

IMPACT OF SOLVENT ON THE ELUTION RATES OF ORGANIC MATTER FROM THE SECONDARY TRANSFORMED PEAT-MOORSH SOILS

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SUMMARY

The rates of organic matter elution in soil samples from 4.5 km long transect of peatland located on secondary transformed organic soils (peat-moorsh soils) were investigated. The rates of the elution process were calculated from the kinetics of the first order reaction model from the absorbance values. The absorbances of samples were monitored with UV-VIS spectrophotometer at four wavelengths $\lambda=272$ nm, 320 nm, 465 nm, and 665 nm. All experiments were repeated in water and 0.5 M ammonium acetate buffer solution at different ionic strength $\mu=0.25$, $\mu=0.40$, $\mu=0.65$.

KEYWORDS: organic matter, ionic strength, peat-moorsh soils, soil kinetic processes

INTRODUCTION

Natural, compatible structures which assist in controlling matter cycles in agricultural landscape are of great importance for enhancement of a countryside resistant to degradation. Various plant cover structures like peatlands, grasslands, stretches of meadows, hedges, shelterbelts, riparian vegetation strips are of special interest. But most important from the point of ecological engineering, is that the biogeochemical barriers exert controlling effects on nonpoint pollution. Peatlands belong to the stable elements in the landscape, which regulate water regime in soils, restrain soil erosion, improve microclimate for agricultural production, and create refuge sites for wildlife. Peatlands show substantial ability to limit spread of chemical elements among the ecosystems in the agricultural landscape (Fuchsman, 1986; Ilnicki, 2002; Szajdak, 2002). Mechanisms responsible for these processes are still elusive, but are generally assumed that the following processes are important: plant uptake and ion exchange capacities.

Nitrate, ammonium and phosphate pollution caused by using of inorganic fertilizers are especially a great threats for rural areas and lead to the eutrophication of ground water. Many physical, chemical, biochemical and biological processes control dispersion of these chemical compounds in soils and finally all these processes depend on the organic matter content and particularly on humic substances (Howard-Williams and Downes, 1993; Szajdak *et al.*, 2002; Szajdak *et al.*, 2003; Życzyńska-Bałoniak *et al.*, 2005). Therefore organic matter plays pivotal roles in several processes, conversions and mechanisms in peatlands, including detoxication of anthropogenic chemicals, C sequestration, water retention, nutrient cycling, soil structure

formation and energy supply to soil microorganisms. These processes include biological conversion, biochemical and chemical degradation, reduction, and hydrolysis etc. (Belkevitch, 1962; Okruszko and Kozakiewicz, 1973). Thus they lie at heart of leading environmental and agricultural issues. Although humus of organic soils is affected by the great number of biological and chemical transformation mechanisms, including microbial processes and phytochemical degradation reactions, decomposition and loss of organic matter through biomineralization in surface layer (Zeitz and Velty, 2002). Humics of different origins can differ significantly with respect to elemental composition, molecular weight, chemical structure etc. These substances represent a class of biogenic, heterogeneous and refractory organic compounds (Kondo, 1976; Hatcher *et al.*, 1986; Lishtvan *et al.*, 1989).

The aim of this study was to estimate the impact of ionic strength on the elution rates of organic matter from the secondary peat-moorsh soils in order to understand their role in functioning peatland as biogeochemical barriers. Additionally, the results obtained from the experiments should give a better insight into the changes, which take place in organic matter of secondary transformed peat-moorsh soils.

MATERIALS AND METHODS

The research site was a transect of peatland 4.5 km long located in the Gen. Dezydery Chłapowski Agroecological Landscape Park in Turew (40 kilometers South-West of Poznań, West Polish Lowland) (Fig. 1). Peat-moorsh soils were described and classified according to Polish hydrogenic soil classification (Systematic of Polish Soils, 1989) and World Reference Base Soil Resources (WRB, 1998). The investigated points were located along to Wyskoć ditch. Two times a month during whole vegetation season the following samples of peat, were taken from four chosen sites marked as Zbęchy, Bridge, Shelterbelt and Hirudo.

Samples of peat-moorsh soils were collected at the depth 0-20 cm. Soils were sampled from 10 sites of each site. Samples were air dried and crushed to pass a 1 mm-mesh sieve. These 10 sub-samples were mixed for the reason of preparing a “mean sample”.

