HOW DO I BUILD A MOVING BED BIOFILM REACTOR (MBBR)?

1. What is a MBBR?

A Moving Bed Biofilm Reactor (or MBBR for short) removes nitrogen from water by converting nitrate into nitrogen gas by means of biological processes. A MBBR consists of a tank filled with water, in which plastic carriers are located that are set in motion (Photo 1Photo 1). The irregular and large specific surface area of the carriers forms an ideal habitat for various micro-organisms (Photo 2Photo 2). On these carriers grows active sludge (biofilm) and this carries out the denitrification.

A MBBR requires little maintenance and is simple to construct yourself with the help of this information sheet.

Photo 1: Set-up of Moving Bed Biofilm Reactor (MBBR) at PCS Ornamental Plant Research

Photo 2: Plastic carriers in a MBBR, on which a biofilm will develop

When constructing a MBBR, many different variants are possible. The principle always remains the same, however. This document describes one type of MBBR that was developed in collaboration with KU Leuven. Here at PCS, it is with this version that we gained the most experience.

2. The components required to build a MBBR

1. Hoses and pipes

2 x 10-meter flexible hoses (32 mm)
3 meters of PVC pipe (32 mm)
2 meters of LDPE hose 15 mm 10x8
4 PVC 90° elbow (32 mm)
1 PVC thread piece 32x40-1"
1 PVC thread piece 32x40-1/2"
1 PVC cap with internal thread 1"
4 PVC bushings 32x40-5/4"
2 Geka hose connection couplings (32 mm)
1 Geka coupling with internal thread 1"
1 Geka coupling with external thread 1"
1 hose connection with external thread 13 mm x 1/2"

2. Pumps

1 Pond pump Aquaforte O-10000
1 Air pump Aquaforte AP-100 (SC455)
1 Etatron dosing pump PKX-MA 05/05

3. Other items

1 Membrane diffuser
1 Etatron Viton injection nipple Teflon
1 dropper with 1 meter of pipe
1 tin of PVC adhesive
1 rubber plug (male)
1 bottle for the carbon source (C-source)
1 Ball valve, galvanized with internal thread 1"
1 electrical enclosure, incl. level measurement
3 hose clamps (32 mm)
2 hose clamps (15 mm)
5 meters of stainless steel cable, plasticized
3 measurement probes (yellow/red/blue) for level control

3. Components

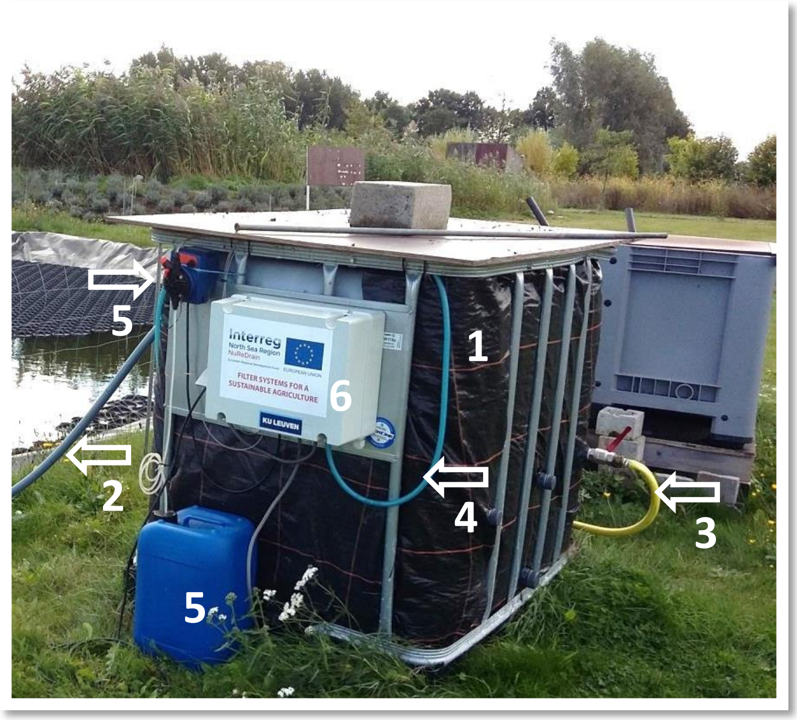


Photo 3: Image showing all the components of a MBBR

The different components of a MBBR are marked in Photo 3.

