, the unit remains the property of the Flemish Region and the operation will be placed in the hands of the selected contractor. The file foresees a 15 year operation term. Afterwards a new operational period can be launched, possibly into a new tender.

The construction costs are at present estimated at approximately 100 million euro (VAT inclusive). Knowing that future budgetary possibilities of the Flemish Region are limited, and in order to comply with the storage deadlines of MDM, Minister Peeters proposed to apply a partial budgetary spread of 1/3 of the construction costs over the period of operations.

Moreover, as from 2009 the Flemish Region will provide about 18 million euro (VAT inclusive) for the processing of this new sludge processing unit.

The starting-up of the AMORAS project is a crucial step in securing the future maintenance dredging works in the port of Antwerp.

Therefore the Port Authority is extremely satisfied with the fact that the Flemish government fills in the first policy priority concerning sea ports of the Flemish government agreement, namely a future oriented and economic sound maritime access.

naming AMORAS:

The abbreviation AMORAS stands for "Antwerp Mechanical Dewatering, Recycling and Application of Sludge". This name probably causes some memories of youth.
"The Isle of Amoras" was the first cartoon of the series "Suske en Wiske" or rather of its predecessor "Rikki en Wiske". It was written by the Flemish cartoonist "Willy Vandersteen".

As the story goes,
Wiske finds an old jar on the bank of the river Scheldt that goes to pieces by an explosion.
Inside the jar is an old parchment manuscript saying that the galleon Antverpia ran aground on an unknown island, which was given the name of Amoras.
Thus the link has been made with the AMORAS project that we touched upon as an unknown processing technique of maintenance dredged material.

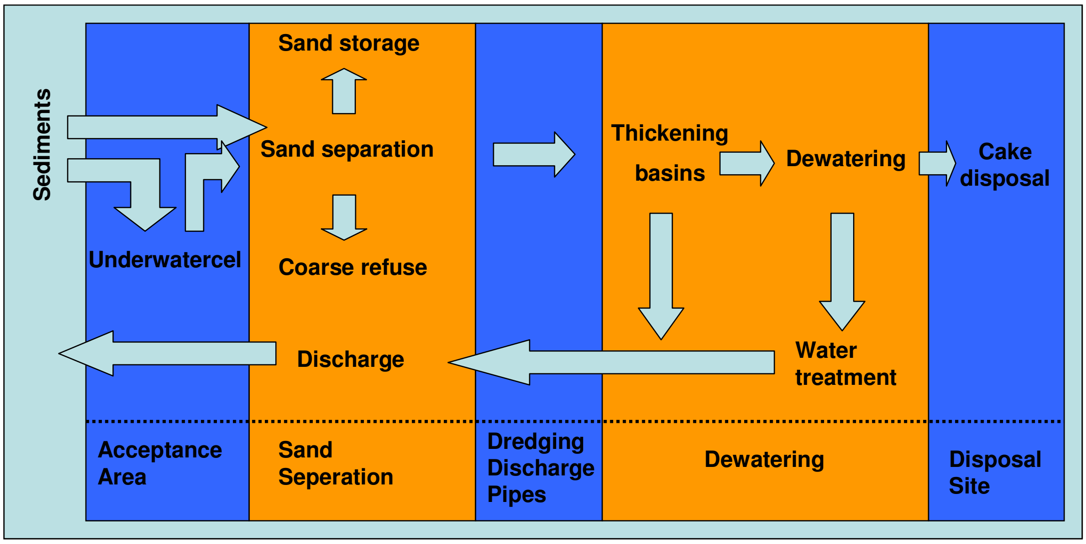
Process:

The design of the installation is based on 600,000 tonnes dry matter of sediments to be treated. The different treatment facilities are divided into several areas:

