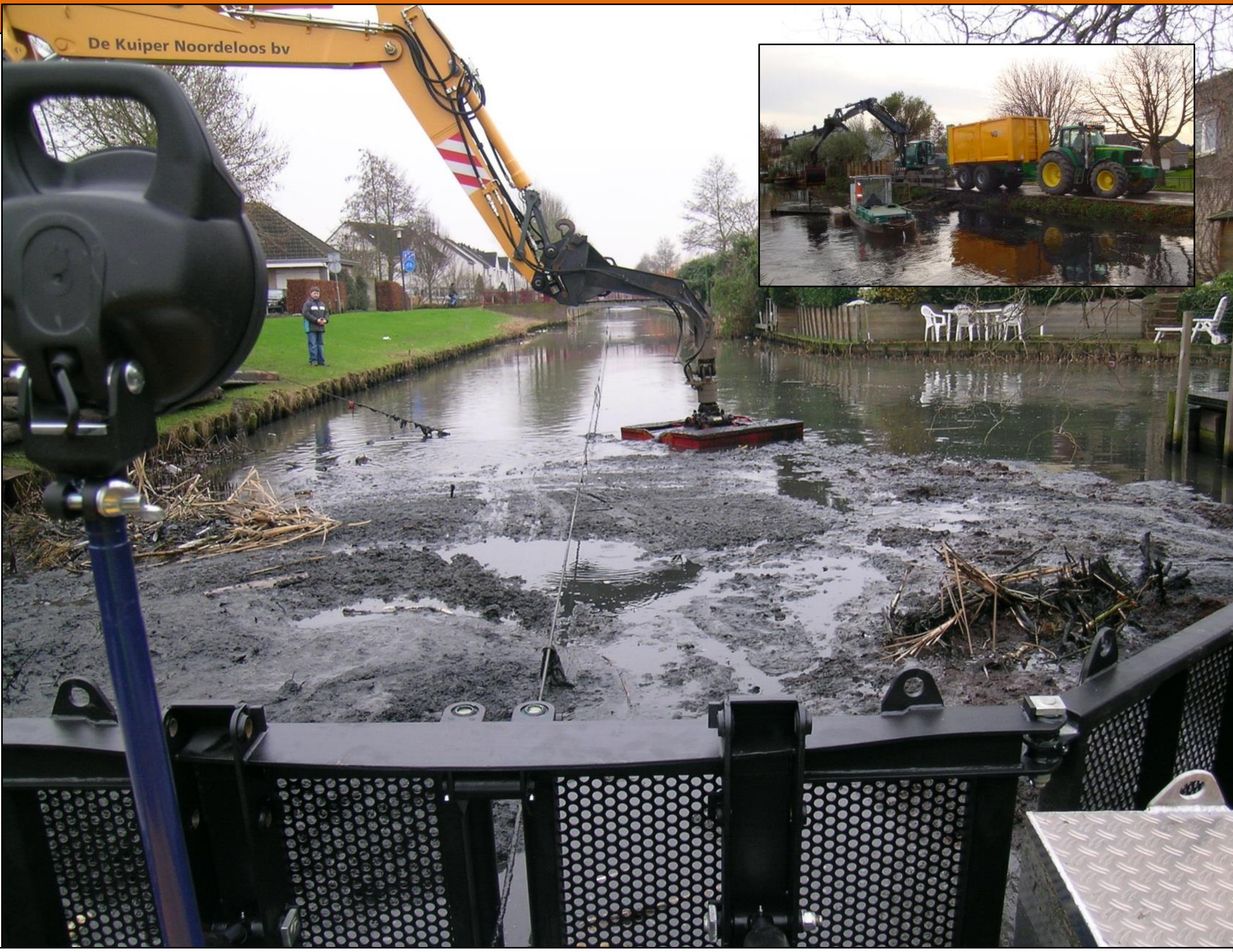
SMALL SCALE DREDGING

AN INTRODUCTION



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1. INTRODUCTION: SMALL-SCALE DREDGING

The word dredging probably originates from the old English word "dragan", or to draw. Dredged materials normally involve a layer of soft matter, which is formed when plants, waste, soil material and leaves cling to the bottom of waterways. In time, this can have an impact on shipping traffic or the capacity of the waterway in question.
Dredging is carried out for a variety of reasons. However, in most cases, dredging is done for maintenance purposes and to ensure sufficient water flow.
Small-scale dredging projects generally involve drainage channels and modified rivers in areas with artificial (pumped) drainage and smaller urban and suburban waterways, which are not used for shipping activities.