1 = Collection reservoir
This is a 1-m³ IBC tank. This will preferably be opaque (black) or will be covered with black geotextile in order to prevent the growth of algae.

2 = Wastewater supply hose
In the wastewater pond, a pond pump pumps the water to the IBC tank via a flexible hose. The water level in the MBBR is controlled using two sensors – one controlling the minimum level and the other controlling the maximum level.

3 = Removal of purified water
The ball valve ensures that the correct quantity of purified water is removed via the yellow hose.

4 = Aeration system
The aeration pump and a membrane diffuser ensure that the tank can be briefly aerated (for a few minutes) at controllable time intervals, such as every 3 hours. That enables the carriers to be switched around and any excess biomass that has formed will be distributed and removed. This is necessary in order to keep the water removal outlets and the carriers clear.

5 = Carbon source and dosing pump
In this instance, the blue vessel contains glycerol or glycerine (Carbo-ST) as a carbon source, but other C-sources can also be used. The quantity of Carbo-ST that is delivered is controlled using a dosing pump.

6 = Electrical enclosure
This ensures that the aeration pump is driven using a programmable timer, that the submersible pump is governed by level sensors and that the dosing of the C-source is governed by the incoming water.

Drawn up in connection with the Interreg North Sea Region project NuReDrain.

During the colder winter months, the system is mostly inactive in order to prevent damage being caused to the pipes and pumps. For that reason, it is therefore important that the supply and outlet hoses are disconnected. In Flanders, it is assumed that the number of active days each year will be between 200 and 240, depending on the area. The system may be restarted from the beginning of March onwards. A MBBR with a volume of 1 m³ is capable of purifying between 2 m³ and 3 m³ of wastewater per day. In general, therefore, an average MBBR is capable of processing between 600 m³ and 720 m³ a year. By setting up the MBBR for frost-free operation, the system can also remain in operation during the winter.

4. Construct your MBBR step by step

1. IBC tank	
	Using a jigsaw, make an opening in the middle of the IBC tank, at the top. The diameter of the opening must be 60 cm.

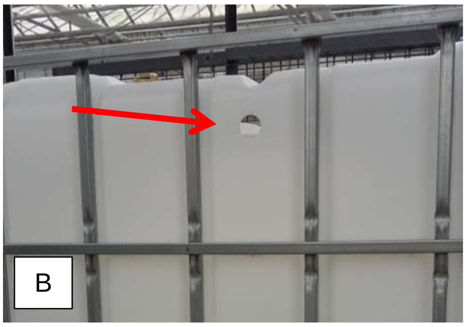
In this information sheet, the side walls of the IBC tank will now be named A, B, C and D (side wall A = the front, side wall B = the left side, side wall C = the back and side wall D = the right side).

2. Supplying of wastewater

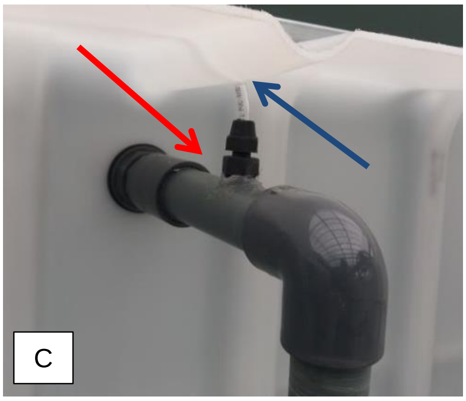
Items required

1 Pond pump (Aquaforte O-10000)
1 Etatron dosing pump PKX-MA 05/05
1 Etatron Viton injection nipple
10-meter flexible hose (32 mm)
2 hose clamps (32 mm)
1 PVC 90° elbow (32 mm)
1 PVC pipe (32 mm) of 70 cm in length
1 PVC pipe (32 mm) of 15 cm in length
1 PVC bushing 32x40-5/4"
1 dropper with 1 meter of pipe
1 Geka coupling with internal thread 1"
1 Geka hose connection coupling (32 mm)
3 measurement probes
5 meters of stainless steel cable, plasticized
1 rubber plug (male)
1 bottle for the carbon source (C-source)

