The influence of secondary transformed peat-moorsh soils on the quantity of chemical compounds of ground water

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Summary

A 4.5 km transect a drainage ditch in peatland located on secondary transformed organic soils (peat – moorsh soils) was studied in relation to purification of ground water flowing through it. The peatland is a landscape element in the Agroecological Landscape Park in Turew, 40 km South-West of Poznań, West Polish Lowland. The investigation revealed marked effects of the peatland on total nitrogen, ammonium, and nitrate concentrations as well as total and dissolved organic carbon in ground water. Peatland decreased the concentrations of the following compounds: nitrates by 38.5%, N-organic by 10%, N-total by 24.5%, ammonium by 38.7%, dissolved total carbon by 33.1%, dissolved total inorganic carbon by 10%, and dissolved organic carbon by 57.5%.

Key index words: forms of organic carbon, forms of nitrogen, secondary transformation of peat

Introduction

Degradation of water quality by non-point source inputs is not a recent phenomenon, but visibility of effects has increased because of greater regulatory, public and research awareness of this pollution source. More recently, the impact of nitrogen, phosphorus, oxygen demand, microbial species, and other materials on non-point source pollution has received attention. This attention coincides with success in reducing point source inputs to receiving waters, resulting in greater emphasis on evaluation and control of non-point sources. For the control of non-point sources information is required on the phenomena resulting from rainfall-runoff and other diverse water movement processes responsible for transporting pollutions (Howard-Williams and Downes 1993).

In agricultural landscapes with high levels of fertilization in cultivated fields, the elements of the landscape which can protect water bodies against eutrophication are of particular importance. Various plant cover structures such as peatlands, grasslands, stretches of meadow, hedges, shelterbelts, and riparian vegetation strips, are of special interest. However, it is most important from the point of view of ecological engineering that the biogeochemical barriers exert controlling effects on non-point pollution. Peatlands belong to the stable elements in the landscape, which restrain soil erosion, improve microclimate for agricultural production, regulate the water regime in soils, and create refuge sites for wildlife (Belkevitch 1962; Fuchsman 1986; Ilnicki 2002; Szajdak 2002). Mechanisms responsible for these processes are still elusive, but it is generally assumed that the following processes are important: plant uptake and ion exchange capacities (Szajdak *et al.,* 2002; Życzyńska-Bałoniak *et al.,* 2005).

The goal of this study was to investigate the influence of peatland located in an agricultural landscape on selected inorganic and organic components of ground water in order to understand its role as a biogeochemical barrier.

Materials and Methods

The research was conducted on a 4.5 km transect in peatland located in the Agroecological Landscape Park host D. Chłapowski in Turew (40 kilometers South-West of Poznań, West Polish Lowland) (Figure 1).

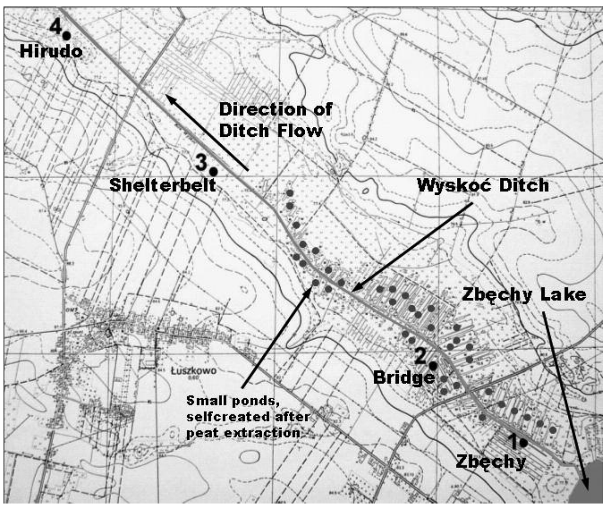

Figure 1. The map of the investigated peatland

The peat - moorsh soils were described and classified according to the Polish hydrogenic soil classification (Okruszko 1976; Systematyka Gleb Polski, 1986) and the World Reference Base Soil Notation (WRB 1998). Twice a month during the entire vegetation season soil and ground water were sampled at four sites (Zbęchy, Bridge, Shelterbelt and Hirudo) along theWyskoć ditch (Figure. 1). The sites are used as intensive but not fertilized meadows. A summary of the soil characteristics of the four sites is presented in Table 1.

Samples of fen peat-moorsh soils were collected at a depth of 0-20 cm. from 10 locations in each site. The samples were air dried, crushed to pass through a 1 mm-mesh sieve and combined to form a composite sample, which was used for the determination of pH (in 1M KCl), total organic carbon (TOC), total nitrogen (N_{total}).

