Extended abstract No. 72

DRAINAGE EFFECTS ON LABILE ORGANIC CARBON FRACTION IN TOP LAYERS OF PEATLANDS

Kalisz Barbara[1], Lachacz Andrzej[1], Glazewski Roman[2]

[1]Dr Barbara Kalisz, Prof. Andrzej Lachacz, Department of Soil Science and Soil Protection, University of Warmia and Mazury in Olsztyn, Pl. Lodzki 3, 10-727 Olsztyn, Poland, e-mail: barbara.kalisz@uwm.edu.pl, andrzej.lachacz@uwm.edu.pl
[2]Dr Roman Glazewski, Department of Environment Protection Engineering, University of Warmia and Mazury in Olsztyn, ul. Prawochenskiego 1, 10-957 Olsztyn, Poland, e-mail: rom@uwm.edu.pl

SUMMARY

Labile organic carbon fraction is cycling fast in the environment. One of labile organic carbon compounds is carbon extracted with hot and cold water. Water-extractable organic carbon does not include all labile organic compounds. However, it is a good indicator of peatland organic matter quality. The studied peatland had undergone the process of organic matter transformation, known as muck-forming process. During this process, intense mineralization and humification of organic matter took place. The contents of cold and hot water-extractable organic carbon fractions were up to 1% of total organic carbon. The results of the study proved that water-extractable carbon fraction is a good indicator of changes in peatlands.

KEYWORDS: soil organic carbon; labile organic carbon, organic soil, muck-forming process
Introduction

INTRODUCTION

Soil carbon is crucial in global carbon quantity and plays an important role in C cycling. It generally consists of labile and refractory carbon forms (Lützow *et al*., 2007; Cheng *et al*., 2008). Most abundant in organic carbon are peats. However, in Poland and Central Europe many of these sites had been drained to obtain fertile agricultural land. Consequently, mineralization of organic carbon compounds occurred. Most susceptible to transformations are labile organic carbon compounds. Soil labile organic carbon is composed of aminoacids, carbohydrates, microbial biomass and other simple organic compounds (Zou *et al*., 2005). It is also a part of soil carbon which is cycling fast in the environment – i.e. up to several years (Harrison *et al*., 1993; Parton *et al*., 1987). Soluble carbon is important, as it has a great impact on dissolved organic carbon concentrations in freshwaters (Clark *et al*., 2005). Hot water-extractable carbon (HWC) is the fraction of organic matter, which is naturally labile and its content is correlated with the mass of micro-organisms. It is therefore an excellent indicator of qualitative changes in organic matter (Sparling *et al.,* 1998; Ghani *et al*., 2002). This fraction is potentially the most susceptible to oxidation to CO_2 (Craswell and Lefroy, 2001; Schulz, 2004), and has great impact on global climate change.
Most studies concerning soil organic carbon fractions are carried out for mineral soils. Not enough attention is focused on organic soil. These soils are a major source of soluble forms of

carbon and other nutrients transported via drainage waters to rivers and lakes (Clark *et al*., 2005). For our study we chose peatlands located in Poland which accumulated during late Pleistocene and Holocene (Lachacz *et al*., 2009; Kalisz *et al*., 2010). As all organic soils, after drainage, they undergo the process of organic matter transformation, known as the muck-forming process (Ilnicki and Zeitz, 2003). During this process, intense mineralization of organic matter take place.

The objective of the paper was to state whether drainage has impact on labile organic carbon in toplayers of peatland.

MATERIALS AND METHODS

The study was carried out in Masurian Lakeland (Fig. 1), which is a geomorphological unit of north-eastern Poland. The research area was shaped during Vistulian Glaciation. Specific features of the region are latitudal moraines, numerous lakes and wetlands. Many wetlands were drained for agricultural purposes in the second half of 19th century and at the beginning of 20th century. For the study a peatland that was drained 150 years ago was selected. Soil samples were taken from 5-10 cm, 15-20 cm and 25-30 cm layers in two sites from the same peatland – first site (peat-muck soil I) was a meadow used as grassland and the second site (peat-muck soil II was a fallow covered by weeds and herbs mostly of *Apiaceae* family. Our idea was to select the same soils in similar conditions but differently used.

In laboratory, loss-on-ignition (LOI) was determined after dry ashing of soil samples during 6 hours at a temperature of 550 ºC. Total organic carbon (TOC) content was measured with a spectrophotometer after oxidation with potassium dichromate (ISO 14235, 1998).