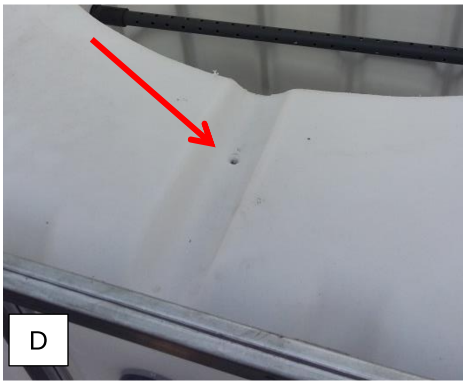
A. Using a saw, cut a section of PVC pipe (32 mm) to a length of 70 cm and another section of PVC pipe (32 mm) to a length of 15 cm. Glue the 70-cm section of PVC pipe to a (32-mm) elbow and glue this to the 15-cm section of PVC pipe. To this section, you glue the tank bushing (but not the edge with the thread – see Photo A).



B. Drill a feed-through hole measuring 32 mm in diameter in the middle of Side Wall A of the IBC tank, 10 cm below the upper edge of the tank (see the red arrow in Photo B).

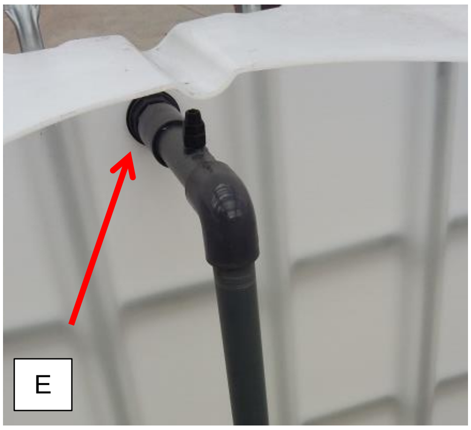


C. In the 15-cm section of PVC pipe, drill 1 small 15-mm hole, 5 cm from the elbow, from above. Then, fix the injection nipple of the dosing pump in that hole. You can seal this with silicone (see the red arrow in Photo C).

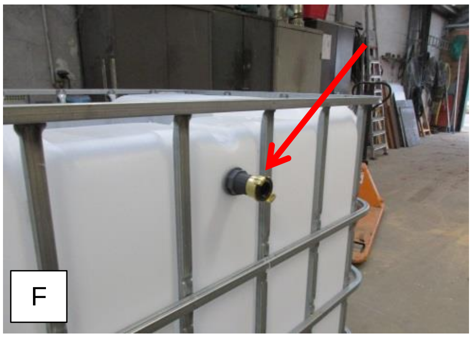


D. Next to the large opening on the top of the IBC tank, drill a small 5-mm hole so that the small hose from the dosing pump can pass through it (see the red arrow in Photo D). This hole should be drilled on the side on which the feed-through hole was drilled in Step 2.B, directly above the dosing pump injection nipple (see the blue arrow in Photo C).

Drawn up in connection with the Interreg North Sea Region project NuReDrain.