1. An acceptance area where sediments are received. This area is located near a dock in the Port of Antwerp and comprises an underwater acceptance cell, a sand separation unit and the necessary piping to transport the sediments to the dewatering installation.
2. The treatment installation is located at a distance of about 3.6 km from the acceptance area. *The place is named 'Bietenveld-Field of Beets'.*
3. A disposal area where the dewatered material will be disposed of. This area is named *'Zandwinningsput-Pit for Sandwinning'.*

The treatment process can be described as follows:

The sediments arrive via the underwater acceptance cell at the sand separation unit. In this installation, the coarse material and the sand are removed from the sediments.
The de-sanded sediments are then pumped by a booster station to the treatment installation, over a distance of about 3.6 km.
The pumped sediments are then discharged into buffering ponds, where thickening of the sediments is allowed to obtain an optimal dry matter content to proceed with the rest of the process.
After thickening, the sediments are pumped to the installation for mechanical dewatering, where the sediments are dewatered using membrane chamber filter presses after performing the desired conditioning of the sediments.
The produced filter cakes are removed and disposed of at a disposal site. This site has a surface area of about 30 hectares and an expected life-time of about 20 years (without re-use of the cakes).
The filtrate, produced during the dewatering of the sediments, is collected and pumped via a buffering pond to the wastewater treatment plant. The filtrate is collected together with other wastewater and treated to reach the prescribed discharge standards.
The supernatant of the thickening buffering ponds, which is not subject to any treatment process, will be discharged after gravitational sedimentation, following the prescribed standards.



AMORAS, as a first step to re-use

This controlled dewatering step is important in order to make maximum re-use possible. After this first step of course a next step must follow, namely a useful application of the dewatered filter cakes. Managing and permitting authorities, universities, engineering companies and contractors should join hands in order to work out useful re-use applications.

Much progress has already been made with respect to re-use. Stimulated by the Low Countries, a lot of experience was acquired with new processing technologies such as fraction separation and useful re-use of consolidated material as soil or building material, etc.

Besides technical and economic feasibility studies, first projects are in the meantime operational or in progress. However, we note that further initiatives must again be encouraged. Although it can be expected that in the short term re-use is expensive, it is probable that in the longer term the cost of space occupation and ultimate decontamination will be compensated for by its sustainability.

Hereafter we name a number of possibilities for re-use of the filter cakes that can applied in the port of Antwerp:

In the first place non process related re-use can be aimed at, such as landscape restoration. Filter cakes can fill old extraction pits. At that moment the restored landscape can be used for further port development.

Another method is landscape construction. The Port Authority and the maritime business world of Antwerp realise that landscape-ecological qualities are important terms in order to have further spatial development. In order to avoid incompatible spatial destinations one next to the other, buffer zones were introduced.
These buffer zones reduce the impact to the surrounding environment. The reuse of consolidated dredging material in buffer zones containing hills, specifically when they can be afforested, fits perfectly in the spatial objective. They perform a buffer function between

incompatible destination types such as industrial area versus agriculture, nature protection and/or residential area.

Furthermore there are also process related re-use possibilities of the filter cakes produced by AMORAS:

An interesting way of re-use for important quantities of mechanical dried silt is the use as filler material in the production of expanded clay grains (e.g. Argex). The advantage of these grains have is their very low density. This material can then be re-used for instance as filling up material in damming constructions in the port.

Given good soil mechanical properties like strength, process ability and permeability the filter cakes can also be applied as a sealing layer at dumping sites and/or clean up operations in the Antwerp port area.

Possibly, through the use of additional additives like lime a direct application in road construction can be obtained. Given the potential market, further tests in this direction surely are advisable.

Sintering is a thermal immobilisation technique that, just like melting, offers a solution for processing silt with a cocktail of contaminated matter. The sintering of dredged material can produce ceramic products such as bricks, tiles, imitation gravel (e.g. additional component in concrete) which are applicable separately or as bound material.