7 g of peat were filled to the fixed level equaled to 50 ml in the glass column (ID=1 cm). Ammonium acetate buffer as mobile phase was pumped at the rate 2 ml min⁻¹ and developed a pressure of 2.5 MPa. Samples of 5 ml were collected at suitable time intervals. The absorbances of these samples were monitored at four following wavelengths $\lambda=272$ nm, $\lambda=320$ nm, $\lambda=465$ nm, and $\lambda=665$ nm. UVmini-1240, Shimadzu, spectrophotometer with 1 cm thickness of layer was used for spectrometric measurements. All experiments were repeated at different ionic strength $\mu=0.25$, $\mu=0.40$, $\mu=0.65$ of 0.5 M ammonium acetate buffer solution regulated by NaCl. In order to determine the reaction order of organic matter release it's the Ostwald's equation was applied for the calculation of the reaction order. All the kinetic experiment was run triplicate and the results averaged.

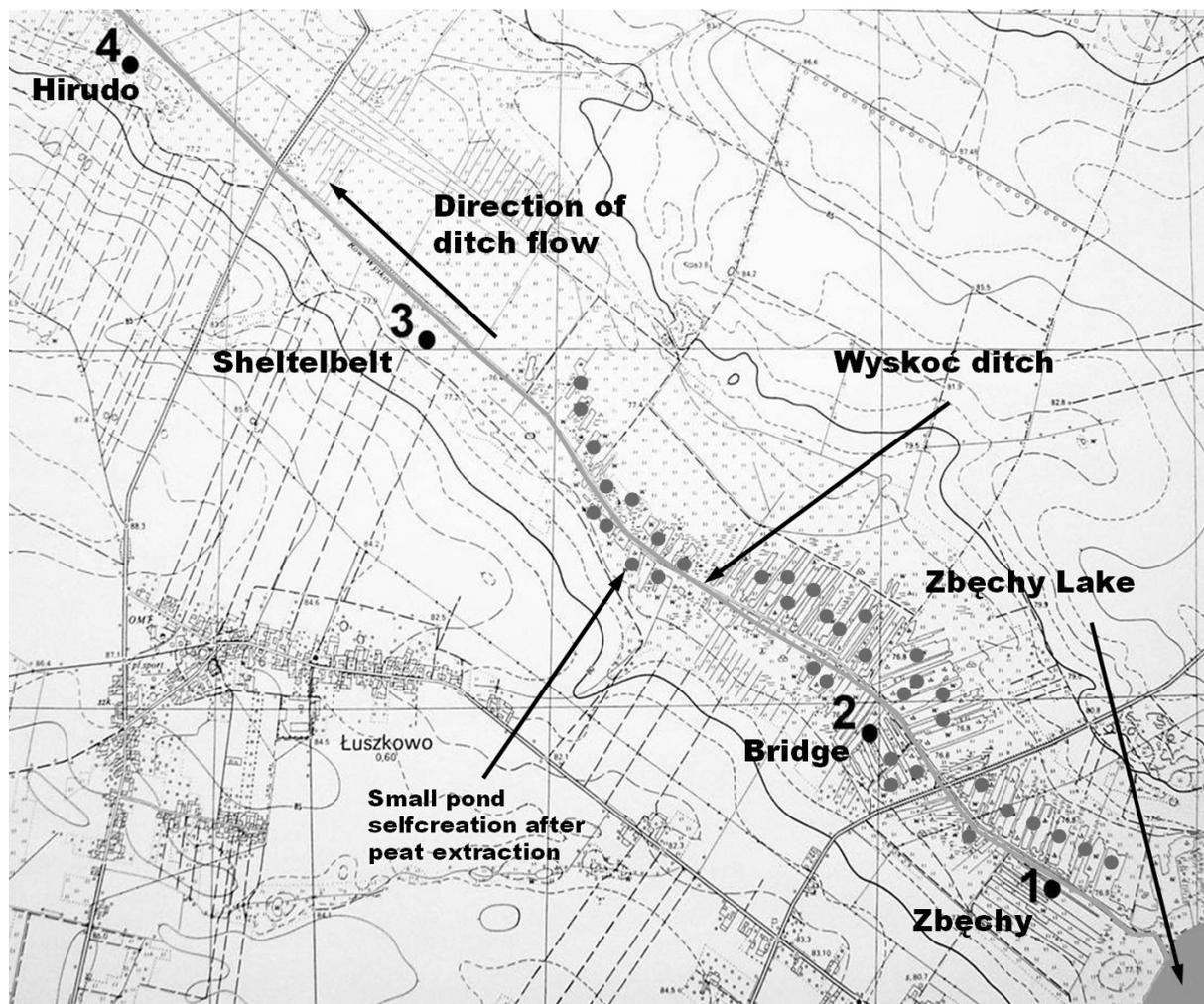


Fig. 1. The map of the investigated peatland.

