PREFERENTIAL FLOW IN WATER REPELLENT PEAT-MOORSH SOIL AS A CONSTRAINT IN REWETTING DRAINED FENS

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Abstract: The main objective of this study was to investigate the influence of water repellence in the experimental site Wykowo, located within Kuwasy drainage and sub-irrigation system. Research on the peat-moorsh soils took place at the Biebrza River Valley. The variability of soil moisture and dry bulk density was studied with intensive sampling on transects. The persistence and degree of water repellence was examined with water drop penetration time (WDPT) and alcohol percentage tests. The highest repellence was reported in the alder peat. The effect of soil moisture content on water drop penetration time was analysed. The research showed a dependence of water repellence on soil water content. The observed patterns in soil moisture in the field were very variable and showed the existence of dry soil areas, located just above the layer with the highest water repellence. The existence of the water repellent layer can have negative influence on capillary rise, infiltration and retention and therefore acts as a constraint in the restoration of drained peatlands by rewetting.

Introduction

Human activities, consisting of draining wetlands and adapting them for agricultural production have contributed to the degradation and significant reduction of provision of the environmental services of peatlands. Degradation of peat soils is mainly associated with mineralization, which is accompanied by the release of carbon dioxide and nitrogen, and deterioration in water retention properties, for example an increase in hydrophobicity. An identification of cause-effect relationship is the basis for good environmental governance of hydrogenic habitats. Wettability is one of the most important characteristics of the soil that directly influences their physical, mechanical, chemical, biological and fertility properties. Water repellent soils display a reduction in infiltration, which may cause accelerated runoff and erosion and reduce plant establishment and growth. Water repellence of soil has also hydrological effects: considerable variation in soil water content and irregular moisture patterns. Moisture variability may be related to the accumulation and migration of biogenic gases in peat soils. Therefore, the objective of the present study was to assess the variability of soil moisture content over short distance in peat-moorsh soil and to relate the observed irregular wetting patterns to soil water repellence.

Materials and methods

The variation in soil water content was studied at Wykowo experimental site located within Kuwasy drainage and sub-irrigation system in the Biebrza River Valley, Poland. The site was used as an extensive meadow. Volumetric water content was determined by sampling the soil profile at different depths using steel cylinders (volume 100 cm³ and height 5 cm). Thirty-one samples were taken from each depth: 5-10, 15-20, 25-30, and 45-50 cm, at close intervals along transects of 300 cm length. The soil was sampled at two different dates. Moisture content of each sample was determined by gravimetric method in the laboratory.
The effects of soil moisture on water repellence were determined using WDPT test: water drop penetration time test (Watson and Letey 1970). Additional samples (in tree replications) were taken from the following soil horizons: 0-10, 10-40, 40-50 and 50-80 cm. The samples were water saturated in the laboratory by placing them on saturated sandbox for about four weeks. During the drying of soil samples daily measurements of mass and WDPT were performed. After about three weeks soil samples were dried in the oven at 105°C in order to measure their final dry weight.

**Results and discussion**

The influence of soil moisture content on WDPT of peat-moorsh soil from Wykowo experimental site is presented in Figure 1. In this figure, the classes of water repellence proposed by Dekker And Jungerius (1990) were depicted. The following five classes of water repellence can be distinguished: wettable or non-water repellent (WDPT < 5 s), slightly (5-60 s), strongly (60-600 s), severely (600-3600 s), and extremely water-repellent (>3600 s). Also values of moisture content corresponding with field capacity (pF=2.0), wilting point (pF=2.7), and permanent wilting point (pF=4.2) were marked. On this figure it can be seen that WDPT is very sensitive to soil water content changes.

### Table 1. Properties of peat–moorsh soil profile (Mt III cb) at Wykowo experimental site

<table>
<thead>
<tr>
<th>Depth [cm]</th>
<th>Ash content [% a.d.m.]</th>
<th>Bulk density [g cm⁻³]</th>
<th>Porosity [% vol.]</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>16.0</td>
<td>0.338</td>
<td>79.5</td>
<td>turf layer</td>
</tr>
<tr>
<td>10-40</td>
<td>15.3</td>
<td>0.270</td>
<td>83.7</td>
<td>moorsh layer</td>
</tr>
<tr>
<td>40-50</td>
<td>11.8</td>
<td>0.156</td>
<td>90.2</td>
<td>alder peat R3</td>
</tr>
<tr>
<td>50-80</td>
<td>11.8</td>
<td>0.127</td>
<td>92.2</td>
<td>reed peat R3</td>
</tr>
</tbody>
</table>

*Table 1.* Properties of peat–moorsh soil profile (Mt III cb) at Wykowo experimental site

![Figure 1](https://www.ser.org/europe/show/2010/2010-images/2010-01-01/2010-01-01-Figure1.jpg)

**Figure 1.** Dependence of water repellency on soil-water content at different depths.
All considered soils represented the range between almost non-repellent at saturated soil moisture content and a rapidly increasing repellence with decreasing water content. The maximum values of WDPT occurred in dry samples in turf and moorsh layers. In the case of alder peat layer (40-50 cm) and reed peat layer (50-80) - the peak in WDPT function of soil water content was observed. The highest value of WDPT occurred for moisture content equal to permanent wilting point or at value slightly lower. Under the field conditions of Wykowo experimental site, where moisture content of peat-moorsh soil seldom decrease below permanent wilting point the turf layer can be classified as non-water repellent, moorsh layer as slightly repellent and alder peat layer as strongly repellent.

Figure 2 shows the spatial distribution of the volumetric moisture content and dry bulk density measured during two sampling dates. Contour plots of moisture and bulk density distributions were obtained using kriging method with Surfer package. The soil moisture profile on September 11th showed vertically oriented pattern at depths between 10 and 30 cm, whereas the bulk density distribution showed horizontally oriented pattern. The isolated dry soil bodies at the depth interval 10-30 cm with soil water content less than 40 % were detected. During the second sampling date, the soil became wetter, however the vertical moisture pattern was still observed. This can be explained by the presence of strongly repellent soil layer (at depth of 40-50 cm), which restricted capillary rise from groundwater to upper layers in the soil profile. The irregular spatial distribution of volumetric moisture content in the soil is typical for soils in which preferential water flow occurs (Ritsema et al. 1993). Repellence can significant influence the restoration of water dynamics in peat-moorsh soil profiles. Consequences of soil water repellence include undesirable effects such as reduced water infiltration, increased surface run-off, leading in some cases to nutrient losses, reduction in plants growth, leaching of agrochemicals and increased soil erosion (Wallis and Horne, 1992, Jordán at el. 2013). Environmental conditions will become much more dynamic as a result of climate change (Goebel at el. 2011). Awareness about the importance of spatial process in the soil and connectivity in the landscape can contribute to more effective restoration.

![Figure 2. Contour plots showing the spatial distribution of the volumetric soil water content and bulk density for two measurements dates.](image)
Conclusions

Water repellence measured by WDPT test is extremely depended on soil water content and in some soil layers in the peat-moorsh soils the maximum value was observed at the moisture content corresponding to permanent wilting point (or slightly lower). The observed soil moisture patterns in the field were very variable and showed the existence of dry soil areas, located just above the layer with the highest water repellence. The existence of the water repellent layer can have negative effect on soil moisture content because of reduction of the amount of water supplied from groundwater by capillary rise, reduction of infiltration from the soil surface and for soil water retention. Therefore water repellent soil layer act as a constraint in the restoration of drained peatlands by rewetting.

Acknowledgements

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References