The hot water-extractable carbon (HWC) and cold water-extractable carbon (CWC) were determined in field-fresh soil samples according to the methods described by Sparling et al. (1998) and Landgraf et al. (2006). The amounts of carbon (OC) and nitrogen (TN) in the extracts were measured on a Hach Lange TOC/TN analyzer. All analyses were performed in duplicate.

RESULTS

The studied toplayers of peatlands consisted of: grainy muck also called proper muck (5-10 cm), peaty muck (15-20 cm) and well decomposed alder-wood peat (25-30 cm). The content of organic matter varied from 717 g kg^{-1} to 859 g kg^{-1}. Higher values were noted in the lowest studied layers suggesting progressing mineralization of organic matter, which begins in top layers. It should also be noted that the first soil, used as grassland, contained more organic compounds that the second one, which was a fallow. The content of total organic carbon showed similar relations (Table 1).

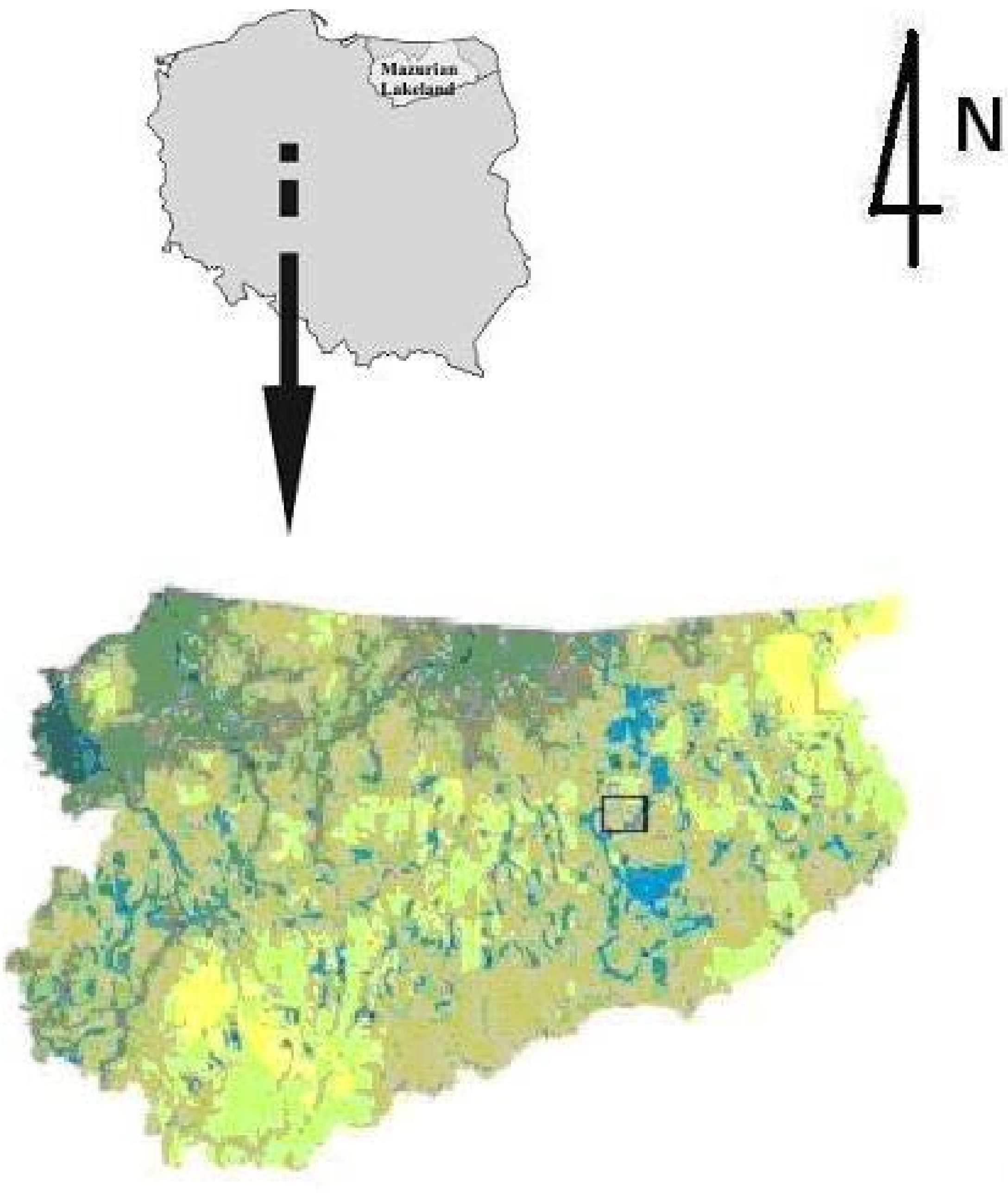

Fig. 1. Location of the studied area.