RESULTS

The modeling kinetic studies of organic matter release from peat were performed. The absorbances of organic matter release as a function of time were characterized by exponential equation (1) (Fig. 2):

$$A = A_0 e^{-kt} \quad (1)$$

Its transformations leads to linear relationship agreed with the first-order reaction model (2) (Fig. 3), (Frost and Pearson, 1961; Lasaga *et al.*, 1981; Connors, 1990):

$$\ln A = \ln A_0 - kt \quad (2)$$

Where: A - value of absorbance, A_0 - absorbance at the time 0, k - pseudo first order rate constant, t - time.

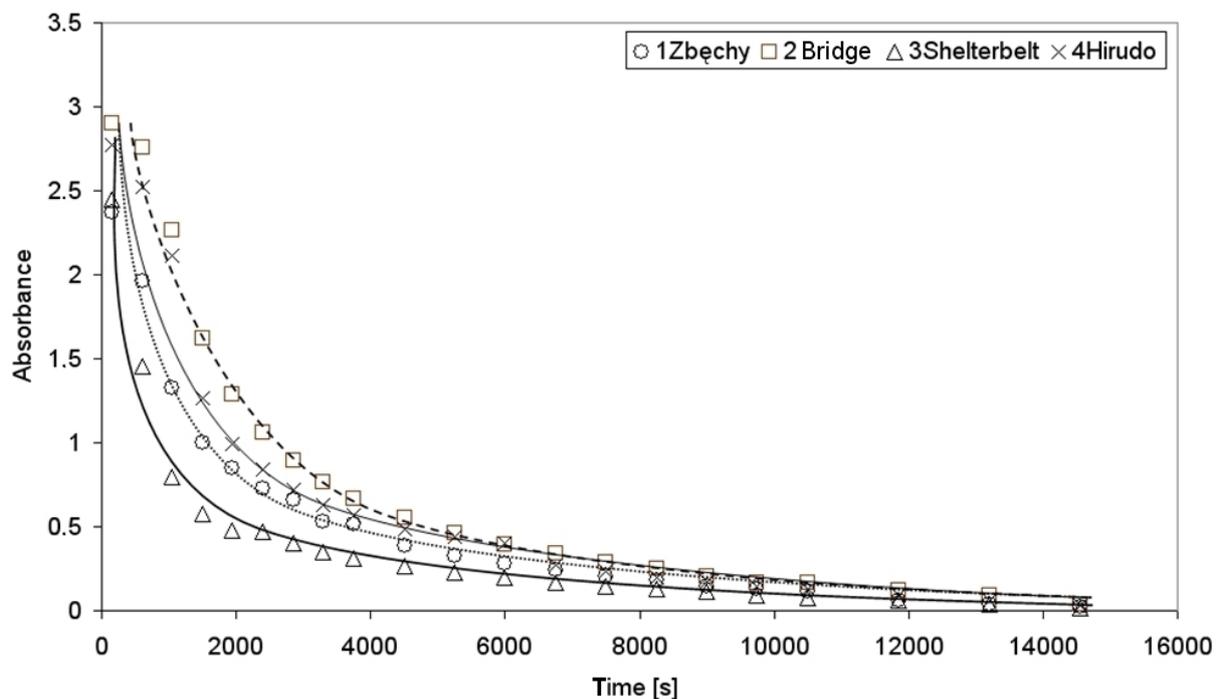


Fig. 2. Typical changes of absorbance at $\lambda=272$ nm of organic matter released from investigated points in accordance with eq. (1).

