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VALUE-ADDING OF REWETTED FEN PEATLANDS USING THEIR PURIFICATION POTENTIAL WITH RESPECT TO SURFACE WATER

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SUMMARY

Within an extended research project, a non-cultivated fen peatland site is ponded by treated waste water mixed with surface water, and the additional purification activity due to the anaerobic conditions and high carbon content of the peat is studied with respect to eco-toxicological substances. If a positive effect should be observed, a value-adding of the peatlands could be considered, (1) with respect to water quality improvement in surface waters, and (2) for biomass production. The special site conditions are affected by high sulfate concentrations in soil and groundwater. These conditions should be taken into the further investigations as possible constraints for an enhanced microbial decay.

Keywords: Hydrology, sulfate, waste water treatment, water protection

INTRODUCTION

A joint research project, started in 2011, is focused on the matter recycling on the regional scale. Under the slogan of “zero emission management”, new methods for phosphorus recycling and treated waste water usage are under consideration (Schaefer et al., 2011). Methods for a mass flux management will be tested for two regions – the suburban area of Berlin (capital of Germany), and the rural Uckermark region (State of Brandenburg), both northeast of Berlin. Two aspects are relevant: water and soil protection, as well as value-adding of recycled mass flux.

For the fen peatlands in the glacial northeast German river valleys like the Randow-Welse valley we consider the combination of a sustainable usage of fen areas with biomass production (either reed or wood). Precondition is the coverage of the water budget, since for this region the water budget in the vegetation period is negative (Dietrich et al., 2000; Dannowski and Balla, 2002). Furthermore, rewetted fen peatlands could be integrated into water protection purposes for the supplemental purification of treated waste water. This is of specific interest since worldwide investigations have shown the impact of toxic substances, e.g. pharmaceutical and personal care products (so called emergent pollutants), on fish fertility in running water systems (Ternes et al., 1999). We hypothesize that with an application of treated waste water on rewetted peat sites the anaerobic decay potential increases due to both, high organic matter in the peat as well as a prolonged residence time during the groundwater passage as shown in Fig.1.

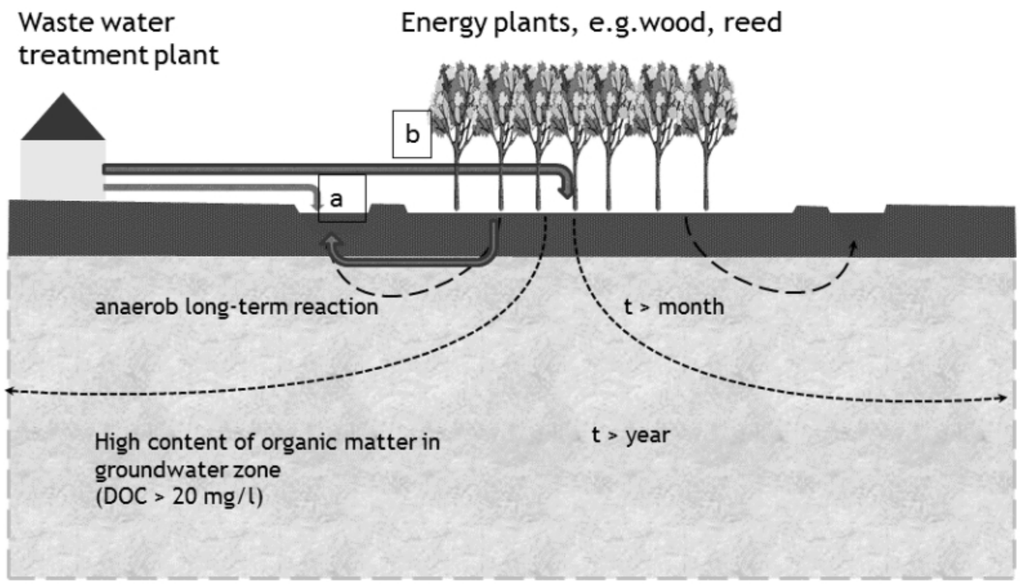

Fig.1. Principle scheme for the inclusion of rewetted fen sites into value-adding chains, as well as additional cleaning stage for waste water treatment, a – common practice for the utilization of treated waste water (as quickly as possible into the running water system), b – hypothesized bypass flux using the anaerobic peat layer and long travel times t (more than months or years) passing the groundwater body into the receiving surface water.

The realization of this idea strongly depends on the proof of harmlessness for the groundwater. In order to preventively protect groundwater bodies from hazardous substances, the EU Water Framework Directive (WFD), and the regulations subsequently introduced at the national level allow the utilization of treated waste water only in very limited volumes and only at sites with a deep groundwater level. This excludes fen peat sites characterized by shallow groundwater level.

Hence, our investigations are focused on the proof of environmental compatibility with respect to groundwater protection, regarding the 33 priority substances listed in the EU-WFD (Directive 2008/105/EC, Annex I). In the project, investigations are performed as field tests and as eco-toxicological tests in soil columns. In this study, we only consider the field investigations. The Biesenbrow site was previously rewetted with supplemental water from 1996 to 2002. From 2002 to 2011 the site was abandoned and intensified peat mineralization began. Before re-starting the irrigation with treated waste water in the new project, a review of the situation was performed. Our intention is also to deal with the site's abiotic aspects after losing the rewetting status.