Table 1. Studied parameters in toplayers of peatlands (all parameters are expressed in g kg^{-1})

Depth [cm]	LOI	TOC	Hot water extraction			Cold water extraction		
			OC	TN	OC/TN	OC	TN	OC/TN
peat-muck soil I								
5-10	807.4	468.3	0.418	0.065	6.390	0.185	0.047	3.936
15-20	837.6	485.8	0.425	0.070	6.103	0.193	0.035	5.496
25-30	859.0	498.3	0.580	0.102	5.669	0.222	0.025	8.880
peat-muck soil II								
5-10	717.3	416.0	0.485	0.072	6.742	0.137	0.058	2.373
15-20	782.2	453.7	0.550	0.095	5.761	0.192	0.071	2.708
25-30	820.5	475.9	0.557	0.092	6.062	0.215	0.029	7.394

The amounts of hot and cold water-extractable carbon fractions were small. However, HWC amounts were twice higher than cold water-extractable carbon. HWC and CWC amounts were higher in peat layer (25-30 cm) than in mucks (5-20 cm) (Table 1). Kaczmarek and Dziadowiec (1999) as well as Gonet *et al*. (2009) stated that higher amounts of soluble organic compounds in deeper layers are a result of migration. The C/N ratios in hot water extracts were quite similar in all layers. However, in cold water extracts much wider ratios were stated in peat layers than in mucks (Table 1). The results of hot water extracts are better indictors as they correspond to microbial biomass. Cold water extracts contain compounds present actually in soil solution.

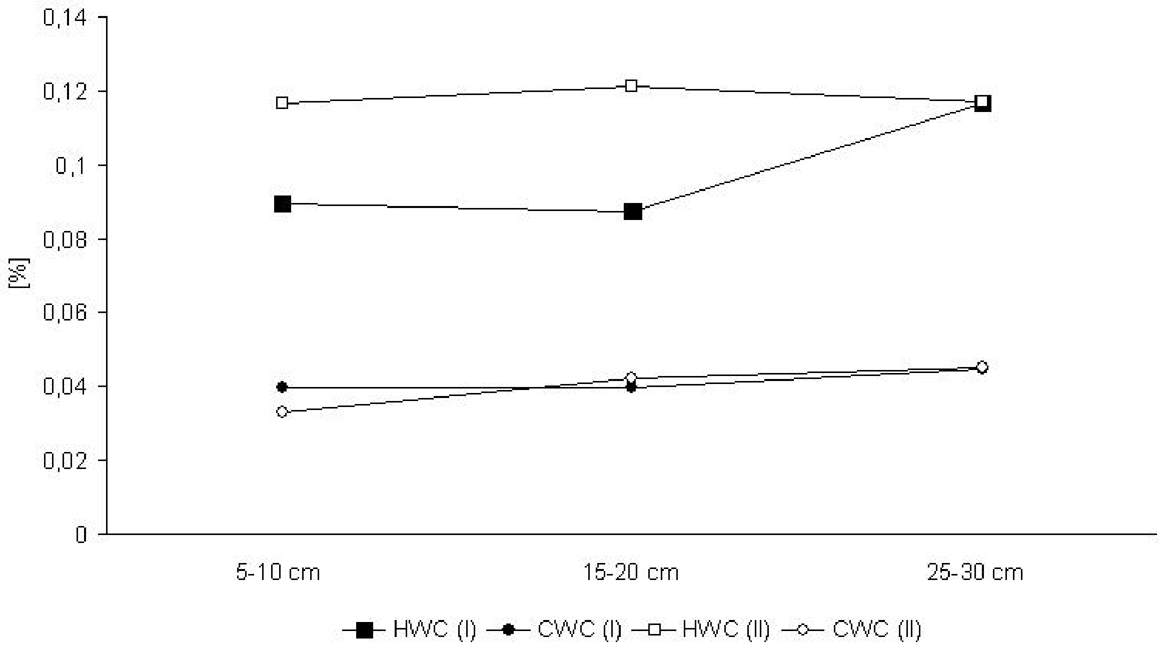

Fig. 2. Share of hot and cold water extractable carbon in total organic carbon.