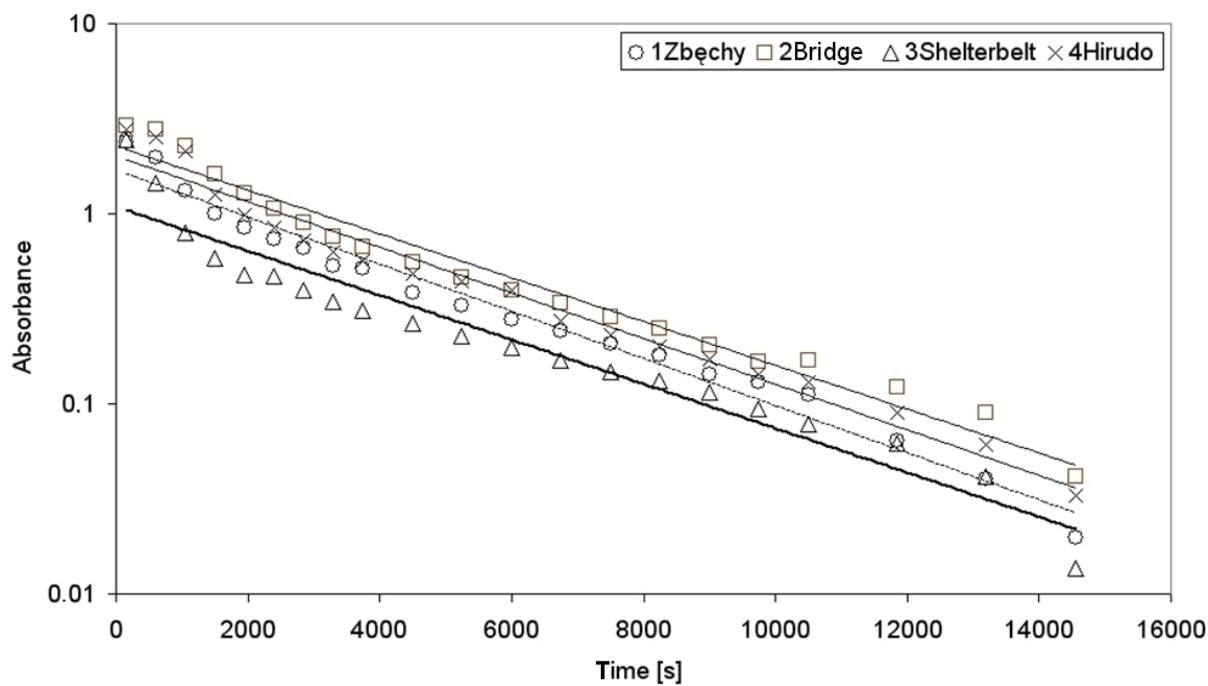


Fig. 3. Semilogarithmic plots $\ln A = \ln A_0 - kt$ for first-order reaction of organic matter release from Zbęchy, Bridge, Shelterbelt and Hirudo measured at $\lambda=272$ nm eq. (2).

The absorbances of organic matter release measured at four following wavelengths as a function of time follows the equation (1) and their graphical illustration is a linear curve. The correlation coefficients ranged from -0.897 to -0.989. However, they yield linear relationships according to equation (2), (Table 1).

Table 1. Pseudo first-order rate constants ($k \times 10^{-4} \text{ s}^{-1}$), half-times (minutes), and correlation coefficients (r) for the reaction of the release of organic matter from peat by 0.5 M ammonium acetate buffer at pH=6.5 and $m=0.25$; $m=0.40$ and $m=0.65$

