
Installation of submerged drains (Jan van den Akker)

Submerged drains (Netherlands)

Onderwaterdrains (NL)

DESCRIPTION

Submerged drains are drains installed in grassland on peatsoils with the aims to decrease soil subsidence and emission of CO2 and N2O due to the oxidation of peat soil, and to maintain suitable groundwater levels in fields for grassland production and grazing.

Contrary to usual drains, submerged drains are installed below ditchwater level. Submerged drains diminish the differences between ditch level and groundwater level in the fields by enabling the infiltration from ditch to field and the drainage from field to ditch.
In summer and dry periods the infiltration from ditch to field is much lower than the evapotranspiration of the grass, resulting in a lowering of the groundwater level some decimetres below ditch water level. With submerged drains the groundwater level is lowered less drastically because infiltration from ditch to field is improved. In winter and wet periods, fields are drained more quickly compared to conventional drainage.

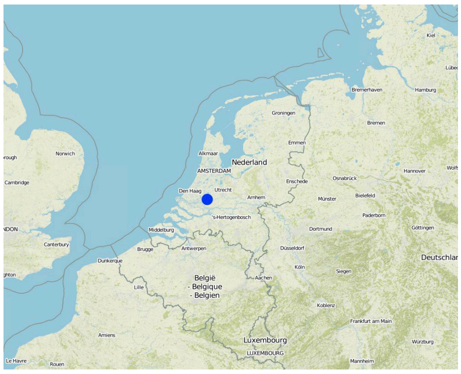
Purpose of the Technology: Submerged drains diminish the differences between ditch level and groundwater level in the fields by enabling the infiltration from ditch to field and the drainage from field to ditch. Under peak rainfall events groundwater levels become less high and remain at high levels for shorter times than in fields without submerged drains.
Due to the increased groundwater level in summer the decomposition of the peat soil is reduced. As a result, the rate of soil subsidence is decreased and also the emission of greenhouse gases and of N and P released to the surface water.

Establishment / maintenance activities and inputs: The installation of submerged drains is done with common drainage installation machines. Submerged drains should be installed between 15 and 25 cm below the ditch water level, and between 45 and 75 cm below the soil surface. The drain pipes should have a diameter of at least 6 cm. The distance between drains is at most 6 m. Drain length is at most 300 m. Submerged drains can be installed in the length or width direction of a field. Drains must be installed level.

Natural / human environment: Submerged drains were designed for peat soils under permanent pasture for dairy farming. More than 70 % of Dutch peat soils are under this land use. Drainage of these peat soils results in subsidence, mainly by decomposition (oxidation) of the peat (partly by shrinkage and consolidation). This is an ongoing process, because every 10 to 15 year ditchwater levels are adapted to the lowered surface in order to enable dairy farming and to prevent the conversion to wetlands. Soil subsidence causes several problems: decreased suitability for grazing and grassland farming, increased flood risk, emission of greenhouse gases, damage to infrastructure (dikes, roads, foundations, sewerage networks) and increased cost of water management.

Submerged drains were tested with a network of practitioners and 10 dairy farmers in the Dutch peat soil area between 2011 and 2013 on an area of 20 ha.

LOCATION



Location: Krimpenerwaard, The Netherlands/Province of Zuid-Holland, Netherlands

No. of Technology sites analysed:

Geo-reference of selected sites
- 4.72384, 51.94813

Spread of the Technology: evenly spread over an area (0.054 km²)

In a permanently protected area?:

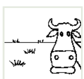
Date of implementation: less than 10 years ago (recently)

Type of introduction
- [ ] through land users' innovation
- [ ] as part of a traditional system (> 50 years)
- [x] during experiments/ research
- [x] through projects/ external interventions
- [x] stimulated by regional authorities

CLASSIFICATION OF THE TECHNOLOGY

Main purpose
- [ ] improve production
- [ ] reduce, prevent, restore land degradation
- [ ] conserve ecosystem

Land use



Grazing land
- Improved pastures

- [ ] protect a watershed/ downstream areas – in combination with other Technologies
- [ ] preserve/ improve biodiversity
- [ ] reduce risk of disasters
- [ ] adapt to climate change/ extremes and its impacts
- [ ] mitigate climate change and its impacts
- [ ] create beneficial economic impact
- [ ] create beneficial social impact