Photos: Reduced water flow

2. CRITERIA FOR SELECTING DREDGING TECHNIQUE

A variety of dredging techniques have been developed over the years. When preparing for dredging activities, a decision must be made of which dredging technique is best suited to the activities in question. When doing so, the following factors must be taken into consideration:

- composition of dredged materials
- type and level of pollution
- specific circumstances
- size of project
- acceptable opacification and spillage
- required accuracy
- side-effects
- ecological considerations

Composition of dredged materials
The choice of dredging technique is also determined by the physical composition of the materials that must be dredged. For instance, different techniques must be used when dredging soft silt than when dredging sand or clay.

Type and level of pollution
Another factor which determines the choice of dredging technique is the presence of gross solids, like household and construction waste. Gross solids on the water bottom can reduce the effectiveness of certain dredging techniques.
The level of pollution on the water bottom is generally not a decisive factor when deciding which dredging technique is going to be used. However, special dredging equipment has been developed to, for example, reduce unwanted dispersion and opacification during dredging activities. This equipment can be damaged by gross solids on the water bottom and cannot be used in all circumstances. The quality of (or level of pollution in) dredged materials determines whether materials can be placed at the water's edge or needs to be transported.

Specific circumstances
The choice of dredging technique is primarily determined by the accessibility, water depth, current speed and dimensions of the waterway in question.
In urban areas, physical objects like lamp posts and parked cars are major obstacles for equipment operated from the banks of the waterway. This also applies to the width of waterways or the height of bridges when floating equipment is used.

Size of project
It may be necessary to dredge large stretches of water bottom when performing new infrastructure work, extracting sand and maintaining waterways. Project size is often expressed as “m3 in situ”.
This refers to the volume of dredged material that must be removed. In addition, the surface area across which materials are spread, thus the layer thickness, also determines the capacity and cost of the deployed dredging technique.

Acceptable opacification and spillage
Materials are removed under water during the dredging process. Material released by a dredging technique, which is not subsequently disposed of via the transport system, is referred to as 'spillage'. Spillage is often manifested via a loose top layer, possibly featuring chunks of sediment. Spillage also results in a loose top layer when suspended particles (opacification) are subject to sedimentation.

However, polluted spillage is often encountered when dredging polluted water bottoms, which means it determines the chemical quality of the water bottom and the surface water.

Accuracy
There are two facets to the accuracy of a dredging technique. On the one hand, it involves the accuracy with which dredging takes place and, on the other hand, how accurately these newly dredged areas match the required profile. Accuracy is a criterion that can be clearly measured and checked. In general, it is assumed that opacification and spillage can be minimized if strict accuracy-related benchmarks are implemented.

Side-effects
In general, it is impossible to avoid unintentional effects of dredging activities, like opacification in the water column. However, contractors can take measures to reduce such effects, which includes installing silt screens. Other unintentional effects, like destruction of tow paths and noise-related nuisance, cause techniques with such side-effects to be avoided when working in vulnerable (natural) areas. These techniques will only be used if there are no viable alternatives, although the environment must be given maximum priority at all times.

Ecological considerations
There is an inter-woven relationship between ecology and dredging. Legislation relating to plants and wildlife imposes additional restrictions on available methods and available periods of the year. Therefore, ecological considerations must always be taken into account when performing dredging activities.

Several dredging techniques or a combination of them may be suitable to successfully complete certain projects. That is why specifications often do not prescribe one particular technique, but only identify boundary conditions or the required end result.

One statement is extremely important when it comes to small-scale dredging activities:

"***There is no such thing as a standard dredging project.***
Each project requires its own unique approach."

