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# Diminishing peat oxidation of agricultural peat soils by infiltration via submerged drains

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**Abstract**
Oxidation of peat soils used in dairy farming in the western peat area of The Netherlands causes subsidence rates up to 13 mm.$y^{-1}$ and emissions of $CO_2$ to about 27 t.$ha^{-1}$.$y^{-1}$. In 2003 experiments started with subsurface irrigation by submerged drains to raise groundwater levels to reduce oxidation and so subsidence and GHG emissions. Subsidence and so $CO_2$ emissions were reduced with at least 50% and the trafficability improved. The advantages of submerged drains for dairy farmers beside the reduction of subsidence are the improved trafficability, reduced drought risk and reduced loss of grass yield in wet periods by trampling. This makes for dairy farmers the use of submerged drains an acceptable solution in contrary to the often suggested solution to raise ditchwater levels. This acceptance by dairy farmers makes submerged drains a promising tool to preserve the valued cultural historic peat soil landscape.
*Keywords: peat soils, subsidence, oxidation, submerged drains, GHG emissions, climate addaptation*

**Extended Abstract**

## Introduction, scope and main objectives

About 9% of the area of the Netherlands is covered by peat soils (about 290,000 ha), mainly drained and in use for dairy farming (about 223,000 ha). Peat soils in the densely inhabited western part of the Netherlands are valued as an open landscape with a rich cultural history, which should be preserved. About 40 years ago a strong modernization and mechanization of dairy farming started. This required improvement of drainage conditions and bearing capacity of peat soils in agricultural use and therefore in large areas ditchwater levels were lowered several decimeters. The lowering of ditchwater levels caused a strong increase of subsidence of the peat soils. The major part of peat soils in the western part of the Netherlands is in use as permanent pasture with ditchwater levels up to 60 cm minus surface. Organic soils above groundwater level are exposed to the air and decompose. This causes a subsidence of 8 – 12 mm per year and emission of greenhouse gasses, mainly $CO_2$. Subsidence of one centimeter per year equates to an emission of about 22 tons of $CO_2$ per hectare per year (Van den Akker et al., 2008). Van den Akker et al. (2008) calculated an emission of 4.25 Mtonne $CO_2$ per year for the agricultural peat soils in the Netherlands. Per ha this is about 19 tonne $CO_2$ per year. The total $CO_2$ emission per year by oxidation of peat soils in agricultural use is about 2.5 % of the national anthropological $CO_2$ emission of the Netherlands.
In the Netherlands every 10 years ditchwater levels are lowered about 10 cm and so adapted to the subsidence. However, in this way also groundwater levels are lowered about 10 cm. In time the upper part of wooden foundation piles are exposed to oxygen and start to rot. In this way subsidence causes damage to infrastructure and buildings. Because the subsidence is not the same everywhere, water management becomes ever more complex and expensive. Many wetlands become difficult to preserve as "wetland" because subsidence of adjacent drained agricultural land results in 'islands of peat' surrounded by lower elevation agricultural lands. The higher wetlands drain towards the lower agricultural land, become too

[1] Van den Akker, J.J.H., R.F.A. Hendriks, 2017. Diminishing peat oxidation of agricultural peat soils by infiltration via submerged drains. FAO 2017. Proceedings of the Global Symposium on Soil Organic Carbon 2017. Food and Agriculture Organization of the United Nations. Rome, Italy. pp. 436-439. http://www.fao.org/documents/card/en/c/d6555d8d-1b19-4c04-a25d-74474e6c0a11/

dry and degrade. In a time with rising sea levels, it is also not wise to allow subsidence rates of one cm per year.
The problems caused by subsidence of peat soils together with the increasing interest in GHG emissions and eutrofication of surface waters by degrading peat soil was reason to start in 2003 the EU funded project EUROPEAT (QLK5-CT-2002-01835) with the aim to identify degradation processes of agricultural peat lands and find ways to diminish peat land degradation (Van den Akker et al., 2008, Van den Akker, 2010). Research on infiltration of ditchwater via submerged drains to raise groundwater levels in summer to conserve peat land started end of 2003 in the EUROPEAT project. The aim was to halve subsidence and $CO_2$ emission in this way.
In this paper we focus on the measurements of subsidence, and so indirect on $CO_2$ emission and on the expected extra supply of inlet water due to the improved infiltration by submerged drains.

