Statement of Verification

EU Environmental Technology
Verification pilot programme

ETA DANMARK

DANETV

Technology:	Root zone container for oil treatment
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1. Technology description

The product is a vertical flow type root zone container with Phragmites australis/communis with an active treatment area of 1.25 m2 (Figure 1). Oil sludge/wastewater is added to it in batches, and water leaving the container is collected in an outlet tank for treated water. Midway through the addition of batches, outlet water is recirculated for additional treatment and collected in the outlet tank again, before the outlet tank is emptied at the end of a treatment cycle.

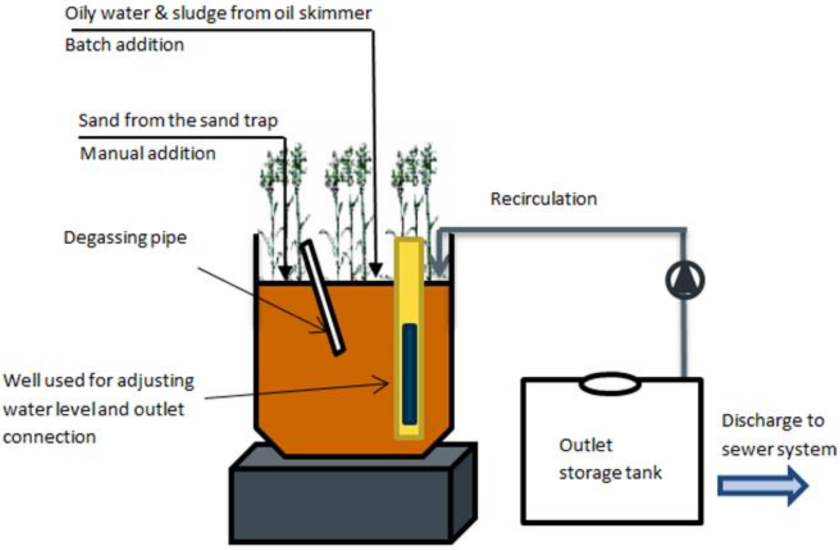

Figure 1: Principle of root zone container for oil treatment. Sketch by DHI.

2. Application

2.1. Matrix

The matrix for verification is oil sludge and wastewater contaminated with oil retrieved when oil skimmers or sand traps at petrol stations are emptied.

2.2. Purpose

The purpose of the root zone technology is the removal of oil constituents in oil sludge and in wastewater contaminated with oil.

2.3. Conditions of operation and use

Water and sludge is collected from oil skimmers and a sand trap. Water contaminated with oil is pumped into an inlet water tank (once a month). From the tank, batches of water are pumped to the surface of the root zone filter at intervals (daily). Solid material from the sand trap is collected separately, drained and added manually to the filter. The treated water is recirculated over the root zone filter. Submersible pumps are used in the inlet and outlet water tank.

2.4. Verification parameters definition summary

Transform’s claims were as follows:

- 80% reduction of oil load in water (based on inlet and outlet water concentration and inlet and outlet water volume, regardless internal recirculation).
- 90% reduction of dry matter sludge, based on dry matter load in inlet water accumulated over the test period as well as added remaining dry matter in sludge layer on top of the root zone after the test period (Figure 2). The 90% reduction refer to the total added dry matter compared to the total discharged dry matter.

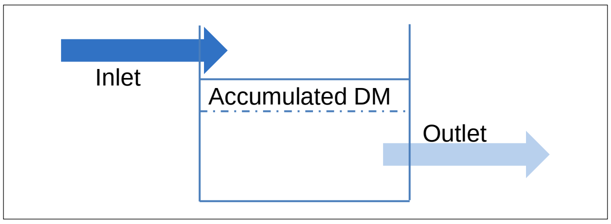

Figure 2: Claim on reduction/retention of dry matter.

According to the Danish regulatory requirements regarding industrial wastewater for discharge to public sewer, the content of mineral oil must be < 20 mg/l.

For BTEX (benzene, toluene, ethylbenzenes and xylenes), phenols and PAHs, a target value of < 1 µg/l is applied for this verification.