The following chapter will examine the most commonly used dredging techniques.

3. DREDGING TECHNIQUES

3.1 Hydraulic excavator

This commonly used piece of equipment - the hydraulic excavator - is a discontinuous excavator, where excavation takes place using single buckets in consecutive cycles. The full bucket is brought to the surface and emptied into the means of transport (truck or barge) or placed on the bank.

Photo: Excavator on pontoon.

The under-water surface is excavated in a circular pattern, where the bucket is lifted by the excavator when it reaches a certain depth. The next circle will be started once one circular section has been completed, and this process will continue until the whole waterway has been excavated. The excavator will then be moved, thus allowing another zone to be excavated or dredged.

The bucket must be carefully positioned after each cycle so it is not easy to perform two consecutive excavation cycles under water without an accurate and reliable system for determining the excavation position.

Water depth and working area
There are two ways of implementing hydraulic excavator:
- work carried out from the water's edge,
- work carried out from a pontoon featuring anchors or spud poles.

The eventual choice will be determined by project-specific circumstances. Depending on the selected method and the size of the excavator, it is possible to achieve water depths up to 10 m or more. Material above the waterline can also be excavated if the location is accessible to the excavation bucket and the means of transport.

Photo: Excavator on the bank.

Available excavation buckets

When using excavators to perform dredging activities in areas subject to nature-related and environmental considerations (for example, land improvement operations), various types of excavation buckets can be used to reduce excavation-related effects.

<u>Digging bucket</u>

A digging bucket excavates materials using a pulling movement and is thus often implemented to remove thin layers of silt. Once the bucket is full, it is raised to the surface and emptied into the means of transport or on to the water's edge. The dredging bucket is slightly different from standard buckets, and is characterized by holes that retain silt while allowing water to escape.

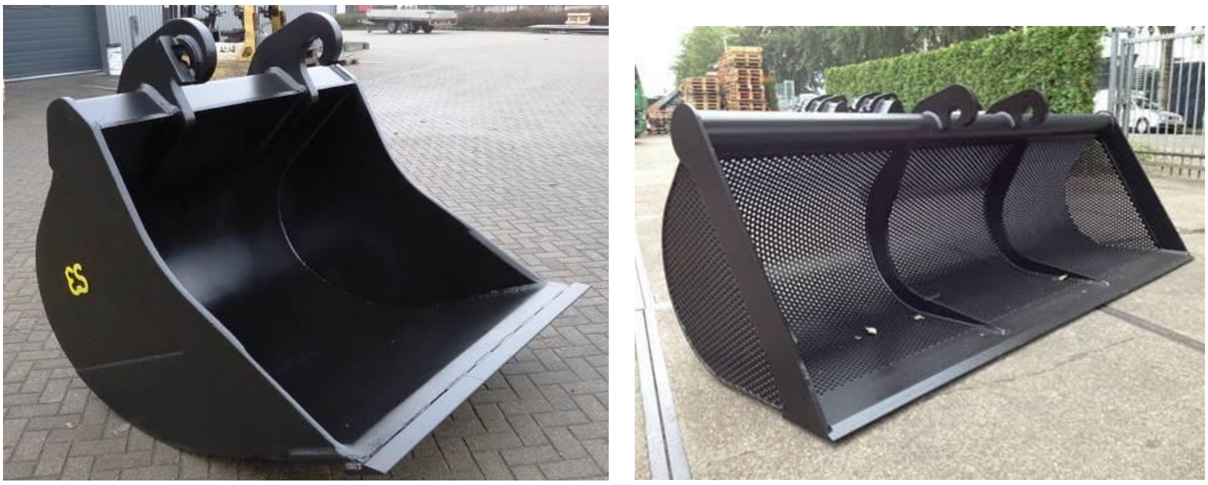

Photo: Digging bucket and dredging bucket

The visor bucket

The visor bucket is a traditional excavation bucket featuring a revolving valve (visor), which can be used to close the top of the bucket. The visor is closed once the bucket is full, so dredged materials are enclosed in the bucket while being raised to the surface. This avoids or drastically minimizes dredged material mixing with the water column. This bucket can be used to excavate thin and very dense layers with low water content. Layer thickness of around 0.5 m is needed in order to collect enough material.