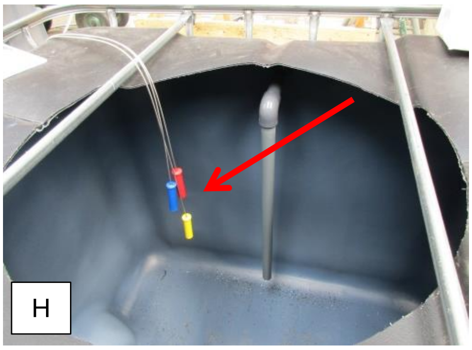


E. Place the PVC bushing from Step 2.A into the feed-through hole (see the red arrow in Photo E).

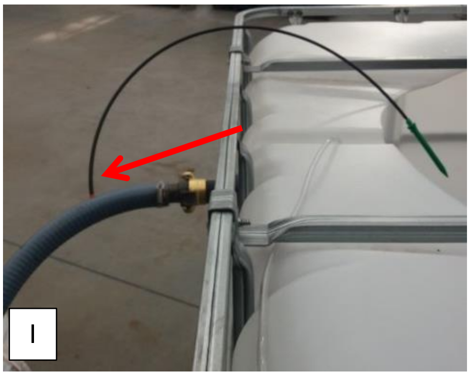


F. On the outside of Side Wall A of the IBC tank, screw the locking nut of the bushing onto the tank bushing. Then, screw the Geka coupling with internal thread onto the tank bushing referred to in the previous step (see the red arrow in Photo F.)

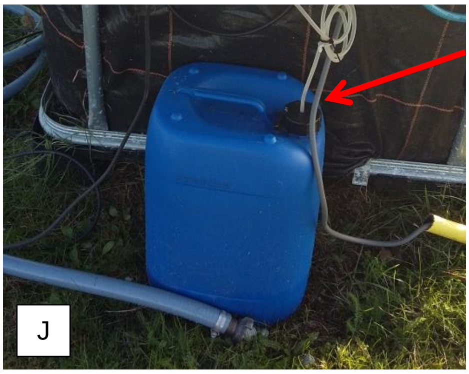
G. Connect the pond pump to a flexible hose (32 mm), through which the water can be transferred from the pond to the MBBR (see Photo G). Secure the flexible hose to the pond pump using a (32-mm) hose clamp. Connect a Geka coupling with hose connection (32 mm) to the other end of the flexible hose and secure this using a (32-mm) hose clamp as well. Connect this flexible hose to the Geka coupling that was fitted to the IBC tank in the previous step.



H. Using the stainless steel cables, suspend the 3 level sensors in the IBC tank via the top opening (see Photo H): the yellow sensor must hang the lowest and can hang down by half a meter, while the red sensor indicates the maximum water level and can therefore hang down 10 cm from the upper edge of the tank. The blue sensor indicates the minimum water level and can hang 20 cm from the upper edge of the tank.

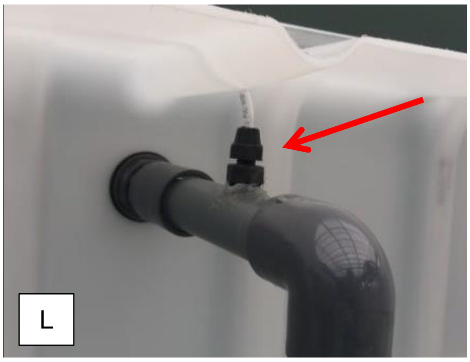


I. Drill a small 5-mm hole into the 32-mm flexible hose which draws the water from the pond. This hole will accommodate a drip hose. The drip hose must be suspended in the MBBR above the water level, so that the supply hose can always drain empty if the pump is switched off (see the red arrow in Photo I).



J. In the screw cap of the bottle containing the C-source, drill a 5-mm hole so the small hose from the dosing pump can pass through. This will prevent rainwater or other contaminants from entering the tank (see the red arrow in Photo E).

K. Attach the C-source dosing pump to the IBC tank. The dosing pump must be set to 5% using a rotary button on the front of the device (see the red arrow in Photo K).



L. Using a hose[1], connect the injection nipple with the dosing pump and also ensure that the dosing pump is connected to the C-source. Also, fix the plug (rubber) on the dosing pump so that the pump can be supplied with power.