MATERIALS AND METHODS

The Biesenbrow site (8 ha) in the Randow-Welse valley (Uckermark) consists of fen peat up to 120 cm in thickness which in former time was drained/sub-irrigated and under intensive agricultural use. The peat layer is discontinuously underlain by muds. The aquifer is formed by sand and gravel with high permeability and thickness. Because of the negative water balance in summer time, supplemental water pumped from the surrounding channel system is necessary to be given upon the surface for rewetting and stabilizing high water table (Dannowski et al., 2000). Channel water is elevated into an intermediate pond system and distributed by pipes into the area (Fig.2). Before rewetting, the area was planted with *Phragmites australis* and several *Carex* varieties. During the rewetting period 1996-2002, an abiotic monitoring of soil parameters, ground- and surface water chemistry was performed (Balla et al., 2004). After 2002, water table control was not continued and hence, the site was not permanently wet. Before starting the new rewetting phase in 2011 with additional use of treated waste water, the vegetation was mown by a crop chopper, and biomass analyses (9 plots; each 0.36 m^2) and a GPS-based topographical survey in a 50 m x 50 m raster were performed. Furthermore, the status quo of soil and groundwater chemistry was provided.

Rewetting with mixed water is limited to the vegetation period April - October. To cover the water demand of the rewetted site (now reduced to 5 ha) as well as to avoid any contamination with toxic substances, the treated waste water is mixed with surface water (1:10). Soil plots combined with groundwater monitoring wells in three depths (2, 4, 6 m) were installed to monitor peat soil parameters inclusive ecotoxicological tests, to screen the groundwater quality with regard to hazardous substances before and after the application period, respectively monthly for heavy metals, cations and anions. Between the soil surface and the upper groundwater layer, mini-piezometers for the extraction of soil solution were set up. Analyses of treated waste water, surface water and groundwater with respect to hazardous substances are performed by the cooperation partners, Berliner Wasserbetriebe, and the Federal Institute of Hydrology. Ecotoxicological investigations are performed by ECT Oekotoxikologie. To determine the residence time in groundwater and the potential solute distribution beyond the rewetted site, the flow and transport patterns will be modeled in a vertical cross section by the finite element Model FEFLOW (DHI-WASY). To calibrate and validate the model, the temperature distribution and thermodynamic parameters at channel bottom are measured and the water flux from the rewetted site to the surrounding channels is determined (Maassen and Balla, 2010). The investigations started in 2011 and will be continued to 2013. As an outcome, an ecotoxicological guidline will be developed for the utilization of treated waste water in rewetted fen peatlands with respect to groundwater protection according to the EU-WFD.

PRELIMINARY RESULTS AND DISCUSSION

Status quo of the post-rewetting area

In comparison of the geodetic survey before rewetting in 1995, in 2011 the area has lost in average of all measurement points 6.6 cm in height, with minimum of 0 and maximum of 18 cm (Fig.2). The elevation differences are heterogeneously distributed. The spatial distribution of the mud, the microrelief, as well as differences in peat thickness and hence, differences in the capillary rise and soil moisture status are possible factors for those variable intensities of peat mineralization. Related to the 16 years without cultivation (no fertilizer, no biomass removal), the loss in elevation is approximately 0.4 cm per year. This is definitely less than 1 cm which is the experienced mineralization rate for the regional conditions (Zeitz 1997) and can be attributed mostly to the very wet and potentially peat accumulating period between 1996 and 2002. Assuming as a minimum no loss during the rewetting phase, in the post-rewetting phase the loss would amount to 0.7 cm per year. Moreover, the above-ground *Phragmites* (and sedges) biomass of 20 t/ha determined in early 2011 had stored 9.7 t/ha C and 0.29 t/ha N, which substantiates former results (Koppitz and Buddrus, 2004).