Photo: Visor bucket and clamshell

The (closed) clamshell

A clamshell or grab bucket operates using a gripping movement. That is why it is used when excavating thick layers of silt and when transferring materials.

A traditional clamshell is open at the top, which means excavated materials are exposed to the water column when it is being raised to the surface. The top of closed clamshells can be sealed off, so exposure between excavated materials and the water column is avoided when it is being raised to the surface. Excavation cannot be done with a high level of accuracy due to the circular closing movement of both clam sections. It is thus difficult to achieve a horizontal surface using this piece of equipment. Layer thickness must be at least 0.5 m in order to achieve reasonable productivity.

Due to advances in hinge technology, an alternative type of grab bucket has been created, which enables an almost horizontal closing movement. The maximum opening of this “environmental grab bucket” is circa 80% larger than a traditional grab bucket, whereby relatively thin layers can also be excavated efficiently.

The Mowing bucket

Mowing buckets have been specially developed to remove vegetation from waterways and are not actually intended as excavation tools. Nonetheless, they are often used in the countryside for cleaning drainage ditches; when the vegetation are cut from the ditches, also thin layers of silt can be removed.

Photo: Mowing bucket

Suitability of technique
When used as a mechanical digger during maintenance-related dredging, hydraulic excavators can be very useful if major dilution is not wanted. In principle, the presence of pollutants is not a significant factor for hydraulic excavators. However, if silt is polluted, then it would be wise to use a closed excavation bucket to reduce opacification and the spread of pollutants.

Presence of gross solids
Hydraulic excavators only experience minor problems if they encounter gross solids.

Means of transport
The advantage of hydraulic excavators is that the excavated quantity remains very similar to the in-situ quantity (little mixing, approximately a factor of 1.1). When using hydraulic excavators, the means of transport for removed dredging material is restricted to trucks, ships/barges or a combination of the two options.
Higher density can result in major cost savings if materials need to be transported over long distances, because the total volume features a lot of dredged material and very little water.


Photo: Excavator on a pontoon loading a barge

Further processing steps
The dredged materials are often transported immediately, to a processing depot (for further dewatering and treatment) or to a dumping site. The method is also suitable for projects where dredged materials can be spread along the banks of waterways. However, in this case, the method's ecological impact on the banks of the waterway must be taken into consideration. Silt processing is also more effective when water content is kept to a minimum.

Environmental effects
Opacification
In principle, the in-situ volume has been excavated from the water bottom. However, slight mixing and volume increase (10 to 40%) will take place depending on the type of sediment. When using traditional excavation buckets, opacification may be encountered as buckets are being raised to the surface. This opacification can be limited by using closed buckets. However, the level of care taken by the excavator operator has a major impact, and also directly influences productivity.

Spillage
The visor bucket and environmental grab bucket help to minimize spillage during normal operations. Once again, spillage can also be reduced if work is carried out carefully.

Photo: Spillage loss

Damage to banks

When using hydraulic excavators on the banks of a waterway, in the presence of high vegetation (bushes, trees, forests, etc.), vegetation must be fully removed from at least one of the banks. This will often be unacceptable from an environmental perspective. In case of low vegetation (grass, reeds, etc.), damage can sometimes be limited by using extra-wide caterpillar tracks or driving plates.

When using excavators on a pontoon together with a transport ship/barge, damage to the banks can be restricted to one or only a few zones.

Variations

Due to height restrictions, propulsion issues and insufficient access to the water bottom, a wide range of variations have been developed for hydraulic excavators over the years.
The following variations can be encountered:

Excavator boat

On excavator boats, an excavator arm has been mounted directly to the pontoon and the power source and cabin have been incorporated into the pontoon. Such excavator pontoons normally feature 3 or 4 supporting legs, which can be used to stabilize the machine while work is being carried out. Because they feature their own means of propulsion, excavator boats are generally very flexible and help to reduce mobilization time and costs.

