

Device for the removal of sludge and/or sand from the bottom of a wetland.

5 This invention relates to a method for the removal of sludge and/or sand from the bottom of a wetland.

The invention applies both to the removal of sludge and to the removal of an underlying sand layer up to a certain
10 depth. For the sake of simplicity, the term sludge is used below, which also refers to the underlying sand layers.

More specifically, the method relates to the in situ pumping up of polluted sludge underwater with minimal turbulence.

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It is generally known that the sludge of maritime waterways may be contaminated with toxic chemicals and heavy metals from accidental or illegal discharges or from seepage from industrial sites, such as, for example, pollution by toxic
20 substances that are often present on the hull of a ship to repel the growth of marine organisms.

These harmful substances remain present in the sludge of port areas and maritime waterways. These pollutions around port
25 areas have a detrimental effect on the local indigenous marine organisms.

However, a problem is that current dredging techniques to remove sludge from the bottom of a wetland are often relatively inefficient in the sense that they create a lot of
30 turbulence, causing sludge churn as well as turbidity or

muddiness in the water.

The water content in the sludge is increased by the churning during dredging. This is not interesting because to clean the pumped up sludge, the moisture content has to be completely or partially removed. An increased moisture content therefore makes the dredging process relatively more expensive and the cleaning of the pumped up sludge more time-consuming.

Another disadvantage of the turbulence caused is that the churned polluted sludge spreads out over the wetland by resuspension of the sludge and possibly mixes with unpolluted sludge, while in fact the dredging and removal of the sludge should remain in situ as much as possible.

In addition, the precipitation of the resuspended sludge completely disturbs or even completely destroys soil organisms.

One consequence of the risk that a lot of turbulence is created using traditional sludge removal techniques, is that such polluted water bodies are left untouched by the authorities to avoid the risk of further dispersal through churn and inefficient removal.

This implies that polluted port areas are not deepened or expanded any further, which means that these areas with potentially high economic value remain unused.

In BE 1.018.005 and BE 1.021.095 of the same inventor,

techniques are already known for in situ dredging, using a diving bell which is pushed into the sludge to be removed and from which the enclosed sludge is pumped away.

- 5 The purpose of the present invention is to further improve these known techniques using a diving bell.

To this end, the present invention relates to a device for the underwater in situ removal of sludge and/or sand from the
10 bottom of a wetland, the device containing:

- a diving bell with an open bottom and a lower free edge;
- means of floating the diving bell with its lower edge to a desired depth into the layer of sludge and/or sand to be removed;
- 15 - a dredge pump installed in the space of the diving bell and provided with an inlet for pumping up the sludge and/or an outlet to which a pipe is connected for pumping the pumped up sludge and/or sand to a collector;
- a compressor for pumping gas under pressure into the space
20 of the diving bell during dredging,
whereby the diving bell is also provided with a gas outlet for the compressed gas, which gas outlet in the diving bell is adjustable in height because the outlet is attached to a float that can float on the sludge.

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This movable outlet of the compressed gas will allow the air above the sludge or sand to escape freely when the diving bell is driven into the sludge or sand, so that the diving bell can be filled with sludge or sand as much as possible
30 without the water being driven out.

The outlet will always be above the sludge or sand to be removed and the float, together with the movable outlet and the supply of the compressed gas, ensure that the water level
5 and the pressure above the water in the bell are self-regulating.

Indeed, the air in the diving bell will be able to escape through the outlet, and the water level will stabilise at the
10 level of the upper edge of the outlet.

As the float and therefore also the outlet mounted on it follow the level of the sludge, the level of the water will also follow the level of the sludge or sand and therefore the
15 level of the sludge or sand and the level of the water will decrease together as more sludge or sand is pumped away.

Because both levels drop at the same time, there is no flow of water through the sludge to the outside, so that the
20 pollution cannot escape to the outside and, in other words, during dredging, the pollution is retained inside the diving bell.

Such automatic regulation of the level and pressure is very simple and very effective as has already been demonstrated in
25 closed trials.

According to a practical embodiment, the aforementioned outlet is formed by the open end of a pipe which, through an opening at the top of the diving bell, releases into the
30 environment and, for example, is guided above the water

surface via a further pipe to prevent turbulence and turbidity caused by rising air bubbles or to be able to purify toxically charged air if necessary.

5 The float with the outlet on it is preferably suspended in the diving bell by means of a chain or the like, whereby the length of this chain is such that when the diving bell is taken out of the water, the float with its underside is approximately at the level of the lower edge of the diving
10 bell and when the diving bell is driven into the sludge, the float immediately comes into contact with the rising sludge in the diving bell.

