



# Phosphorus binding forms in fens influenced by degree of peat decomposition

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## Summary

Due to a possible increasing release of phosphorus (P) in fens after re-wetting it is important to characterize different inorganic and organic P binding forms in peat substrates.

Labile P, redox-sensitive P and P adsorbed to metal oxides are the inorganic P forms that could be released from the fen peat substrate by re-wetting.

In peat soil samples with different degrees of peat decomposition (DPD) a sequential extraction method was carried out for the detection of P binding forms in fens. The samples have been taken from fens in north-eastern Germany represented by different environmental conditions.

In peat soil samples with completely humification the P concentration in each fraction is higher than in poorly humified peat. For P releases after re-wetting, completely humified horizons are decisive because they have been changed pedogenetically.

**Key index words:** fens, humification, peat type, re-wetting, sequential extraction

## Introduction

Huge areas of fens in north-eastern Germany have been drained over several decades. Anaerobic and saturated conditions with peat conservation changed into an aerobic environment with humification and mineralisation of the peat. Structural damages of the peat body have been occurred (Veltj *et al.*, 2006; Zeitz and Veltj, 2002).

Kyoto Protocol and European Water Framework Directive promote the regeneration of fens. Many degraded fens have been re-wetted.

Re-wetting can be often accompanied by a release of P due to changes in the redox potential of P-adherent chemical elements (Paludan, 1995; Gelbrecht and Koppisch 2001; Gelbrecht *et al.*, 2003). Especially, the reductive dissolution of Fe(III)- and Mn(IV)-oxyhydroxides is likely to be a significant mechanism for P release by re-wetting, because P is strongly bound to these elements.

The sequential extraction of P in peat soil samples provides additional information about the potential mobility of P under different environmental conditions. The determination of P binding forms in peat substrates will help to understand the mechanisms of P release in fens after re-wetting and P release potentials may be estimated prospectively. For these objectives inorganic P binding forms are determined in fens by sequential extraction and related to the DPD.

## Materials and Methods

### *Peat type and degree of peat decomposition*

Reed peat, sedge peat, wood peat and mixed peat with different DPD have been chosen as representative peat types in fens of north-eastern Germany. Fens with both aerobic and anaerobic conditions have been selected.

The selection of the DPD was done with the help of a decomposition scheme after von Post (1924; von Post and Granlund, 1926) divided into a ten-class scale. Higher numbers indicate stronger peat decomposition.

### *Phosphorus fractionation*

The sequential extraction method after Psenner *et al.* (1984), originally used for the detection of P binding forms in lake sediments (Jensen and Thamdrup, 1993; Hupfer, 1995; Paludan and Jensen, 1995; Lewandowski, 2002), was applied. This method was adapted to take account to the special properties of peat (Jordan *et al.*, 2007).

The fractionation was carried out on field fresh peat samples with replications as soon as possible after collection, since drying induces oxidation of the peat and leads to irreversible changes in the fractional composition.

Each peat sample (5 g into a 25 ml centrifugation tube) was extracted sequentially into three fractions representing different P binding forms (Table 1).



**Table 1.** Fractionation scheme (the three extraction steps with fraction, extraction solvent and P binding form; BD = Bidithionite, SRP = soluble reactive phosphorus, TP = total phosphorus).

Fraction	Extraction solvent	P binding form
NH <sub>4</sub> Cl-TP	1 M NH <sub>4</sub> Cl	labile, loosely bound or adsorbed P; immediately available
BD-TP	0,1 M NaHCO <sub>3</sub> -Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub> -Solution	redox-sensitive P, mainly from Fe(III)- and Mn(IV)-oxyhydroxide surfaces
HCl-SRP	0,5 M HCl	P adsorbed to metal oxides (Al-, Fe- and Mn-bound P); apatit-P and P bound in carbonates

P concentration in the extracts and TP were detected photometrically (at  $\lambda = 680$  nm) using a modified Molybdenum Blue Method after Murphy & Riley (1962).