Photo: Conver C97M Multi-Purpose dredger

Amphibious excavators

These modified excavators have had their standard caterpillar track replaced by a floating caterpillar track system, which allows the machine to also operate in wet and swampy areas. The arms of standard excavators need to be extended in order to work beyond the dimensions of large caterpillar pontoons.

Such a machine fitted with side pontoons with spud poles, it is possible to work in water up to 5 meters deep.

Photo: Amphitrax amphibious excavator

Tractor with side-arm

This is a 2-part hydraulic arm that has been assembled to a tractor, and is used to clean ditches using a mowing bucket or a dredging pump (see dredging pump section).

Photo: Herder mowing bucket, simultaneous mowing and dredging

3.3 Silt push boats

A silt push boat or silt pusher is like a floating bulldozer, which has been developed especially for cleaning ponds, lakes and small waterways. The machine is primarily used in situations where it is difficult to work from the water's bank. Silt pushers are characterized by an adjustable dozer blade, which can be set to a pre-set working depth. The dozer blades can be adjusted to the required depth and width.

The silt pushers pulls itself using a winch system and uses the dozer blade to push silt towards a collection point. This often involves an excavator being placed at a strategic location on the bank or pontoon, and using it to transfer silt from the water into the means of transport.

Photo: Silt pushers are often used in urban areas.

Range of applications
Silt pushers are primarily suitable for soft water bottoms (silt, clay, turf, mud, etc.). Silt pushers are particularly effective on relatively long, straight waterways. This allows the winch cables to be anchored far away, whereby time needed for set-up is reduced. The machine is extremely effective when dredging thin layers of materials and silt, spread across a large surface area. However, silt pushers can also be used for thicker layers. Depending on the circumstances, alternative dredging techniques could be more financially appealing.

Silt pushers are only effective in relatively shallow waters. Depending on the dimensions of the machine, it is possible to work in depths of up to 2,0 m. Special modifications need to be made when working in depths up to 3,0 m, and the machine becomes unsuitable when depths exceed 3,0 m.

Photo: Silt pusher in operation

Pollution level and susceptibility
In principle, the level of pollution does not have an impact on silt pushers. For instance, even large pollutants like bricks, bikes, shopping trolleys, etc. do not restrict the workings and efficiency of silt pushers. Due to the high level of opacification, the machine is less effective when dredging highly polluted water bottoms, unless specific measures have been taken to limit dispersion.

Means of transport
Silt pushers are primarily suited to collecting thin layers of silt on waterways. Further disposal of collected dredged materials will be determined by how the materials are transported. In general, Silt pushers are used together with an excavator, and transport takes place in dumpers or barges. However, Silt pushers can also be used together with cutter suction dredgers, whereby silt is hydraulically pumped via a pipeline to a depot or processing site.

Environmental effects
A high level of opacification often takes place around the push boat when dredged materials are pushed along the waterway. If necessary, dispersion of opacification can be restricted by using floating screens. However, they are unnecessary in most cases.

Accuracy
Silt pushers allow a vertical accuracy of 0,1 m to be realized

Photo: Silt pushers are also well suited in rural settings.

Spillage
In principle, there is no spillage when dredging is carried out using a silt pusher because scraped materials are pushed forwards. If dredged materials are pushed forwards over long distances, they will pile up in front of the dozer blade. If too much material builds up in front of the dozer blade, or if the boat is pulled over excessive distances, there will be loss via the sides, which will subsequently cause spillage. This can be limited by working in short distances and by overlapping dredged areas. This layer can be kept to a minimum if a clean-up run is also carried out.

Damage to banks
Damage to the banks can be reduced significantly when silt pushers are used. Because hydraulic excavators are mostly used to transfer materials, damage will be limited to transfer points that are located every 100 to 200 meters. Therefore, collection points must primarily be chosen at the least valuable locations along the bank.

Variations
Dutch civil engineers are renowned for making innovative use of existing techniques. The machine below is physical proof of this - a dozer blade mounted to the arm of an excavator with a modified base structure, which makes it possible to work in shallow ponds without using winches.