Samples of ground water were taken from wells established for this investigation at the four sites and ground water pH, (N_{total}), N-NO_3^-, N-NH_4^+, DTC (dissolved total carbon) and DOC (dissolved organic carbon) were measured. Twice distilled water from silica glass equipment was used. For the investigation of DOC, soil samples were heated in redistilled water at 100°C for two hours in the reflux condenser. Extracts were separated by means of filter paper and analyzed with TOC 5050A facilities (Shimadzu, Japan) (Smolander and Kitunen 2002). N_{total} was evaluated by the semimicro-Kjeldahl method, and ammonium and nitrate ions by the Sprurwaya method (Rowell 1994; Szajdak Matuszewska 2000).

Satisfactory precision based on replicate analyses, were: ±0.01 for pH measurements, ±3.5% for TOC, ±3.4% for DOC, ±4.3% for Ntotal, ±3% for N-NO_3^-, ±3% for N-NH_4^+.

All analyses were performed on 5 replicate subsamples, and the results were averaged. All the chemicals used in this study were of analytical grade.

Results and Discussion

The investigated peatland represents different kinds of fen peat-moorsh soils (Table 1).

Our earlier investigations have shown that the organic soils of the transect represent different stage of moorshification, characterized by different chemical properties (Szajdak and Szczepański 2006). Zbęchy, located at the beginning of the peatland, is characterized by weak moorshfied soil. With an increase in the distance from the edge, the peatland soils are medium and strongly moorshified. The most moorshified is the soil of the shelterbelt, representing peaty and humic moorsh.

All the soils were slightly acidic (No 2 and 4) to neutral (No 1 and 3), with pH values ranging from 5.82 to 7.56 (Table 2) (Szajdak 2002). The highest pH was recorded in peat from Shelterbelt and the lowest for Hirudo.

The concentrations of TOC ranged from 14.67% to 36.37% in the soils. The highest yearly mean content of TOC (33.25%) was recorded at the Bridge site and the smallest (22.54%) at Zbęchy. Yearly mean soil N_{total} content ranged from 2.0l% to 2.19%. The highest mean value was found at Hirudo.

The ground water pH values ranged from 6.40 to 7.52 (Table 2). Highest values were observed at Hirudo and the lowest at Zbęchy.

The concentration of N-NO_3^- in ground water changed with increasing distance from the edge of the peatland. The highest yearly mean value (0.52 mg/l) was measured at the beginning of the transect and the lowest (0.32 mg/l) at Hirudo, at the end of the transect. The decrease in N-NO_3^- over the entire transect was equal to 38.5%.

The changes in N-NH_4^+ concentrations were similar to those for N-NO_3^- with a decrease of 38.5% over the length of the transect.

A similar trend was observed for N_{total}, with the highest mean concentration (11.39 mg/l) being recorded at Zbęchy and a decrease in N_{total} with increasing distance from the edge of the peatland. Along the 4.5 km transect the decrease in N_{total} was equal to 25%.

The concentrations of N_{org} likewise decreased with increasing distance from the edge of the peatland. The overall decrease in organic compounds including nitrogen in their structures was equal to 10%.

Both forms of carbon measured in ground water decreased with increased length of the transect. These forms represent organic compound which are available for plants and microorganisms. During the entire vegetation season DTC concentrations ranged from 108.1 to 189.5 mg/l. The yearly mean content of DTC was highest at Zbęchy and lowest at Hirudo -169.73 mg/l and 113.53 mg/l, respectively. The decrease of the DTC with increased distance through peatland was equal to 33.1%.

Similar changes as for DTC were recorded for DOC in ground water. The highest content of DOC was observed at the beginning of the transect (82.75 mg/l) and the lowest at Hirudo (113.53 mg/l). Along the distance of the transect the decrease in DOC was equal to 57.5%.

The results suggest that peatland is a very effective landscape element for removal of dissolving organic carbon and nitrogen compounds from-through-flowing waters when the nitrogen is in the form of nitrate rather than ammonium N or dissolved organic N. Thus this element of the landscape, representing a soil-plant system, plays a significant part in the purification of ground water.

Conclusions

The results of this study show that peatland located on secondarily transformed fen peat-moorsh soils can significantly reduce the concentrations of nitrogen and carbon compounds in ground water. In the present case the average reductions achieved were: nitrates 38.5%, N-organic 10%, N-total 24.5%, ammonium 38.7%, dissolved total carbon 33.1%, dissolved total inorganic carbon 10%, and dissolved organic carbon 57.5%.