The Biochemical Oxygen Demand (BOD_5) requirement for rootzone systems discharging treated sanitary wastewater to the environment is < 30 mg O_2/l in the outlet or > 90% removal.

3. Test and analysis design

3.1. Existing and new data

No existing data were accepted for the verification.

3.2. Laboratory or field conditions

One root zone container was placed at a petrol station with a carwash facility, located in Isterød, Rudersdal municipality, in the North Zealand area of Denmark. The rootzone was loaded with water and sludge collected from oil skimmers and a sand trap. The test period covered one full climatic cycle, and meteorological conditions as well as soil temperature were monitored. During the winter 2015/16, the root zone was frozen solid, and loading with wastewater and sludge had to be suspended.

3.3. Matrix compositions

The oil content in the collected wastewater and sludge varied between the sampling days. The carwash sand trap contained a large fraction of sand. The dry matter in the added sand/sludge was therefore dominated by a mineral fraction, which does not degrade.

3.4. Test and analysis parameters

The following tests parameters were investigated (Table 1)

<table>
<tr><th>Performance parameters</th><th>Operational parameters</th></tr>
<tr><td rowspan="3">Mineral oil concentration in influent, water to be recirculated and effluent
Mineral oil content in accumulated sediment and filter material
Reduction of oil content as mass balance
Retention of dry matter
BOD_5 concentration in influent, water to be recirculated and effluent
BTEX in in influent, water to be recirculated and effluent
Phenols concentration in influent, water to be recirculated and effluent
PAHs in influent, water to be recirculated and effluent</td><td>Volumes, pH, conductivity, temperature, odour</td></tr>
<tr><th>Environmental parameters</th></tr>
<tr><td>Covered by performance parameters</td></tr>
</table>

Table 1: Test and analysis parameters overview

3.5. Tests and analysis methods summary

Analyses were performed at an external laboratory. The choice of methods for each parameter is summarised in the section below. The 95% confidence interval (CI) of the mass removal ratio in the water was calculated as the square root of the sum of the relative variances.

3.6. Parameters measured

Table 2 gives an overview of the parameters analysed by an external laboratory.

Parameter	Method
Biochemical Oxygen Demand (BOD_5)	DS/EN 1899-1
Mineral oil	ISO 9377-2, with fractions C6-C10, >C10-C15, >C15-C20, >C20-C35
Dry matter	Danish Standard 204, 1980.
BTEX (benzene, toluene, ethylbenzenes and xylenes)	GC-MS
Phenols	GC-MS
PAHs	GC-MS

Table 2: Overview of parameters analysed

4. Verification results

4.1. Performance parameters

Reduction of oil load in water, retention of dry matter and degradation of oil in the system

The inlet and discharge concentrations of mineral oil are shown in Figure 3. The mass removal of mineral oil from water was on average > 88% (95% CI ± 20%). Transform's claim was 80%.