Water supply

- [x] rainfed
- [ ] mixed rainfed-irrigated
- [ ] full irrigation

Purpose related to land degradation

- [ ] prevent land degradation
- [x] reduce land degradation
- [ ] restore/ rehabilitate severely degraded land
- [ ] adapt to land degradation
- [ ] not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

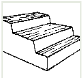
physical soil deterioration - Pw: waterlogging, Ps: subsidence of organic soils, settling of soil

water degradation - Hg: change in groundwater/aquifer level, Hp: decline of surface water quality

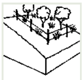
SLM group

- water diversion and drainage
- ground water management

SLM measures



structural measures - S4: Level ditches, pits



management measures - M7: Others

TECHNICAL DRAWING

Technical specifications

The picture shows a cross section through an agricultural field, bounded by two ditches. A submerged drain (yellow bar in the picture) is installed at 80 cm below the soil surface. It ends in the ditch on the left side at 20 cm below the water level in the ditch. The dotted line indicates the position of the groundwater table in the situation without the submerged drain; the continuous blue line indicates the position in the situation where the submerged drain is installed. The lines show that in summer the groundwater level is raised to nearly the level of the ditch water by the submerged drain, whereas the level would be approximately 30 cm lower without the drain.
In winter, in the situation with the submerged drain, the groundwater level is around 40 cm below the soil surface. This enables the farmer to use the field for grazing or to traffic the field. However, in the situation without the drain, the groundwater level nearly reaches the soil surface in the centre of the field, impeding traffic or grazing on the field.

Technical knowledge required for field staff / advisors: moderate (Estimates of economic benefits due to increased grass production and grazing periods vary between years with meteorological conditions.)

Technical knowledge required for land users: moderate (Specific conditions apply to the dimensions and positioning of submerged drains in the fields. Level position and lebgth are critical.)

Technical knowledge required for companies installing the drains: moderate (Specific conditions apply to the dimensions and positioning of submerged drains in the fields. Level position and lebgth are critical. Soil must have sufficient bearing capacity during installation.)

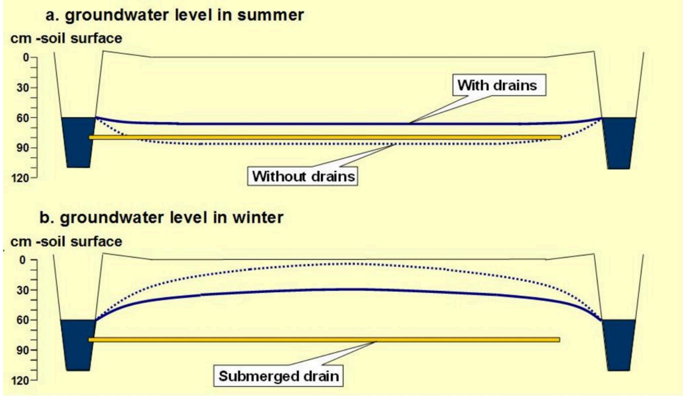
Technical knowledge required for water board: moderate (submerged drains increase the water supply and discharge from groundwater level management units. Additional pumping effort can be prevented by informed water level management.)

Technical knowledge required for researchers: (the implications of submerged drains on the water management in an entire management unit should be explored using coupled hydraulic and rainfall-runoff models.)

Main technical functions: improvement of topsoil structure (compaction), maintaining soil organic matter

Secondary technical functions: increase of infiltration, increase / maintain water stored in soil, drainage of excess rainfall

Other type of management: Maintaining high groundwater levels.



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ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated:
- Currency used for cost calculation: **euro**
- Exchange rate (to USD): 1 USD = 1.09 euro
- Average wage cost of hired labour per day: n.a

Most important factors affecting the costs

We do not have information on specific cost items, only on establishment costs ad between 1500 and 1800 euro/ha, and annual cost of 117 €/ha incl maintenance, assuming a 20-year life time. Establishment costs can also be expressed per m of drain, i.e. 1.10 EURO per m including materials (drain of 6 cm diameter). Determinate factors include size and geometry of fields; installation in the length direction is cheaper, and results in fewer outlets in the receiving ditch.