The share of hot water-extractable organic carbon in total organic carbon amount varied between the sites – a part of peatland which was used as grassland contained more HWC (in relation to TOC) in peat layer than in muck layers. A share of HWC in TOC in a part of peatland that was a fallow was similar in all studied layers. Cold water extractable carbon did not show clear variations between the layers and sites (Fig. 2).

CONCLUSIONS

The studied area was drained 150 years ago and underwent various transformation processes. One of them was mineralization of organic matter of peat after lowering groundwater level. Consequently, peat formations were transformed into mucks. At the beginning of this process the muck could be described as peaty. However, progressing muck-forming process contibuted to further transformations of muck, leading to the formation of grainy muck. Hot and cold water-extractable organic carbon fractions were analysed in field moist soil samples taken from top layers of the peatland. Drainage of organic soils increases the mobility of labile organic carbon compounds. These compounds are finally transported to the oceans.

ACKNOWLEDGEMENTS

The research was financially supported by the Ministry of Science and Higher Education, Poland, grant No N N305 157639.

REFERENCES

Clark, J.M., Chapman, P.J., Adamson, J.K. and Ane, S.L. (2005). Influence of drought-induced acidification on the mobility of dissolved organic carbon in peat soils. *Glob. Change Biol*. **11**, 791-809.

Craswell, E.T. and Lefroy, R.D.B. (2001). The role and function of organic matter in tropical soils. *Nutr. Cycl. Agroecosys*. **61**, 7-18.

Ghani, A., Dexter, M. and Perrott, K.W. (2002). Hot water carbon as an integrated indicator of soil quality. *17th WCSS in Thailand, Symposium no. 32*, 1650-1-1650-6.

Gonet, S.S., Debska, B., Dziamski, A., Banach-Szott, M., Zaujec, A. and Szombathova, N. (2009). Properties of organic matter in Haplic Luvisol under arable, meadow and forest management. *Pol. J. Soil Sci*. **40(2)**, 139-148.

Harrison, K.G., Broecker, W.S. and Bonani, G. (1993). The effect of changing land-use on soil radiocarbon. *Science* **262**, 725–726.

Ilnicki, P. and Zeitz, J. (2003). Irreversible loss of organic soil functions after reclamation. In: Parent L-E. and Ilnicki P. (eds) Organic soils and peat materials for sustainable agriculture. CRC Press, pp. 15-32.

ISO 14235. (1998). Soil quality – Determination of organic carbon by sulphochromic oxidation.

Kalisz, B., Lachacz, A. and Glazewski R. (2010). Transformation of some organic matter components in organic soils exposed to drainage. *Turk. J. Agric. For*. **34**, 245-256.

Karczmarek, J. and Dziadowiec, H. (1999). Humification process of soil organic matter in various forest stands. *Humic Subst. Environ*. **1**, 27-33.

Lachacz, A., Nitkiewicz, M. and Kalisz, B. (2009). Water repellency of post-boggy soils with a various content of organic matter. *Biologia, Sec. Botany* **64(3)**, 634-638.

Lützow, M.V., Kögel-Knabner, I., Ekschmitt, K., Flessa, H., Guggenberger, G., Matzner, E. and Marschner, B. (2007). SOM fractionation methods: Relevance to functional pools and to stabilization mechanisms. *Soil Biol. Biochem*. **39**, 2183-2207.

Parton, W.J., Schimel, D.S., Cole, C.V. and Ojima, D. (1987). Analysis of factors controlling soil organic matter levels in the Great Plains grasslands. *Soil Sci. Soc. Am. J*. **51**, 1173-1179.
Schulz, E. (2004). Influence of site conditions and management on different soil organic matter (SOM) pools. *Arch. Agron. Soil Sci*. **50(1)**, 33-47.

Sparling, G., Vojvodić-Vuković, M. and Schipper, L.A. (1998). Hot-water-soluble C as a simple measure of labile soil organic matter: the relationship with microbial biomass C. *Soil Biol. Biochem*. **30**, 1469-1472.

Zou, X.M., Ruan, H.H., Fu, Y., Yang, X.D. and Sha, L.Q. (2005). Estimating soil labile organic carbon and potential turnover rates using a sequential fumigation-incubation procedure. *Soil Biol. Biochem*. **37**, 1923-1928.