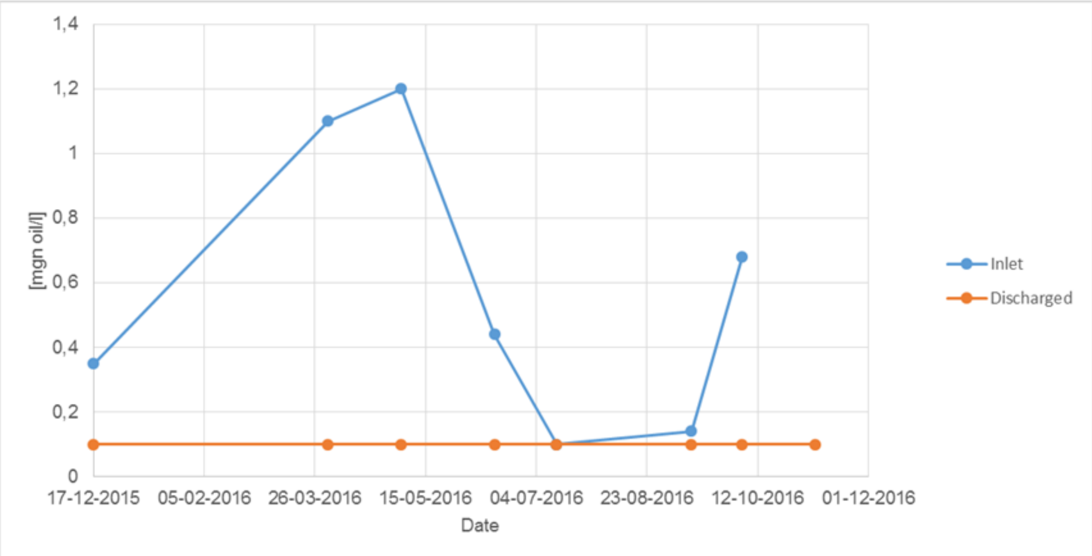

Figure 3: Inlet and outlet concentrations of mineral oil. Discharge at the limit of detection.

Due to accumulation of sand in the rootzone, the total reduction of dry matter in the rootzone was not determined (deviation 11). Instead, the retention of dry matter was calculated. The rootzone retained 99% (95% CI, 6%).

Overall, 11% (95% CI ± 39%) of the mineral oil was estimated to have been degraded by the filter at the end of the test (based on dry matter measured in added sand/sludge). The expanded relative uncertainty of the determination of mineral oil is 30%. Hence, the estimated removal ratio is within the analytical variation.

Reduction of mineral oil and oil-related contaminants from the water

The detected inlet concentrations of mineral oil in water varied between below the limit of detection of (0.1 mg/l) and 1.2 mg/l. Discharge concentrations of mineral oil were below the limit of detection of 0.1 mg/l at all times. The maximum permissible value for discharge of industrial wastewater to a sewer is < 20 mg/l of mineral oil.

Inlet concentrations of BTEX in the water phase varied widely, from below the limit of detection (< 0.02 µg/l) to 105 µg/l. Discharge concentrations of BTEX were below the limit of detection, except on two occasions where the concentration of xylenes was 0.043 µg/l. Discharge concentrations were well below the target value of 1 µg/l.

Phenols and methyl-phenols in the inlet varied from below the detection limit to 320 µg/l and 17 µg/l, respectively. In the discharge water, phenols and methyl-phenols were below the limit of detection (0.02 µg/l) at all times.

The PAH concentration in the inlet was highest in the beginning of the test period (sum of PAHs 4.5 µg/l to 7.8 µg/l June-November 2015). The PAHs were dominated by naphthalene and phenanthrene. Later the sum of PAH in the inlet was below 1 µg/l or below the limit of detection (0.01 µg/l for the individual PAHs).

PAHs were rarely detected in the discharge water. On one occasion, naphthalene was found at a concentration of 0.01 µg/l, and acenaphtylene was found at a concentration of 0.11 µg/l. The legal requirement for inland water quality is 2.4 µg/l for naphthalene and 1.3 µg/l for acenaphtylene. The detected concentrations were well below these concentrations and also below the verification target value of 1 µg/l.

Reduction of BOD5

The average concentration of BOD5 in inlet water was 54 mg/l. The outlet concentrations were below 8 mg/l, except on one sampling day where the concentration was 35 mg/l (Figure 4). On that occasion, there were only 50 L of water left in the outlet tank, and homogenization of the water caused a re-suspension of the tank sediment. The calculated mass removal ratio over the test period was 97% (95% CI, ± 7%). The verification target value for BOD5 is < 30 mg/l, or >90% removal.