## Results and Discussion

For profiles with completely saturated horizons (except the upper horizon) in fens a relationship between P binding form concentrations and DPD has been found for labile P (Fig. 1), redox-sensitive P (Fig. 2) and metal oxide bound P (Fig. 3).

In fen profiles with non-saturated or saturated, but former aerobic horizons the relationship between P binding form concentrations and DPD is weak (Fig. 4...6). For one sedge peat profile with three horizons of different DPD the concentration of metal oxide bound P was nearly similar (Fig. 6).

Jordan *et al.* (2007) found in all investigated peat samples highest labile P concentrations in poorly humified peat samples and figured out that with increasing DPD the concentration of labile P decreases. They also presented that the concentrations of redox-sensitive and metal oxide bound P increases with increasing DPD.

In the present study such a relationship between P binding form concentrations and DPD could only be found for a few investigated peat samples. Different environmental conditions (aerobic/anaerobic milieu) influence to a strong extent the relationship between P binding form concentrations and DPD. Thus, these sampling site conditions

have to take into special consideration for the interpretation of the measured values. We suppose that for the peat sampling and the following analytics the seasonality is also an important indicator that should not be neglected. In any case, for a P release after re-wetting a drained peat soil in fens, completely humified horizons have to be taken into account because they have been changed pedogenetically.

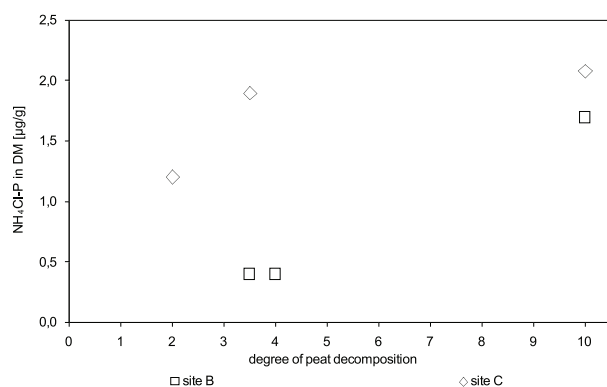
For the interpretation of a qualified correlation of the P fractions organic and refractory bound as well as total P and metals will be analysed in a next step. Additionally, peat soil samples taken from a fen at different seasons will be completely fractionated.

## Acknowledgements

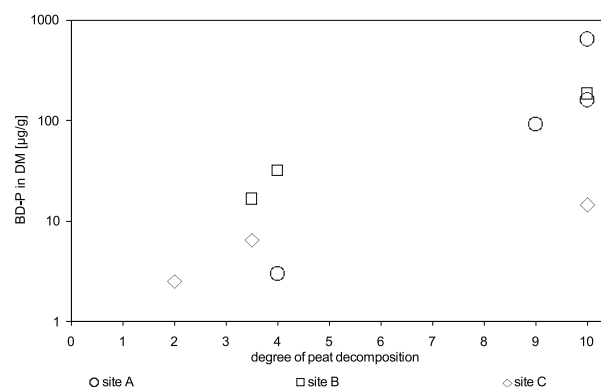
We thank the Central Laboratory Analytics (Humboldt Universität zu Berlin) for the support of the chemical analyses, Jörg Gelbrecht and Dominik Zak (Central Chemical Laboratory at the Leibniz-Institute for Fresh Water Ecology and Fishery) for interesting discussions. Research is financially supported by the Deutsche Bundesstiftung Umwelt (DBU) within the scholarship programme.