Preferably, the float is such that it floats on the sludge or
15 sand, but still does not have sufficient buoyancy to, together with the weight of the pipe, float the compressed gas outlet on the water.

The float, for example, is formed by a sufficiently
20 dimensioned sheet to support the weight of the pipe on the sheet on the sludge or sand.

According to a simple practical embodiment, the pipe is formed by a rigid metal tube which rests and is attached to
25 the float with one end and, with the other end, releases into the outside environment of the diving bell via a flexible coupling at the top of the diving bell.

Preferably, the dredge pump is attached at a fixed location
30 in the diving bell so that it is floated into the sludge

together with the diving bell and the inlet of the dredge pump is situated at the level of the lower free edge of the diving bell.

- 5 To obtain the aforementioned balance in the diving bell, a compressor is used, the pressure of which is set to a maximum pressure higher than the pressure of a water column with a height equal to the difference in level between the water surface of the wetland and the lower free edge of the diving
10 bell.

Optionally, the diving bell near the lower edge can be provided with one or more water jets that are fed by a jet pump that injects water into the sludge or sand, which can be
15 useful when the sludge is a hard substance.

To drive the diving bell into the sludge, for example, a hydraulic crane or excavator with a hydraulic unit group that supplies the hydraulic power to drive the dredge pump and the
20 optional jet pump, whereby the diving bell is suspended from the crane's arm, can be used.

For example, the hydraulic crane is installed on a work boat or pontoon, together with the aforementioned compressor.

- 25 The means to drive the diving bell into the sludge or the sand may include a vibration or pile-driving installation, which may be mounted on the crane, for example.

To allow the crane operator to see or know what he is doing,
30 means can be provided to assess the depth of the diving bell

in the layer of sludge or sand as well as means to assess the thickness of the sludge layer.

The invention also relates to a method for the underwater in
5 situ dredging of sludge or sand.

With the intention of better showing the characteristics of the invention, some preferred embodiments according to the present invention are described hereinafter by way of an
10 example, without any limiting nature, with reference to the accompanying drawings, wherein:

figure 1 schematically shows a device according to the invention at the start of the dredging;
15 figures 2 to 4 show the device of figure 1 during consecutive phases of the dredging in one and the same place;
figure 5 shows another embodiment of the device of figure 1;
20 figures 6 and 7 show other embodiments.

The device 1 according to the invention as shown in figure 1 by way of an example, contains the following elements:

- a hydraulic crane 2 set up on a pontoon 3;
- 25 - a diving bell 5 suspended from the arm 4 of the crane 2 with an internal space 6 with an open bottom 7 which is delimited by an upper wall 8 and sidewalls 9, the lower edge 10 of which is made like a blade;
- a dredge pump 11 which is attached in the space 6 of the
30 diving bell 5 by means of a rigid suspension 12 and

which is provided with an inlet 13 for pumping up the sludge 14 and an outlet 15 to which a pipe 16 is connected to pump the pumped up sludge to a collector 17;

- 5 - a hydraulic motor 18 to drive the dredge pump 11, the motor 18 being connected via pipes 19 to the hydraulic unit 20 of the crane 2;
- 10 - a compressor 21 which is installed on the pontoon 3 to pump air under pressure during dredging via a supply pipe 22 and a passage 23 in the upper wall 8 into the space 6 of the diving bell 5.
- 15 - a discharge pipe 24 to evacuate the pumped air through a gas outlet 25 from the diving bell 5 to the open air above the water level 26, whereby the part of the discharge pipe 24 in the diving bell 5 is made as a rigid metal tube 24a connected with one end via a flexible coupling 24b to the part 24c of the discharge pipe 24 on the outside of the diving bell 5, in such a way that the tube 24a with the gas outlet 25 on the other end can rotate around the flexible coupling 24b down and up;
- 20 - a float 27 that can float on the sludge 14 and to which the end of the tube 24a with the outlet 25 is attached;
- 25 - a chain 28 with which the lower end of the tube 24b is suspended in the diving bell 5 and the length of which is such that the freedom of movement of the float 27 is restricted to the situation as shown in figure 1 whereby the underside of the float 27 is on the same level as the lower edge 10 of the diving bell 5.

The use of the device 1 according to the invention is simple and as follows.

Using the hydraulic crane 2 the diving bell 5 is pushed down
5 and, together with the dredge pump 11, is driven into the
sludge 14 with the blade at the lower edge 10 of the diving
bell 5 in a horizontal position.

When the diving bell 5 reaches the level of the sludge 14 as
10 in the initial situation of figure 1, the float 27 lies just
above the sludge 14.