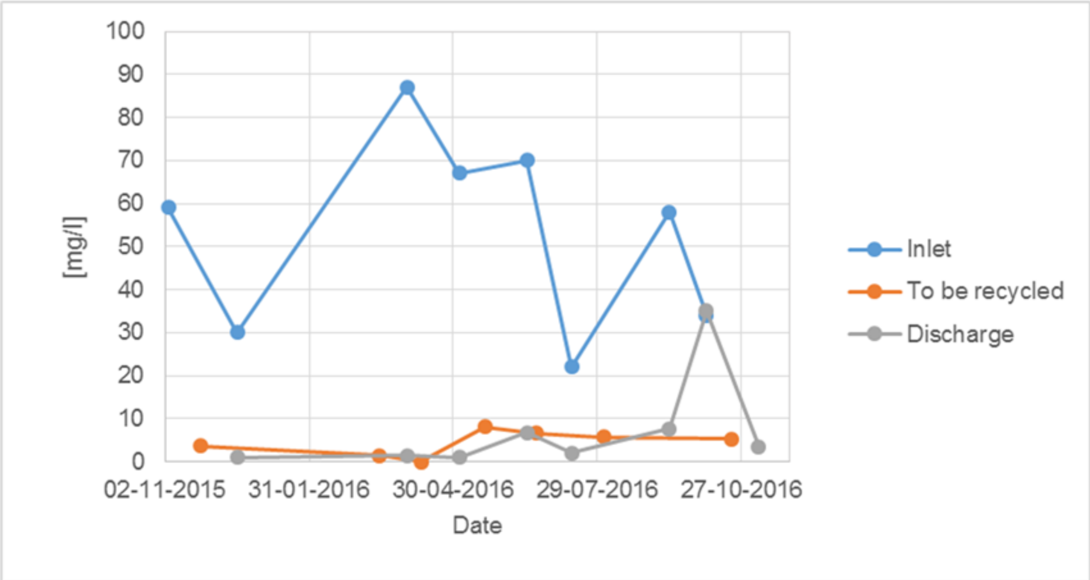

Figure 4: Concentration of BOD5 in inlet water, water to be recycled and outlet water.

4.2. Operational parameters

Operational conditions during the tests are reported in the Test Report.

4.3. Environmental parameters

The main environmental parameter is the effluent quality, and it is reported among the performance parameters.

4.4. Additional parameters (with comments or caveats where appropriate)

The operating instructions only provide a brief overview of the technology and its operation. The operating instructions are therefore insufficient for a client to operate and maintain the system on their own. Particularly, there is no description of the removal and disposal of accumulated sludge. It is part of Transform's concept that their root zone systems are delivered and installed by Transform and that a service contract for maintenance of the system is agreed upon with the client.

5. Additional information

The sediment accumulated on top of the filter material needs to be removed after some time of operation. According to Transform, removal of accumulated sediment will be necessary after 4 to 5 years if there is sand in the sediment, otherwise after approximately 25 years. A sediment layer of 20-30 cm will be removed, after which the plants will produce new shoots.

During the verification test (June 2015-November 2016), a significant layer of sediment accumulated on top of the filter material. The average thickness of the layer was 16 cm. At the rate of accumulation observed during the test, the sediment would have to be removed after 2-3 years of operation.

According to Transform, sediment with sand must be sent to a facility for cleaning contaminated soil. Sediment without sand can be treated by incineration, high-temperature composting or landfilling. The method of choice will depend on the content of contaminants in the sediment. At the end of the root zone container's life, the filter material should be analysed for contaminants and sent to soil cleaning for reuse, incineration or landfilling.

Winter conditions may require the user to stop loading the system, in case the root zone is frozen solid. A large fraction of sand in the sediment may lead to accelerated build-up of sediment on top of the filter material, which needs to be removed and disposed of.

Lack of control and maintenance may lead to deteriorated plant health and treatment efficacy. Pump failure may lead to interruption of the treatment. Leakage of the root zone system may cause infiltration of contaminated water into the ground and needs to be prevented reliably.

6. Quality assurance and deviations

The verification was carried out according to the Quality Assurance Plan described in the verification protocol. During testing, internal and external audits were carried out by DHI and ETA Danmark, respectively.

There were twelve deviations to the specific verification protocol and test plan (see Verification report). Most deviations were of practical nature, such as a damage to the rootzone container during delivery (had to be mended), weather conditions (winter), the consistency of the sediment and difficulties pumping it.

Deviation no. 11 affected the calculation of a performance parameter. The specified method of calculation of reduction of dry matter did not take into consideration the accumulated layer of sand from the sand trap in the rootzone. Consequently, the retention of dry matter was calculated instead. There is no legal requirement for reduction or retention of dry matter.

None of the deviations were considered to have significant impact on the verification.