[1] *The package containing the dosing pump already contains two hoses and a filter for the C-source.*

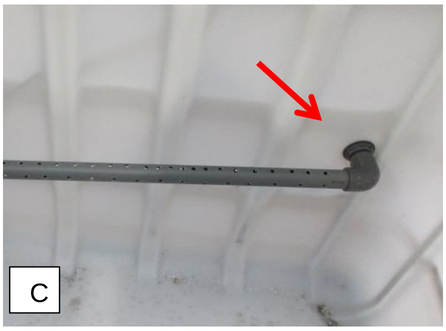
3. Removal of purified water

Items required

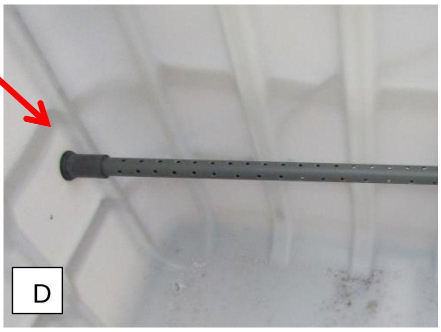
10-meters flexible outlet hose (32 mm)
1 PVC 90° elbow (32 mm)
1 PVC pipe (32 mm) of 45 cm in length
1 PVC cap with internal thread 1"
2 PVC bushings 32x40-5/4"
1 Ball valve, galvanized with internal thread 1"
1 Geka coupling with external thread 1"
1 Geka coupling with hose connection 32 mm
1 hose clamp (32 mm)

A. Drill two 40-mm feed-through holes in the side wall of the IBC tank. In the first hole, a PVC pipe must be fixed in Side Wall C of the IBC tank by using a PVC bushing (see the red arrow in Photo A). The other opening is the outlet opening in Side Wall B for the purified water (see the blue arrow in Photo A). Both outlet holes must be located at the same height (40 cm from the bottom of the IBC tank), but on a different side wall, each one 15 cm from the edge.

B. Using a saw, cut a section of PVC pipe (32 mm) to a length of 45 cm. Drill a 7-mm hole every 3 cm along the entire length of the pipe. Do this on all 4 sides, i.e. 4 rows of holes (see Photo A).

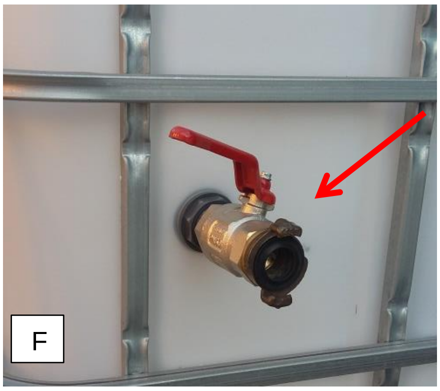


C. On one side of this PVC pipe, glue a elbow with a tank bushing that goes through the IBC tank on Side Wall C, as in Photo C.

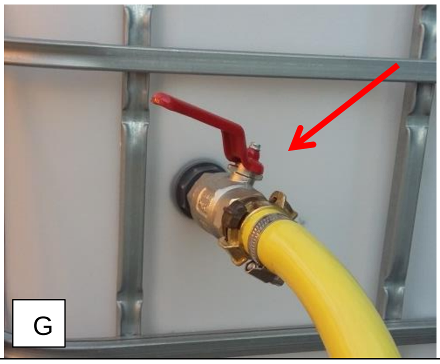


D. On the other side of the PVC pipe, glue a tank bushing, which you then attach to Side Wall B (see Photo D).

E. On the outside of Side Wall C of the IBC tank, screw a PVC cap with a 1" internal thread onto the bushing.



F. On the outside of Side Wall B of the IBC tank, screw a ball valve onto the tank bushing, as in Photo F. Then screw a Geka coupling with a 1" external thread onto the ball valve. The ball valve allows the flow rate in the outlet to be controlled.

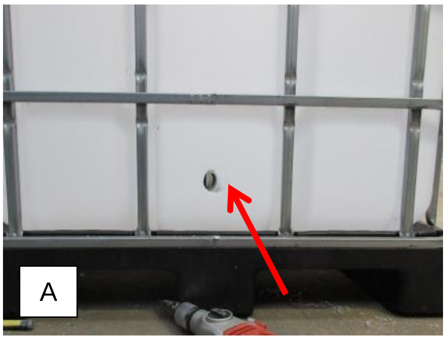


G. Connect a flexible 32-mm outlet hose, to which a Geka coupling with hose connection (32 mm) is attached, to the ball valve so that the purified water can be removed. Secure the flexible hose using a (32-mm) hose clamp.