When the diving bell 5 is driven into the sludge 14 at a
depth A, as shown in figure 2, the float 27 follows the
15 movements of the upper level of the sludge 14 in the diving
bell 5, with the tube 24b rotating up around the flexible
coupling 24c, driven by the float 27.

Because the space 6 in the diving bell 6 above the sludge 14
20 is always connected to the outside air, as the level of the
sludge 14 rises in the space 6 of the diving bell 5, the air
is driven out.

In the position of figure 2, the supply and discharge of the
25 compressed air in the space 6 of the diving bell 5
automatically achieves a balance of the level 29 of the water
30 in the diving bell 5 which is approximately equal to the
upper edge 31 of the gas outlet 25 and thus at a fixed height
B above the level 29 of the sludge 14 in the diving bell 5.

When the dredge pump 11 is driven, the sludge 14 that is enclosed in the diving bell 5 is pumped away to the collector 17.

- 5 As the dredging progresses, the level of the sludge 14 in the diving bell 5 decreases and the float 27, and thus the level 29 of the water 30, follows the level of the sludge 14 in the diving bell.
- 10 The level 30 is controlled by pumping with the dredge pump 11 until all the sludge 14 in the diving bell 5 has been pumped out, as shown in figure 3.

In other words, water is never driven out that could
15 otherwise cause pollutions present in the sludge to be rinsed out.

In this way, only the sludge 14 that is caught in the diving bell 5 is dredged without disturbing the sludge 14 all
20 around.

The level 29 of the water 30 above the level of the sludge therefore depends on the height of the upper edge 31 of the outlet 25 and can therefore be regulated by positioning it
25 higher or lower in relation to the float 27.

Preferably, the float 27 is designed to float on the sludge 14, but yet does not have sufficient buoyancy in water to, together with the weight of the pipe 24b, float on the water,
30 so that the float 27 can lower down on to the sludge 14.

To this end, the float 27 can be made as a simple sheet dimensioned in such a way that the pressure exerted by the sheet on the sludge by the weight of the tube 24b is less
5 than the load-bearing capacity of the sludge.

Alternatively, the tube 24b can also be replaced by a flexible hose, the lower end of which is attached to the float 27 and whereby if necessary the float 27 is weighted to
10 allow it to sink into the water on to the sludge.

The compressor 21 is set so that the maximum pressure is higher than the pressure of a water column with a height equal to the difference in level C between the water level 26
15 of the wetland and the blade at the lower free edge 10 of the diving bell 5.

After all the sludge 14 has been pumped out of the diving bell 5, the diving bell 5 can be driven deeper into the
20 sludge 14 to be able to remove the deeper sludge 14 as well.

If necessary, an underlying sand layer 14' with a higher density can also be removed up to a certain depth, in which case the diving bell 5 must be driven into the sand 14' to
25 this depth.

In this case or in the case of relatively compact sludge 14, the hydraulic crane can be equipped with a vibration or pile-driving installation to vibrate or pile-drive the diving bell
30 into the sand or the sludge.

After dredging to the desired depth, the diving bell 5 can be pulled up again to be driven back into the sludge at another location to dredge there. In this way, consecutive dredging operations can efficiently clean up an entire area in a short period of time.

The crane 2 and the compressor 21 do not necessarily have to be mounted on a pontoon 3, but can also be installed on a quay, for example.

It is clear that instead of the hydraulic crane 2, also other means are conceivable for driving the diving bell 5 into the sludge.

The dredge pump 11 does not necessarily need a fixed position in the diving bell 5, but can, for example, be attached to a device that can move the dredge pump 11 in the diving bell 5.

Several dredge pumps 11 may also be provided.

Figure 5 shows an alternative embodiment of a device 1 according to the invention which, in relation to the device in figure 1, is provided with the following extra elements:

- means of measuring the depth A of the diving bell 5 in the sludge 14, such as for example a depth scale 32 on a sidewall 9 of the diving bell 5 and a camera 33 to enable the crane operator in the crane 2 to see what is going on in the diving bell 5;
- means (not shown) of measuring the thickness D of the

- layer of sludge, e.g. by means of sonar;
- ~ an installation to generate a water jet to breach hard sludge in the diving bell 5, in other words, to break it up;
 - 5 ~ a jet pump 34 with an inlet 35 on the outside of the diving bell 5 and an outlet 36 connected with pipes 37 to passages 38 on the underside of the sidewall 9 of the diving bell 5, so that a water jet is generated in a horizontal direction;
 - 10 ~ the jet pump 34 is provided with a hydraulic motor 39 which is also connected to the hydraulic unit 20 of the crane 2.