Establishment activities

1. maintenance of drains and outlet in ditch (Timing/ frequency: None)
2. installation of submerged drains (Timing/ frequency: in dry periods)

Establishment inputs and costs

Specify input	Unit	Quantity	Costs per Unit (euro)	Total costs per input (euro)	% of costs borne by land users
Labour					
maintenance of drains and outlet in ditch	ha	1.0	30.14	30.14	100.0
installation of submerged drains	ha	1.0	1980.0	1980.0	100.0
Total costs for establishment of the Technology				**2'010.14**	
Total costs for establishment of the Technology in USD				*1'844.17*	

Maintenance activities

1. maintenance of submerged drains (Timing/ frequency: several times in lifetime of drains (30 y))

Maintenance inputs and costs

Specify input	Unit	Quantity	Costs per Unit (euro)	Total costs per input (euro)	% of costs borne by land users
Other					
Annual cost incl maintenance	ha	1.0	127.0	127.0	100.0
Total costs for maintenance of the Technology				**127.0**	
Total costs for maintenance of the Technology in USD				*116.51*	

NATURAL ENVIRONMENT

Average annual rainfall

- [ ] < 250 mm
- [ ] 251-500 mm
- [ ] 501-750 mm
- [x] 751-1,000 mm
- [ ] 1,001-1,500 mm
- [ ] 1,501-2,000 mm
- [ ] 2,001-3,000 mm
- [ ] 3,001-4,000 mm
- [ ] > 4,000 mm

Agro-climatic zone

- [x] humid
- [x] sub-humid
- [ ] semi-arid
- [ ] arid

Specifications on climate

Distribution of rainfall over the year: 23% (winter), 19% (spring), 27% (summer) and 31% (autumn)

Thermal climate class: temperate

Slope

- [x] flat (0-2%)
- [ ] gentle (3-5%)
- [ ] moderate (6-10%)
- [ ] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

Landforms

- [x] plateau/plains
- [ ] ridges
- [ ] mountain slopes
- [ ] hill slopes
- [ ] footslopes
- [ ] valley floors

Altitude

- [x] 0-100 m a.s.l.
- [ ] 101-500 m a.s.l.
- [ ] 501-1,000 m a.s.l.
- [ ] 1,001-1,500 m a.s.l.
- [ ] 1,501-2,000 m a.s.l.
- [ ] 2,001-2,500 m a.s.l.
- [ ] 2,501-3,000 m a.s.l.
- [ ] 3,001-4,000 m a.s.l.
- [ ] > 4,000 m a.s.l.

Technology is applied in

- [ ] convex situations
- [ ] concave situations
- [ ] not relevant

Soil depth

- [ ] very shallow (0-20 cm)
- [x] shallow (21-50 cm)
- [ ] moderately deep (51-80 cm)
- [ ] deep (81-120 cm)
- [x] very deep (> 120 cm)

Soil texture (topsoil)

- [ ] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [x] fine/ heavy (clay)

Soil texture (> 20 cm below surface)

- [ ] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Topsoil organic matter content

- [x] high (>3%)
- [ ] medium (1-3%)
- [ ] low (<1%)

Groundwater table

- [ ] on surface
- [x] < 5 m
- [ ] 5-50 m
- [ ] > 50 m

Availability of surface water

- [ ] excess
- [x] good
- [ ] medium
- [ ] poor/ none

Water quality (untreated)

- [ ] good drinking water
- [ ] poor drinking water (treatment required)
- [x] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to:

Is salinity a problem?

- [ ] Ja
- [ ] Nee

Occurrence of flooding

- [ ] Ja
- [ ] Nee

Species diversity

- [ ] high
- [x] medium
- [ ] low

Habitat diversity

- [ ] high
- [ ] medium
- [ ] low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation

- [ ] subsistence (self-supply)
- [ ] mixed (subsistence/ commercial)
- [x] commercial/ market

Off-farm income

- [x] less than 10% of all income
- [ ] 10-50% of all income
- [ ] > 50% of all income

Relative level of wealth

- [ ] very poor
- [ ] poor
- [x] average
- [ ] rich
- [ ] very rich

Level of mechanization

- [ ] manual work
- [ ] animal traction
- [ ] mechanized/ motorized

Sedentary or nomadic

- [ ] Sedentary
- [ ] Semi-nomadic
- [ ] Nomadic

Individuals or groups

- [x] individual/ household
- [ ] groups/ community
- [ ] cooperative
- [ ] employee (company, government)

Gender

- [ ] women
- [ ] men

Age

- [ ] children
- [ ] youth
- [ ] middle-aged
- [ ] elderly

Area used per household

- [ ] < 0.5 ha
- [ ] 0.5-1 ha

Scale

- [ ] small-scale
- [ ] medium-scale

Land ownership

- [ ] state
- [ ] company

Land use rights

- [ ] open access (unorganized)
- [ ] communal (organized)