Photo: a variation of the push boat; a dozer blade on an excavator.

3.4 Cutter suction dredger

A cutter suction dredger is a dredging machine that is used in continuous excavation processes and is positioned using spud poles or winch cables. The cutter features a suction opening that has been connected to a dredging pump. The cutter cuts away the soil and mixes it with water. The mixture is then pumped to a (drainage) depot or processing installation via a discharge pipe. A large amount of water is needed to pump the mix. For organic silt, the best mix ratio is 1:3; for sand, the ideal mix ratio is 6 parts water for 1 part sand.

Photo: Cutter suction dredger being used in a marina

The cutter revolves around a pivot, which could be a spud pole or another anchor point. In dredgers with swivel ladders, which are often used for small-scale dredging activities, the only thing that moves back and forth (from side to side) is the construction (ladder) to which the cutter has been mounted.
Once the swivel movement has been completed, the suction device shifts further using the spud pole or winch cables, after which a new cycle is started.

Range of applications
Cutter suction dredgers are suitable for dredging all soil types, from very soft silt bottoms to rocky bottoms. Cutter suction dredgers can be used to dredge turf, clay, mud, sand, rubble, stones and soft rocks.
In small-scale dredging activities, suction dredgers are generally only suitable for silt, clay and sand, and can, depending on the dredger design, be used up to 6 m deep. The soil type and project conditions must be known for each project, so the most appropriate type of cutter can be selected.
For harder bottoms (i.e. sand), a cutter with larger cutting sections must be selected in order to penetrate the layer of sand. When doing so, it must be kept in mind that there is more wear and tear on the cutter and in transport pipes.


Photo: Cutters for sand and silt

Wear and tear is a less significant factor in cohesive clay bottoms, but the clay could block the cutter or balls of clay could be formed during hydraulic transport, which means extra pumping capacity will be needed.

Pollution level and susceptibility

Cutter suction dredgers are not vulnerable to chemical/organic pollutants, but are vulnerable to gross solids and larger objects that could block the cutter and the pipes. Therefore, if possible, it would be wise to remove all gross solids from the waterway before dredging activities are started.

Transport method

When using cutter suction dredgers, dredged materials are pumped to a depot or processing installation via a transport pipe. Transport via a pipeline is an advantage when dealing with polluted dredged materials, because direct contact with the environment is avoided. The disadvantage is that large quantities of water need to be mixed with dredged materials which, for highly polluted silt, cannot be discharged into the environment and must be purified.

Mixed materials will encounter resistance during hydraulic transport via pipelines, which means transport is only possible over a limited distance. However, booster stations can be used to increase the transport distance.

Due to the pipelines, this type of dredging is often unsuitable in urban settings where depots are located further away from the dredging site.

Environmental effects

The revolving movement of the cutter will cause fairly intensive dispersion of extracted particles in the area around the cutter, and will also result in opacification. This effect will intensify as the speed of the cutter increases. But this effect can also be managed by effectively adjusting the speed.

Photo: Cutter Suction Dredger being launched

Spillage

Although the suction mouth is located inside the cutter, some spillage can be expected because the silt is partly dispersed due to the revolving movement of the cutter. There is a fine balance between cutter production and suction capacity; if the cutter rotates too fast, there will be more spillage. The layer which is formed by settled spillage can be limited by careful operation. Often a clean-up run is carried out.

Damage to banks

Cutter suction dredgers will not damage banks because the dredging process takes place on the water. At places where anchors have been placed on the banks and where floating pipelines cross over from water to land (limited) damage may occur.

Accuracy

Cutter suction dredgers permit a very high degree of accuracy.

3.5 Dredge pump

Dredge pumps are used to suck dredging materials from the water bottom. The pump's suction opening, which is sometimes extended using a suction pipe, is guided through the centre of ditches to maximize contact with dredged materials.
However, dredge pumps can be mounted to a tractor or crane, or can also be placed on a boat. The production capacity of a dredging pump is determined by the dimensions of the pump and the capacity of the carrying vehicle.