## Methodology

To test whether subsurface irrigation with drainage tubes (see Figure 1) will indeed reduce subsidence and so emission of $CO_2$ of peat soils, we started in autumn 2003 with installing submerged drains on two parcels (Zegveld 2 and Zegveld 3) on a fen peat soil without a thin clay cover. Distances between the drains were 4, 8 and 12 meter. As a reference in a part of the parcels no drains were installed. On Zegveld 3 we monitor already from 1970 on the surface level of the reference part of the parcel. The long term subsidence of Zegveld 3 is 10.8 mm per year. The ditchwater level is 55 cm below the surface level.

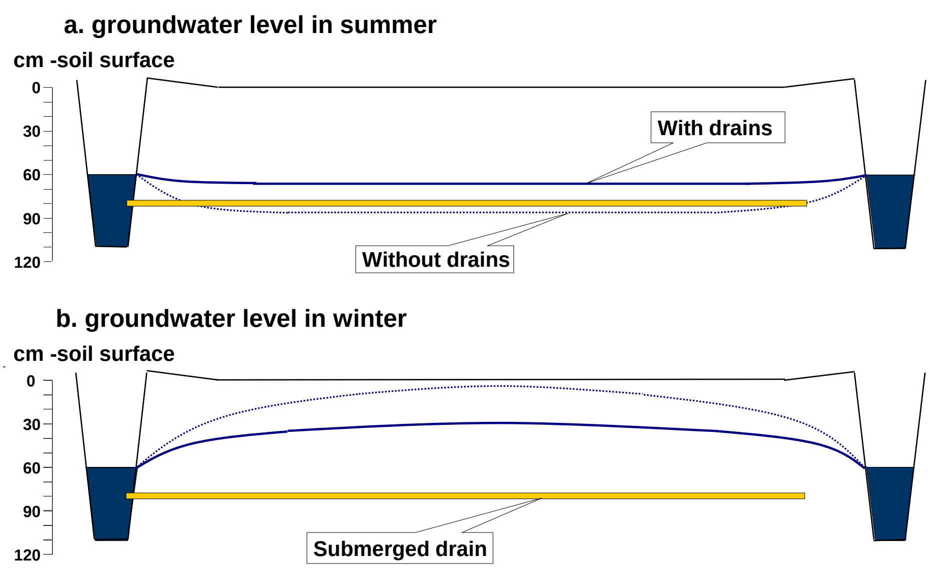


**Fig. 1: Reduction of peat oxidation and subsidence and $CO_2$-emissions by raising groundwater levels with infiltration via submerged drains in summer level. In wet periods the submerged drains will function as drainage.**

Starting in early spring 2004 the surface level was measured in three cross sections. In the reference the distance between the cross sections was 10 m. In the plots with submerged drains the cross sections were situated in the middle between two submerged drains. The measurements were performed in early spring, just before the grass starts to grow and to evaporate soil water. At that moment the swell of the peat is at his maximum. In this way we avoid as much as possible that we measure subsidence due to temporally drying shrinkage of the peat, which can be more than 10 cm at the end of a dry summer.

## Results

The results of Zegveld 3 are presented in Figure 2. The subsidence in the period 2004 – 2015 is strongly influenced by the fact that 2003 was a very dry year and that the summers in the period 2004 – 2015 were all moderately or very wet. This means that the soil was not completely rewetted and swollen in spring 2004 and had a potential of swelling in the following moderately or very wet years. These specific circumstances resulted in a subsidence rate of the reference of just 5.2 mm per year, while the long term subsidence is 10.8 mm. The effect of the large swelling potential after the dry year 2003 becomes also clear in the situation with drains at a distance of 4 meter: the subsidence rate is just 2.5 mm per year and in spring 2008, after the very wet year 2007, the level of the soil surface is even higher than in spring 2004. It is clear that the subsidence rate of the reference is about twice the subsidence rate of the parcel area with drains at distances of 4 meter.