We can roughly say that the dewatered filter cake produced by the AMORAS installation has taken great step nearer towards the re-use. Through the specific ground mechanical properties that can be given to the filter cakes by the AMORAS technique, a much wider range of re-use applications has become possible.

In the future the batches of maintenance dredged material for which there is no solution within the existing norm framework should be limited to the minimum in order to reduce the costs and space occupation caused by controlled storage.

Hereby we make an appeal to the licence granting authorities not to play a waiting game, but to take initiatives by making their concerns clear and to formulate suggestions in order to neutralize the risks. Managing authorities such as port authorities should impose to re-use more maintenance dredged material at their infrastructural projects.

Contractors should refine and optimise re-use techniques in order to make re-use possible. Further I advise them to invest as well, so that re-use gets a financial chance of survival.

References

1. Min. of the Flemish Community. Policy plan Decontaminate Channel bed Lower Scheldt. February 1995.

2. RIZA/ POSW 96068 Fase II. Mechanical dewatering of dredged sludge, Inventarisation of results in practice. DHV. 1992-1996.

3. Port authority of Antwerp. Ground mechanical study; reorganize Sand winning pit and Bietenveld. Results of lab research on dredged sludge. BETECH – ALPHA-Studiebureau. November 1999.

4. Integrated dredged material management system of Bremen-Seehausen. Port authority Bremen. Detlef Hegemann GmbH. Heinrich Hirdes GmbH. Umtec Prof. DR-Ing. Ernst Biener – Dipl.-Ing. Sasse.

5. Dredged Material – Raw Material for the Construction and other Industries, H.-D. Detzner, Cats Congress 4 “Characterisation and treatment of sediments”, Antwerp, Belgium, 1999.

6. Lagooning and storage of sludge from the Lower-Scheldt. Department LIN Administration of Waterways and Naval Affairs. January 1999.

7. Der Schlickhügel in Francop. Freie und Hansestadt Hamburg, Wirtschaftsbehörde, Strom- und Hafenbau. 2000.

8. Treatment, Benificial Use and Disposal in Hamburg, A. Netzband, AKWA Waterbouwcongres, Rotterdam, 2002.

9. Reuse of dredged sediments in landscape construction : ecotoxicological risks and ecological implications.Jan Mertens, Ghent University, Laboratory of Forestry, Geraardbergse Steenweg 267, 9090 Melle-Gontrode, Belgium (Jan.Mertens@UGent.be); Frederic Piesschaeert, Institute of Nature Conversation, Kliniekstraat 25, B-1070 Brussels, Belgium (Frederic.Piesschaert@inbo.be); Paul De Rache, Port of Antwerp, Siberiastraat 20, Kaai 63, 2030 Antwerp, Belgium (paul.derache@haven.antwerpen.be).

10. Port authority of Antwerp. AMORAS Part I: Pilot campaign mechanical dewatering by using chamber filter presses. BETECH. September 2000 – April 2001.

11. Port authority of Antwerp. AMORAS Part II: Comparison of lagooning and mechanical dewatering. BETECH. July 2001.

12. Port authority of Antwerp. AMORAS Part III: Location study – Evaluation of the sites for mechanical dewatering and storage of dredged sludge. BETECH. October 2001.

13. Port authority of Antwerp. Environmental Impact Assessment AMORAS. ECOLAS. December 2004.

14. Public Waste Agency of Flanders (OVAM) http://www.ovam.be. Part I: Dredging and techniques of transport. Part II: Evaluation of maintenance dredged sludge.

15. Public Waste Agency of Flanders (OVAM) http://www.ovam.be. Analyse document Dredging- and maintenance silt (art. 6: Best Existing Techniques). September 2003.

16. Ministry of Traffic and Water state. Rijkswaterstaat DWW. Building with dredged sludge, daily practice. DHV, AKWA/DWW. Delft 2004.

17. Public Waste Agency of Flanders (OVAM) http://www.ovam.be. Guide and general code of good practice of dredging and maintenance silt. February 2006.

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