Figure 6 shows another embodiment of a device 1 according to the invention whereby in this case the diving bell 5 is suspended by a cable from a catamaran 40 or the like, whereby the diving bell 5 can be lowered into the sludge using winches 41 or the like and can be hoisted back after the dredging work has been completed to dredge a subsequent zone.

20 In this case too, it can be useful to install a vibration or pile-driving installation on the diving bell 5.

Figure 7 describes another embodiment whereby the diving bell 5 is not completely under water to remove the sludge 14, but partly sticks out of the water.

In the example shown, the diving bell 5 is provided with means of transport 42 to move the dredge pump 11 horizontally and/or vertically within the diving bell 5 and with a

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vibration device 43 to vibrate the diving bell 5 in the sludge 14 and/or the sand 14'.

5 The present invention is by no means limited to the devices described by way of an example and shown in the figure, but, a device and a method for the removal of sludge according to the invention can be realised in all kinds of ways, without departing from the scope of the invention.

Claims.

- 1.- Device for the in situ underwater removal of a layer of
5 sludge and/or sand from the bottom of a wetland, the device
containing:
- a diving bell with an open bottom and a lower free edge;
 - means of driving the diving bell with its lower edge to a
desired depth into the layer of sludge to be removed;
 - 10 - a dredge pump installed in the space of the diving bell and
provided with an inlet for pumping up the sludge and/or an
outlet to which a pipe is connected for pumping the pumped up
sludge and/or sand to a collector;
 - a compressor for pumping gas under pressure into the space
15 of the diving bell during dredging,
- characterised in that** the diving bell is also provided with a
gas outlet for the compressed gas, which gas outlet is
adjustable in height in the diving bell because the gas
outlet is attached to a float that can float on the sludge.
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- 2.- Device according to claim 1, characterised in that the
gas outlet is formed by the open end of a pipe which releases
via an opening at the top of the diving bell into the
environment.
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- 3.- Device according to claim 2, characterised in that the
pipe discharges above the water level of the wetland.
- 4.- Device according to any one of the previous claims,
30 characterised in that the outlet is located with its upper

edge at a height above the float.

5.- Device according to any one of the previous claims, characterised in that the float with the outlet mounted on it, is suspended in the diving bell by means of a chain or the like, the length of which is such that when the diving bell is taken out of the water, the float with its underside is approximately at the level of the lower edge of the diving bell.

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6.- Device according to any one of the previous claims, characterised in that the float is such that it floats on the sludge, but does not have sufficient buoyancy to allow the compressed gas outlet to float on the water, together with the weight of the pipe and the outlet.

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7.- Device according to claim 6, characterised in that the float is formed by a sufficiently dimensioned sheet to bear the weight of the pipe on the sheet on the sludge.

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8.- Device according to any one of the previous claims, characterised in that the pipe is formed by a rigid metal tube which rests and is attached to the float with one end and with the other end releases via a flexible coupling at the top of the diving bell into the environment of the diving bell.

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9.- Device according to any one of the previous claims, characterised in that the dredge pump is attached to a fixed place in the diving bell with its inlet on the level of the

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lower free edge of the diving bell.

10.- Device according to any one of the previous claims, characterised in that the maximum pressure to which the
5 compressor is set is higher than the pressure of a water column with a height equal to the difference in level between the water surface of the wetland and the lower free edge of the diving bell.

10 11.- Device according to any one of the previous claims, characterised in that the lower free edge of the diving bell is made as a blade.

12.- Device according to any one of the previous claims,
15 characterised in that near the lower edge of the diving bell it is provided with a water jet that is fed by a jet pump that sprays water into the sludge inside.

13.- Device according to claim 12, characterised in that the
20 jet pump is mounted on the outside of the diving bell and via pipes is connected with passages in the wall of the diving bell, which pipes discharge in the diving bell in a direction perpendicular to this wall.

25 14.- Device according to any one of the previous claims 12 or 13, characterised in that the means to drive the diving bell in the sludge are formed by a hydraulic crane with a hydraulic unit that supplies the hydraulic power to drive the dredge pump and the optional jet pump.

15.- Device according to claim 14, characterised in that the hydraulic crane is set up on a work boat or a pontoon, together with the aforementioned compressor.

5 16.- Device according to any one of the previous claims, characterised in that it is provided with means to assess the depth of the diving bell in the layer of sludge.

10 17.- Device according to claim 16, characterised in that the means to assess the depth of the diving bell in the sludge are formed by a depth scale on the sidewall of the diving bell and a camera.

15 18.- Device according to any one of the previous claims, characterised in that it is provided with means to assess the thickness of the layer of sludge.

20 19.- Use of a device according to any one of the previous claims, characterised in that the device is used for the removal of a layer of sludge and/or sand from the bottom of a wetland.