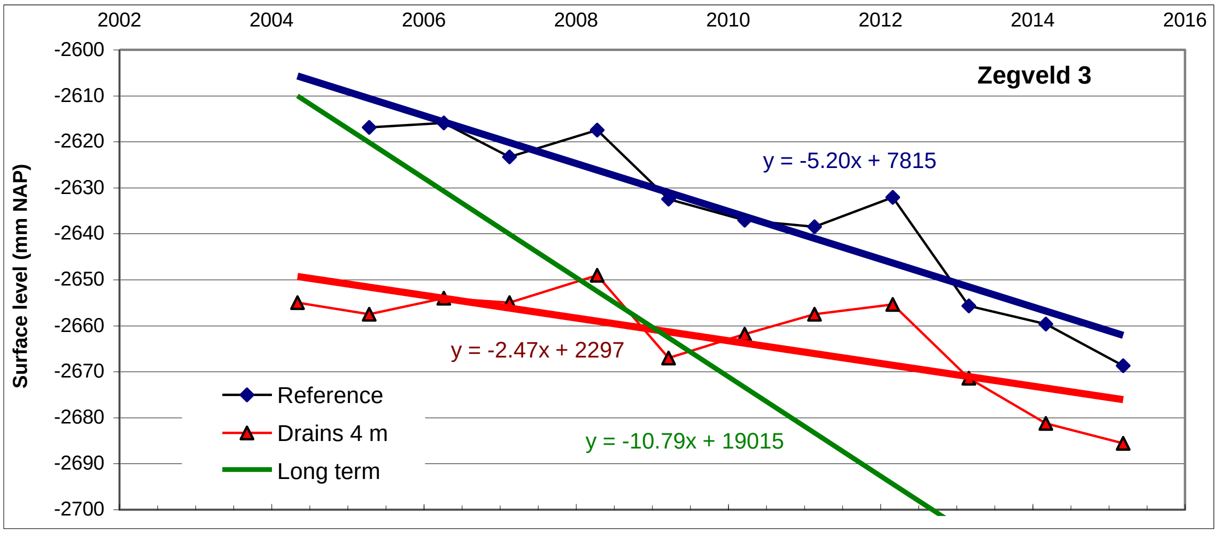


**Fig. 2: Subsidence 2004 – 2015 of peat soil without submerged drains (Reference) and with submerged drains at a distance of 4 meters (Drains 4 m). The long term subsidence is 10.8 mm per year. NAP = the Dutch national reference level, which is about the average sea water level.**

## Discussion

The effect of the very dry year 2003 and the wet summers of 2004 – 2015 on the subsidence rate is pronounced and requires a longer period of monitoring. In fact we would like to include some very dry years because then we expect to benefit most from the infiltration of ditchwater to reduce peat oxidation. Nevertheless the results are convincing and the use of submerged drains to minimize subsidence is promising because even without dry years the subsidence is halved. This makes it rather sure that the aim to halve the subsidence and $CO_2$ emission can be fulfilled.

The PBL Netherlands Environmental Assessment Agency investigated in a recent report (Van den Born et al., 2017) possible measures to reduce subsidence and $CO_2$-emissions. The study shows that subsurface irrigation by submerged drains in agricultural areas leads to a halving of subsidence without exerting negative effects on grass yields. The measure preserves agricultural features and improves the outlook for dairy farming on peatland. This measure is at the moment directly suitable for at least 40% of the peatlands and is an economical feasible measure for the dairyfarmers and for the society as a whole. The measure is also appropriate for areas with deeper ditchwater levels if ditch water levels are raised. In that case peat oxidation can be reduced to about a quarter of the original oxidation, while the drainage function of the submerged drains prevent that the peatland becomes too wet.

Farmers are firmly opposing the often suggested raising of ditchwater levels, however, are positive about the use of submerged drains for subsurface irrigation. Raising ditchwater level reduces trafficability and increases the risk of trampling by cows, while the use of submerged drains has the opposite effect. Farmers also appreciate the fact that the use of submerged drains makes farm management easier and reduces the problems in case of long wet periods. Therefore we have good hope that submerged drains will be widely adopted in practice.

## Conclusions

The use of submerged drains can reduce peat oxidation and subsidence and $CO_2$-emissions of peatlands in agricultural landuse with at least 50%.
The fact that the use of submerged drains is an acceptable solution for dairy farmers and no landuse change is required makes the introduction of the measure relatively easy.

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