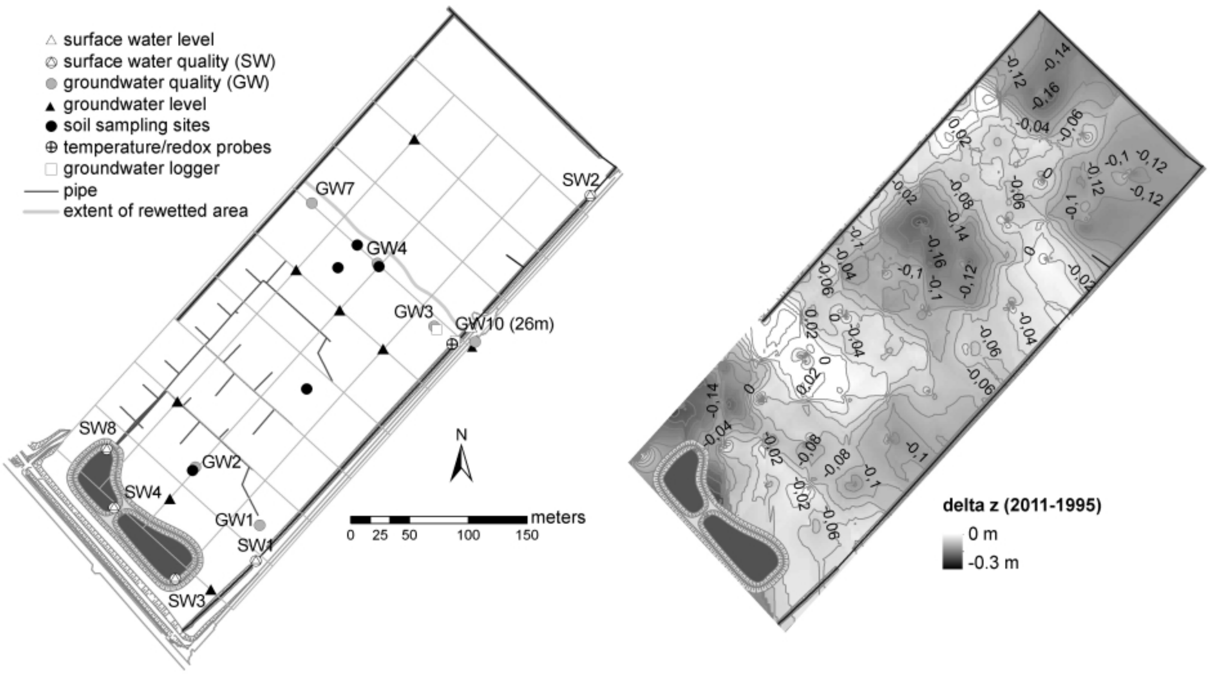

Fig.2. (Left) Biesenbrow research and pilot site for testing the applicability of treated waste water in rewetted fen peatlands with monitoring equipments. For research purposes, the treated waste water of the WWTP Passow (3100 equivalents) is mixed with surface water in the pond system and distributed over the peat surface by pipes after passing the ponds. (Right) Changes of surface elevation delta z during the time period 1995 – 2011.

The water chemistry of the monitored groundwater wells showed a significant increase of sulfate concentration (SO_4) as well as a decrease of soluble phosphorus (SRP) and dissolved organic carbon (DOC) during the last ten years (Fig.3). The chloride concentration (Cl) is nearly constant. The obvious rise of sulfate is most likely attributed to peat mineralization and the release of soil bound sulfur, whereas the trends of the other parameters might be a result of the regional mineralized[1] groundwater seeping again through the peat area. When rewetting by pumping was abandoned, the groundwater table of the research plot, which was higher compared to the surrounding area, ceased and no local groundwater body was formed. This influenced the site-specific groundwater dynamics and streamlines.

[1] There is a well-known mineral anomaly in groundwater in the north-western reach of the location whose chemical composition will be subject to further analysis.

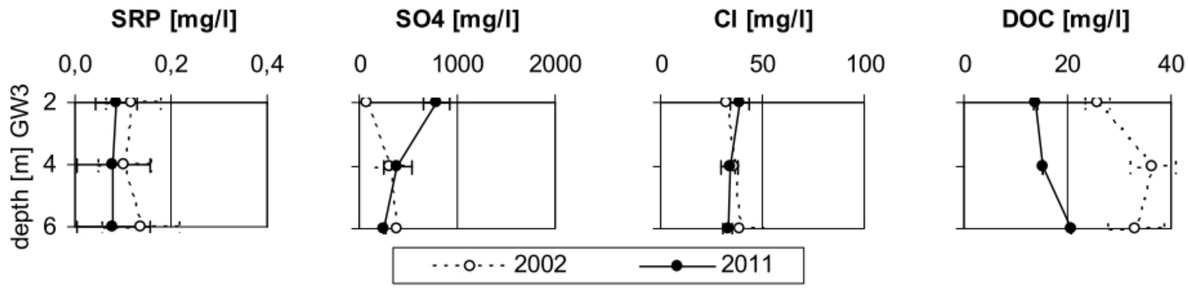

Fig.3. Changes in groundwater chemistry after the 10-years post-rewetting phase for a selected groundwater monitoring wells in different depths.

Treated waste water usage

In general, after 3-month irrigation with 400 m^3 of treated waste water and 5000 m^3 of surface water pumped from the channel in 2011, no adverse effects on the underlying groundwater body have been found. It is obvious that the time is too short yet for well-founded proofs. But some conclusions are formulated for the further monitoring program. The treated waste water of the rural area shows 'hot spots' in the concentration of the pharmaceuticals Diclophenac and Carbomacepin as well as the flame retardant Tris-(chlorisopropyl)phosphate, which are known to be persistent substances. To prevent enrichment in the groundwater, these parameters will be monitored in 2 m depth in shorter time intervals (14 days). It is assumed that in this carbon-rich peat layer anaerobic decay could prevail. Another question to be answered is whether the observed high sulfate concentrations could lead to higher production of toxic hydrogen sulfide and therefore reduce overall microbial activity (Aesoy et al., 1998).

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