0.5 M ammonium acetate buffer solution at pH=6.5, $\mu=0.25$				
Wavelength nm	Place of sampling			
	Zbęchy	Bridge	Shelterbelt	Hirudo
$\lambda=272$	$k=1.8675$	$k=1.8758$	$k=2.2354$	$k=1.8830$
	$t_{0.5}=61.85$	$t_{0.5}=61.57$	$t_{0.5}=51.67$	$t_{0.5}=61.34$
	$r=-0.974$	$r=-0.975$	$r=-0.990$	$r=-0.974$
$\lambda=320$	$k=1.9405$	$k=1.8569$	$k=2.2005$	$k=1.9870$
	$t_{0.5}=59.52$	$t_{0.5}=62.20$	$t_{0.5}=52.49$	$t_{0.5}=58.13$
	$r=-0.970$	$r=-0.973$	$r=-0.989$	$r=-0.973$
$\lambda=465$	$k=1.8027$	$k=1.7222$	$k=2.0809$	$k=1.8552$
	$t_{0.5}=64.07$	$t_{0.5}=67.06$	$t_{0.5}=55.51$	$t_{0.5}=62.26$
	$r=-0.963$	$r=-0.965$	$r=-0.987$	$r=-0.966$
$\lambda=665$	$k=1.6939$	$k=1.6332$	$k=2.0566$	$k=1.7406$
	$t_{0.5}=68.19$	$t_{0.5}=70.72$	$t_{0.5}=56.16$	$t_{0.5}=66.36$
	$r=-0.956$	$r=-0.961$	$r=-0.994$	$r=-0.962$
0.5 M ammonium acetate buffer solution at pH=6.5, $\mu=0.40$				
$\lambda=272$	$k=1.8540$	$k=1.8339$	$k=1.7948$	$k=1.8605$
	$t_{0.5}=62.30$	$t_{0.5}=62.98$	$t_{0.5}=64.35$	$t_{0.5}=62.08$
	$r=-0.975$	$r=-0.974$	$r=-0.971$	$r=-0.975$
$\lambda=320$	$k=1.8588$	$k=1.9179$	$k=1.7837$	$k=1.8803$
	$t_{0.5}=62.14$	$t_{0.5}=60.22$	$t_{0.5}=64.75$	$t_{0.5}=61.43$
	$r=-0.973$	$r=-0.973$	$r=-0.959$	$r=-0.970$
$\lambda=465$	$k=1.8412$	$k=1.7617$	$k=1.6617$	$k=1.7936$
	$t_{0.5}=62.73$	$t_{0.5}=65.56$	$t_{0.5}=69.51$	$t_{0.5}=64.39$
	$r=-0.970$	$r=-0.963$	$r=-0.951$	$r=-0.966$
$\lambda=665$	$k=1.7397$	$k=1.6122$	$k=1.5350$	$k=1.6958$
	$t_{0.5}=66.39$	$t_{0.5}=71.64$	$t_{0.5}=75.25$	$t_{0.5}=68.11$
	$r=-0.964$	$r=-0.943$	$r=-0.931$	$r=-0.959$
0.5 M ammonium acetate buffer solution at pH=6.5, $\mu=0.65$				
$\lambda=272$	$k=1.8507$	$k=1.8609$	$k=2.3557$	$k=1.8939$
	$t_{0.5}=62.41$	$t_{0.5}=62.07$	$t_{0.5}=49.03$	$t_{0.5}=60.98$
	$r=-0.975$	$r=-0.976$	$r=-0.991$	$r=-0.975$
$\lambda=320$	$k=2.0508$	$k=1.8541$	$k=2.3396$	$k=1.8357$
	$t_{0.5}=56.32$	$t_{0.5}=62.29$	$t_{0.5}=49.37$	$t_{0.5}=62.92$
	$r=-0.966$	$r=-0.969$	$r=-0.991$	$r=-0.974$
$\lambda=465$	$k=1.9284$	$k=1.7578$	$k=2.2686$	$k=1.8686$
	$t_{0.5}=59.89$	$t_{0.5}=65.71$	$t_{0.5}=50.91$	$t_{0.5}=61.81$
	$r=-0.963$	$r=-0.963$	$r=-0.989$	$r=-0.966$
$\lambda=665$	$k=1.8137$	$k=1.6733$	$k=2.4827$	$k=1.7562$
	$t_{0.5}=63.68$	$t_{0.5}=69.03$	$t_{0.5}=46.52$	$t_{0.5}=65.77$
	$r=-0.955$	$r=-0.959$	$r=-0.991$	$r=-0.960$

k - first-order rate constant, $t_{0.5}$ - half-time,

The slopes of the equation describe the rates of leaching process. It appeared that the rates of organic matter elution for all samples of peats were significant different at four used wavelengths $\lambda=272$ nm, $\lambda=320$ nm, $\lambda=465$ nm, and $\lambda=665$ nm. It was observed that the rates increased between $\lambda=272$ nm and $\lambda=320$ nm and decreased from $\lambda=465$ nm to $\lambda=665$ nm. Although, the lowest values of the pseudo first-order rate constants measured at $\lambda=665$ nm for all samples of peats from four places ranged from $1.9524 \cdot 10^{-4} \text{ s}^{-1}$ to $2.7361 \cdot 10^{-4} \text{ s}^{-1}$. Therefore the highest values of $t_{0.5}$ ranged from 46.5 to 75.3 minutes for all samples from Zbęchy, Shelterbelt, Bridge and Hirudo (Table 1).

CONCLUSION

Decrease in $t_{0.5}$ of organic matter release was observed along with increase in ionic strength μ from 0.25 to 0.65 of 0.5 M acetate buffer. The investigations have shown the impact of solvent on the rates of the elution of organic matter.

ACKNOWLEDGMENTS

This work was supported by a grant No. N N310 310039 founded by Polish Ministry of Education.

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