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Table 1. Some properties of fen peat - moorsh soil

Place of sampling	Type of peat-moorsh	Stage of soil moorshification, degree of decomposition	Kind of moorsh formation	pH	TOC %	N-total %
Zbęchy	Wooden-sedgemoorsh soil with peat, light degree of moorsh process MtI, deep soil developed with low *Carex-Phragmiteti* strongly decomposed(sapric) peat, 10YR 2/1 black, amorfic-fibrus structure. The upperpeathorizon have thin 1-2 mm mineral layers. Peaty muck horizon with subangularblocky structurewith low fiber content. Moorsh horizon Mt 0-10cm depth. Polish hydrogenicsoil classification (Okruszko, 1976): MtIcc. World Reference Base (WRB 1998) soil notation: Sapri-Eutric Histosols.	MtIcc 0-20 cm, R3	Z_1	*6.22-6.97*	**22.54** *16.73-32.12*	**2.01** *1.64-2.62*
Bridge	Alder, moorsh soil with peat, medium degree of moorsh process MtII, deep soil developedwith low strongly decomposed(sapric) wood peat, 10YR 2/1 black, angular blocky structure. Humic muck horizon with subangularblocky microstructure. Very good developedM1 moorsh sod subhorizon and subangular blocky M2 muck undersod subhorizon. Moorsh horizon Mt 0-20cm depth. Polish hydrogenic soil classification (Okruszko, 1976): MtIIcc. World Reference Base (WRB 1998) soil notation: Sapri-Eutric Histosols.	MtIIcc 0-20 cm R3	Z_2	*6.00-6.46*	**33.25** *30.18-36.37*	**2.14** *1.54-2.82*
Shelterbelt	Sedge-rushes, moorsh soil with peat, strong degree of moorsh process MtIII, deep soil developedwith low *Carex*-wood decomposed(sapric) peat, 10YR 3/1 very dark gray, angular-fibrus blocky structure. Moorsh horizon strongly draied, subangular blocky microstructure. Good developedsubhorizons M1, M2. Degraded moorsh M3 subhorizon have light identificable. Moorsh horizon Mt 0-32cm depth. Polish hydrogenic soil classification (OKRUSZKO 1976): MtIIIcc. World Reference Base (WRB 1998) soil notation: Sapri-Eutric Histosols.	MtIIIcc 0-20 cm R3	Z_2 Z_3	*7.05-7.56*	**30.23** *27.53-33.23*	**2.01** *1.55-2.62*
Hirudo	Alder, moorsh soil with peat, medium degree of moorsh process MtII, deepsoil developedwith low wood decomposed(sapric) peat, 10YR 2/2 very dark brown, angular blocky structure. Moorsh horizon strongly draied, subangularblocky macro and microstructure. Good developedsod and undersod subhorizons M1 and M2. Moorsh horizon Mt 0-20cm depth. Polish hydrogenic soil classification (Okruszko, 1976): MtIIcc. World Reference Base (WRB 1998) soil notation: Sapri-Eutric Histosols.	MtIIcc 0-20 cm R3	Z_2	*5.82-6.41*	**26.47** *14.67-35.9*	**2.19** *1.55-2.54*

Mt- stage of soil moorshification, MtI- weakly moorshified, MtII- medium moorshified, MtIII-strongly moorshified; a –according to classification WRB 1998-Sapri-Eutric Histosols, Z_1- grain moorsh, Z_2- peaty moorsh, Z_3- humic moorsh, bold – mean, italic - range

Table 2. Contents of chemical compounds in ground water

Place of sampling	pH	$N\text{-}NO_3$ mg/l	N-total mg/l	$N\text{-}NH_4$ mg/l	N-org mg/l	DTC mg/l	DOC mg/l
Zbęchy	*6.51-7.06*	**0.52** *0.50-0.55*	**11.39** *8.40-14.56*	**5.76** *5.60-5.88*	**5.60** *2.80-8.68*	**169.73** *159.00-183.50*	**82.75** *81.25-84.59*
Bridge	*6.78-7.52*	**0.44** *0.30-0.63*	**11.01** *8.96-13.44*	**6.25** *5.88-6.16*	**4.76** *3.08-6.72*	**178.43** *171.00-189.50*	**64.90** *60.70-68.50*
Shelterbelt	*6.40-7.46*	**0.46** *0.35-0.64*	**10.08** *8.96-11.76*	**3.74** *3.36-4.48*	**7.34** *4.48-11.37*	**137.47** *135.70-139.70*	**32.97** *31.00-36.00*
Hirudo	*6.98-7.44*	**0.32** *0.25-0.35*	**8.59** *7.00-10.08*	**3.55** *1.68-7.28*	**5.04** *2.80-7.00*	**113.53** *108.10-121.90*	**35.17** *30.14-38.09*

DTC-dissolved total carbon, DOC-dissolved organic carbon, bold – mean, italic - range

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