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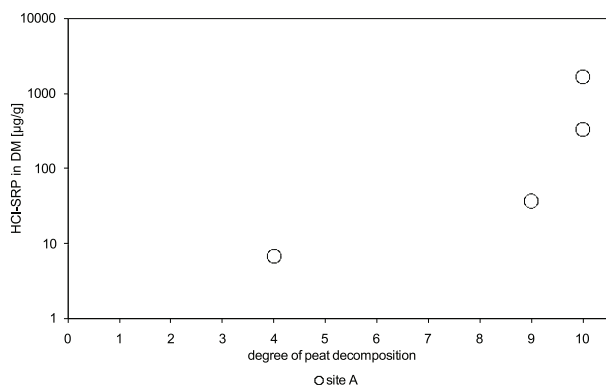
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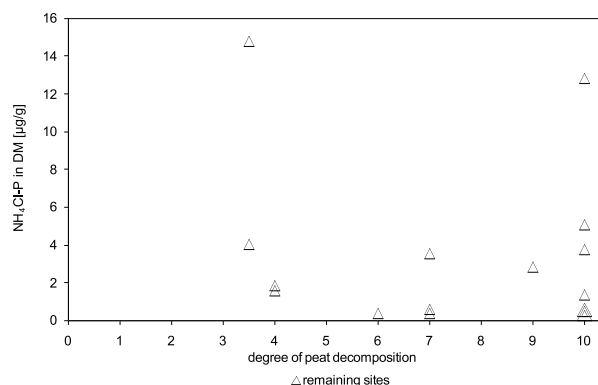
**Figure 1.** Relationship between labile P (NH<sub>4</sub>Cl-P) and degree of peat decomposition in peat samples (n = 6) from site B (Moor am Saefkowsee / Müritz-Nationalpark) and C (Hakenberg / Rhinluch). DM = dry matter.



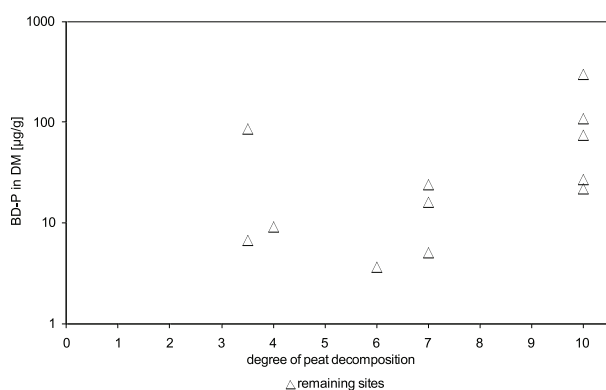
**Figure 2.** Relationship between redox-sensitive P (BD-P) and degree of peat decomposition in peat samples (n = 10) from site A (Rohrbruch / Barnim), B (Moor am Saefkowsee / Müritz-Nationalpark) and C (Hakenberg / Rhinluch). DM = dry matter.



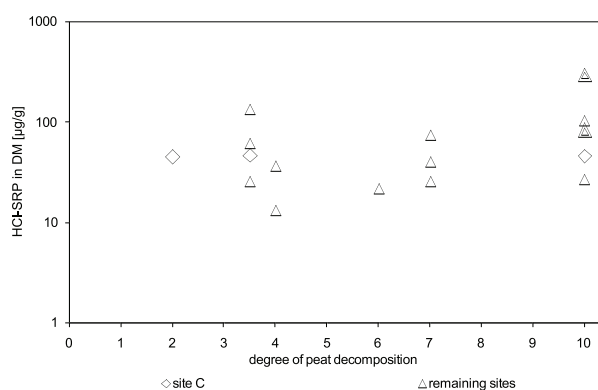
**Figure 3.** Relationship between metal oxide bound P (HCl-SRP) and degree of peat decomposition in peat samples ( $n = 4$ ) from site A (Rohrbruch / Barnim). DM = dry matter.



**Figure 4.** Labile P ( $\text{NH}_4\text{Cl-P}$ ) and degree of peat decomposition in peat samples ( $n = 16$ ) from remaining sites. DM = dry matter.



**Figure 5.** Redox-sensitive P (BD-P) and degree of peat decomposition in peat samples ( $n = 12$ ) from remaining sites. DM = dry matter.



**Figure 6.** Metal oxide bound P (HCl-SRP) and degree of peat decomposition in peat samples ( $n = 18$ ) from site C (Hakenberg / Rhinluch) and remaining sites. DM = dry matter.

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