- 1-2 ha
- 2-5 ha
- 5-15 ha
- 15-50 ha
- ✓ 50-100 ha
- 100-500 ha
- 500-1,000 ha
- 1,000-10,000 ha
- > 10,000 ha

- large-scale

- communal/ village
- group
- individual, not titled
- ✓ individual, titled

- leased
- ✓ individual

Water use rights

- open access (unorganized)
- communal (organized)
- ✓ leased
- individual

Access to services and infrastructure

health	poor / good (✓ good)
education	poor / good (✓ good)
technical assistance	poor / good (✓ good)
employment (e.g. off-farm)	poor / good (✓ good)
markets	poor / good (✓ good)
energy	poor / good (✓ good)
roads and transport	poor / good (✓ good)
drinking water and sanitation	poor / good (✓ good)
financial services	poor / good (✓ good)

IMPACTS

Socio-economic impacts

fodder production

decreased / increased (✓ middle)

Quantity before SLM: 10.7-12.4 tons DM/ha11575
Quantity after SLM: 9.8-12.4 ton DM/ha10975
Net grass yields (DM) measured on experimental plots. May slightly decrease due to SMD, but less loss due to trampling, increased length of grazing season. This delivers 500 kg DM/ha extra fodder produced and 30 extra grazing days.
But also loss possible: From 11575 kg DM/ha to 10975 kg DM/ha Decrease in grass yield is possible between 3 and 9%. This does not take into account losses due to tramping in situation without drains and longer grazing season under SMD.

risk of production failure

increased / decreased (✓)

SMD enable a longer grazing season, increased bearing capacity and reduced risk of flooding of fields

expenses on agricultural inputs

increased / decreased (✓)

reduced additional feedstock; benefits of extra grass yields and grazing days amount to 171 euro/ha

farm income

decreased / increased (✓)

net benefits of installing SMD are approx. 54 euro per ha per year

workload

increased / decreased (✓)

trafficability and workability of fielfds improved due to drier topsoil conditions and increased bearing capacity

inlet and drainage of water

None / None (✓)

SMD require an increased inlet and drainage of water in the ditches by the water board, increased pumping hours: 10-22% in dry years; 7-12% in wet years.
Inlet: extra 36-86 mm/y in dry years, 19-45 mm in wet years
Drainage: 17-59 mm in dry years; 33-60 in wet year

Socio-cultural impacts

community institutions

weakened / strengthened (✓)

Community of Practice on SMD in peat soils enabled knowledge transfer between land users, research insttitutes, farmer's association and authorities

national institutions

weakened / strengthened (✓)

The CoP has informed water boards and provinces in the part of The Netherlands with problems due to soil subsidence

Improved livelihoods and human well-being

decreased / increased (✓)

The long-term experiments in The Netherlands, pilots and activities of the farmers organisation LO Nederland, the Veenweide Informatie Centrum and the Community of Practice Submerged Drainage on Peat soils have increased the understanding of participating farmers of submerged drainage, the water accounting of their land, soil and soil quality. Tjey acquired practical knowledge on the implementation of the technology. Participating farmers continue to exchange knowledge and intend to extend the area under SMD. As a result of the pilots and the activities of the Community of Practice, interest for submerged drainage was raised among other dairy farmers, policy makers and authorities.

Ecological impacts

water quality

decreased — increased

slight decrease of export of N, P and SO4 to the surface water

excess water drainage

reduced — improved

SMD increased drainage by 20-65 mm per year in 2011 and 2012

soil moisture

decreased — increased

SMD increased infiltration by 8-93 mm per year in 2011 and 2012

soil compaction

increased — reduced

decreased soil subsidence to 50% (reductions of 3-6 and 5-8 mm/year)

animal diversity

decreased — increased

no direct impact on breeding conditions for meadow birds

emission of carbon and greenhouse gases

increased — decreased

decreased GHG emissions in CO2 eq: 6.8-13.5 t/ha per year (pilot Keulevaart) and 11.3-18.1 (pilot Demmeriksekade)

Hazard towards adverse events

improved — reduced

quicker lowering of groundwater table after extreme rainfall events (1-5 days)