Photo: Dredging pump on a mowing boat

Range of applications
Dredge pumps are only suitable for soft water bottoms (silt, turf, etc.). Because silt is attracted automatically, the dredging pump only has to be moved in the deepest part of the ditch. This means the banks of waterways do not have to be disturbed.
This dredge technique is primarily suited to waterways with non-polluted silt, whereby extracted dredged materials can be sprayed directly on to adjoining land. Dredge pumps allow activities to be performed at depths of up to circa 2 meters.
In the same way as a cutter suction dredger, a cutter can also be attached for dredging more solid water bottoms.

Pollution level and susceptibility
Many dredge pumps feature a blade at the opening of the pump, which chops up plants, reed and small branches which are sucked into the pump intake. However, in the same way as cutter section dredgers, dredge pumps are susceptible to stones and branches, which could block the opening. As a result, due to the large amounts of waste that can be expected in waterways, dredge pumps are less suited to dredging activities in urban settings.

Means of transport
Dredge pumps are primarily used to spread dredged materials on adjoining land. However, a discharge pipe can also be used to pump dredged materials over short distances.

Accuracy
Dredging pumps allow a vertical accuracy of 0,1 m to be realized. When dredging pumps are used to clean waterways, some sludge often has to be left behind for ecological purposes. This approach does not disturb the banks because only the centre of the waterway is cleaned.

Opacification
This approach results in very little opacification.

Spillage
Spillage is not encountered when dredging pumps are used.

Variations
A dredging pump must be seen as a (often hydraulic) powered tool that needs a carrying vehicle capable of supplying the required energy, which allows the pump to move in the required manner. An overview of potential applications has been provided below.


…on a mowing boat


…on a push boat


…on a (amphibious) excavator


…on an amphibious tool carrier


…on a tractor


…on a special tracked vehicle

4. TRANSPORT OF DREDGED MATERIALS

The dredging techniques mentioned above can be considered during the first step in the treatment process - the removal of dredged materials.

The second step involves transporting dredged materials to storage and/or processing site, and can be divided into two main categories, namely continuous transport and discontinuous transport.

During discontinuous transport, dredged materials are transported in batches - as in mechanical dredging. A silt push boat pushes a certain quantity of materials towards an excavator. The excavator then transfers it (bucket by bucket) to the means of transport (tipping truck or barge), which then transports the load to a disposal site (possibly via one or several transfer points).

Continuous transport refers to techniques where dredged materials are transported without interruption. For instance, this is the case in hydraulic dredging: silt is mixed and pumped via a pipeline.

Discontinuous transport
By road
During transport by road, dredged materials are loaded into a truck using mechanical equipment. Loading only takes place mechanically, thus reducing the truck's exposure to water that has been mixed with dredged materials. The dredged materials are transported to a processing site once the truck has been filled.

Photo: Transporting dredged materials by road

The advantage of road transport is that no or very little dilution is needed during the transport process. This means dredged materials are more stable (less viscous) during transport. The used containers are water-tight and can be covered, which helps to avoid spillage during transport. The size of the truck will be determined by legal restrictions for transport by road.

By water
During transport by water, dredged materials are loaded on to a barge or barge container mechanically or via, for example, a disposal chute.

Photo: Transport by barge container

The size of the barge will be determined by the specific conditions within a project. The barges used in urban areas are smaller than those used to transport dredged materials via rivers.

Continuous transport
During transport via pipelines, the discharge pipe normally connects the dredging site directly to the processing site, through the dredger. Depending on the distance between the sites one or more booster stations might be needed. This type of transport is normally only used when implementing cutter suction dredgers or dredging pumps.

Photo: Discharges pipes

5. STORAGE OF DREDGED MATERIALS

The third step involves storing the dredged material at a dredging depot, temporarily or permanently. Some depots are located in surface water (e.g. former sand excavation pits) while others are located on land.

A more stable product can be created by draining dredged materials, which can then be used for a variety of applications. Draining dredged materials allows the structure and volume of the materials to be improved. Because organic compounds break down over time, the quality of dredged materials can also improve if it is kept for long periods. In such cases, this is not referred to as a draining process, but as land farming.

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