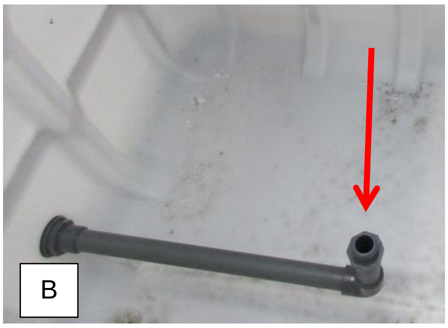
4. Aeration

Items required

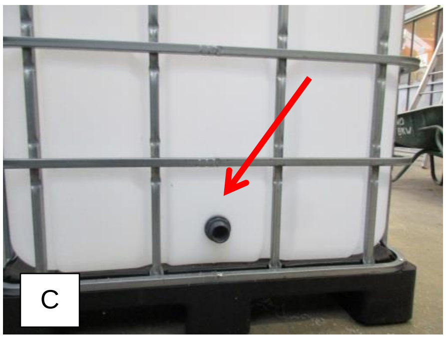
1 Air pump Aquaforte AP-100 (SC455)
1 Membrane diffuser
2 meters of 15-mm LDPE hose 10x8
2 PVC 90° elbows (32 mm)
2 PVC pipes (32 mm) of 10 cm in length
1 PVC pipe (32 mm) of 50 cm in length
1 PVC bushing 32x40-5/4"
1 PVC thread piece 32x40 - 1"
1 PVC thread piece 32x40 - ½"
1 hose connection with external thread 13 mm x ½"
2 hose clamps (15 mm)
1 hose clamp (32 mm)
Teflon



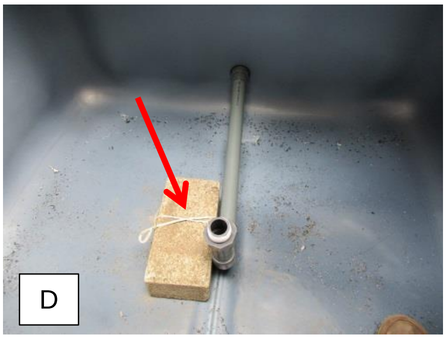
A. For the aeration system, drill a feed-through hole measuring 40 mm in diameter in the middle of Side Wall B of the IBC tank, 10 cm from the bottom of the tank (see Photo A).



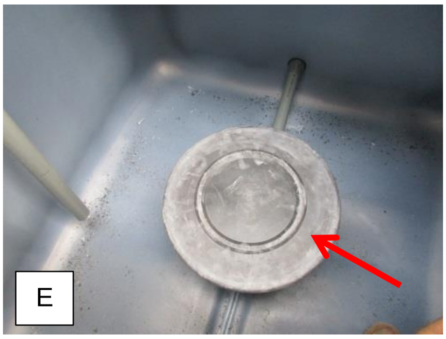
B. Using a saw, cut one section of PVC pipe (32 mm) to a length of 50 cm and another to a length of 10 cm. Glue the 50-cm section of PVC pipe to a (32-mm PVC) elbow and then glue the 10-cm section of PVC pipe to this. Then glue on a thread piece 32 x 40 - 1". On the other side, glue a tank bushing (see Photo B).



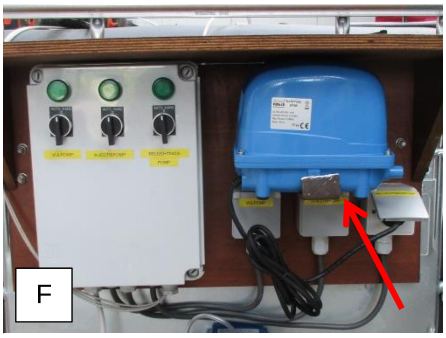
C. Place the PVC bushing from Step 4.B into the feed-through hole (see the red arrow in Photo C).