Water management

harder — easier

More easy water management in polders: Fewer sub-polders with fixed ditch water level; possibility to create areas with high and low surface levels

Off-site impacts

damage on public/ private infrastructure

increased — reduced

reduced costs of infrastructure protection (30% or 3.5 M€/year until 2100 in the Frisian peat meadow area)

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns — very negative — very positive

Long-term returns — very negative — very positive

Benefits compared with maintenance costs

Short-term returns — very negative — very positive

Long-term returns — very negative — very positive

A longer grazing season and the extra yield of fodder are the basis for a viable implementation of submerged drainage for land users. The CBA considers establishment and maintenance costs together: establishment costs of € 1800,-/ha, discounted over 20 years, including maintenance, result in annual cost of € 117,-/ha (6.5% of the investment). Benefits include 500 kg DM/ha extra grass use and 30 extra grazing days. This would yield € 171/ha, resulting in a net saldo of € 54,-. In addition SMD are an investment in sustainable soil management, resulting in an increased economic value of the land in the long term.

CLIMATE CHANGE

Gradual climate change

annual temperature increase — not well at all — very well

Climate-related extremes (disasters)

local rainstorm — not well at all — very well

local windstorm — not well at all — very well

drought — not well at all — very well — Answer: not known

general (river) flood — not well at all — very well

Other climate-related consequences

reduced growing period — not well at all — very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- [ ] single cases/ experimental
- [ ] 1-10%
- [ ] 11-50%
- [ ] > 50%

Number of households and/ or area covered

13

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- [ ] 0-10%
- [ ] 11-50%
- [ ] 51-90%
- [x] 91-100%

Has the Technology been modified recently to adapt to changing conditions?

- [ ] Ja
- [ ] Nee

To which changing conditions?

- [ ] climatic change/ extremes
- [ ] changing markets
- [ ] labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Submerged drains increase the number of days with a good bearing capacity of grassland, and therefore enable a longer grazing season and less trampling of grass.
- Higher effective yield in total.
- Short term: slightly cost effective. Long term: good cost effective.

Strengths: compiler’s or other key resource person’s view

- Submerged drains allow a strong reduction of soil subsidence and GHG emissions (at least 50%, even >50% if combined with higher ditch water levels).

  How can they be sustained / enhanced? Further implementation by dairy farmers in the peat-meadow area. For this purpose the Community of Practice is recommended, as well as the arrangement of subsidies and the active involvement of regional government and water board. This applies to all mentioned advantages.
- The quality of surface water in ditches will slightly improve.
- Less problems with difference between subsiding soil surfaces and constant water levels in lakes and high water ditches (along houses).
- Less sub-polders with a certain fixed ditch water level, and possibility to create areas with a high surface level (with submerged drains) and a low surface level (without SD).

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Grass yield is lower due to reduced mineralization of nitrogen. Yield could be increased due to better usage of manure (better NUE). On the other hand yield is increased due to increased number of days with a good bearing capacity of grassland, and a longer grazing season and less trampling of grass.

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s viewhow to overcome

- Submerged drains require more inlet water to polders. Reduction of inlet requirement is possible by smart water management. This implies water level margins of +/- 10 cm and the use of weather forecasting.
- Submerged drains require a bit more pumping to drain water under extreme rain events.

REFERENCES

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Full description in the WOCAT database
https://qcat.wocat.net/af/wocat/technologies/view/technologies_1704/

Linked SLM data
n.a.

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Project
- Preventing and Remediating degradation of soils in Europe through Land Care (EU-RECARE)

Key references
- Several reports on submerged drainage are available from Alterra, Wageningen UR (in Dutch). The report used for this WOCAT QT is:Effecten van onderwaterdrains in peilvak 9 van polder Groot-Wilnis Vinkeveen : modelstudie naar de effecten van onderwaterdrains op maaivelddaling, waterbeheer, wateroverlast en waterkwaliteit in peilvak 9 Author(s)Hendriks, R.F.A.; Akker, J.J.H. van den; Jansen, P.C.; Massop, H.Th.L. SourceWageningen : Alterra Wageningen UR, 2014 (Alterra-rapport 2480) - p. 124Other literature (in Dutch): Waarheen met het veen. Woestenberg, M. 2009. Uitgeverij Landwerk and Alterra, Wageningen URhttp://www.levenmetwater.nl/static/media/files/Boek_wmhv_def.pdf: Alterra Reports are available atlibrary.wur.nl