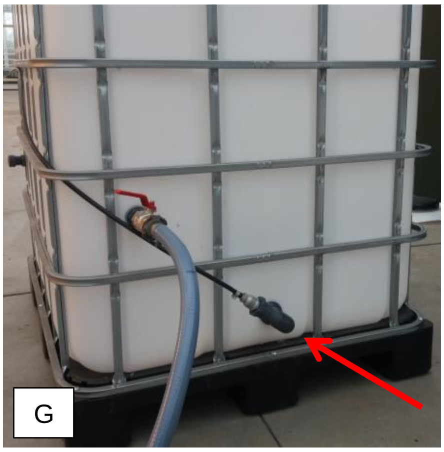
D. Tie the open end with the elbow to a brick so that the system cannot float to the top (see Photo D).



E. Screw the membrane diffuser to the thread piece, using Teflon (see Photo E).

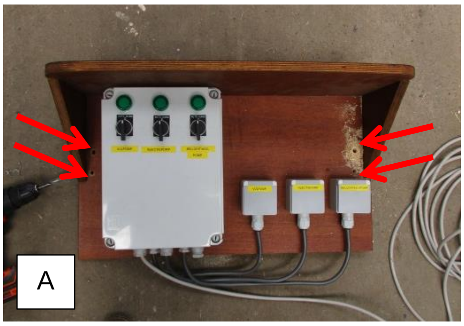


F. Attach the air pump to the IBC tank (see Photo F).



G. Use a elbow (PVC 32 mm) to connect the tank bushing of the IBC tank from Step 4.E to the flexible hose (15 mm) that is connected to the aeration pump (see Photo G). Use the hose connection with external thread 13 mm x ½" to connect the flexible hose to the aeration pump, then secure it using a 32-mm hose clamp. Use the two 15-mm hose clamps to fasten the flexible hose firmly.

Drawn up in connection with the Interreg North Sea Region project NuReDrain.

5. Electrical enclosure	
	The electrical enclosure must be attached to the IBC tank. **A.** Drill four holes in the electrical enclosure (see Photo A).
	**B.** Fix the electrical enclosure to the IBC tank and insert the plugs of the aeration pump, dosing pump and pond pump into the sockets (see Photo B).

5. A few important points when constructing a MBBR

1. Fill the IBC tank with carriers until 40% full. At PCS, AnoxKaldnes K5 carriers are used with a specific surface area of 800 m^2/m^3. It takes a few weeks for the biofilm to develop on the carriers, but this can be accelerated by transferring a certain number of carriers from a MBBR installation already in operation.
2. The presence of water in the supply hose will cause the MBBR to operate less effectively. The reason for this is because still water in the hose will cause large quantities of biomass that can cause clogging. The drip hose attached to the hose will ensure that all water in the hose will flow back to the pond. As long as the pump is not working, the hose will remain empty.
3. When connecting the hoses and couplings, use Teflon so that no leaks occur. To ensure a good connection between the hose and the hose connections, hose clamps should also be used.
4. To guarantee the service life of the tanks, it is best to use black tanks or to use white IBC containers covered with black geotextile.
5. Check the level of the carbon source once a week.
6. To set the flow rate of purified water (ball valve), you can assume a quantity of 3 m^3 per day, which corresponds to a flow of 2.8 litres per minute.
7. It is important to check the nitrate concentration at the outlet on a regular basis. This can be done by nitrate strips. The nitrate level must be below 50 mg/l.

   If the nitrate concentration is too high, there are four things you can check:
   1: The level of the carbon source
   2: Whether the dosing pump is working correctly
   3: The outlet flow (1.4 l/min to 2.8 l/min)
   4: The nitrate concentration of the wastewater to be processed.
   The MBBR can only treat between 2 m^3 and 3 m^3.

6. For further information, please contact PCS

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