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# KINETICS OF ORGANIC MATTER RELEASE AT TWO TEMPERATURES FROM SELECTED PEAT MATERIALS AT DIFFERENT STATE OF SECONDARY TRANSFORMATION

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A b s t r a c t. Laboratory experiments were performed to study the influence of time and temperature on the amount of organic matter released from soil. Samples of six different peat materials that represent: weakly, medium, strongly and very strongly secondary transformed peats were submitted to release experiments at 20 and 90 °C. Beside time and temperature, the state of secondary transformation of peat material has influenced on the amount of released organic matter. Two shapes of kinetic curves were obtained.

K e y w o r d s: organic matter, kinetic curves, peat material, secondary transformation, release experiment.

## INTRODUCTION

About 80% of Polish organic soils have been drained and at present are agriculturally used. Changes occurring in the peat soils after drainage result in the state of secondary transformation. In general, the secondary transformation process can be defined as a set of mucking, secondary humification and mineralization processes. In the consequence of that, degradation of these soils is almost a rule and they become little productive. One of the reasons for this phenomenon might be organic matter release. It is worth to remind here that the presence of dissolved organic matter (DOM) plays an essential role in the formation of aggregates, nutrient cycling, pollutant detoxicity. Organic matter plays a significant role in a number of physico-chemical processes. Among others, soil organic matter governs the processes coupled with acid-base properties and especially: pH buffering, ionic balance, metal leaching. Furthermore, the nature and the amount of the dissolved organic matter in soil solution can influence quality of ground and surface waters

[4,6]. Availability of DOM and its mobility depends on different factors such as pH, temperature, ionic strength, adsorption phenomena and others [7]. One of them, temperature has been studied in this paper. It was reasonable to carry out studies on the peat material, as peat-moorsh soils are large sources of DOM.

The aim of this work was to investigate releasing of organic matter at 20 $^{o}$C and 90 $^{o}$C from peat-moorsh soils at different state of secondary transformation. However, it should be kept in mind that the true field situation might include further factors and be quite different from the one presented in this paper.

## MATERIALS AND METHODS

The study was conducted on selected peat materials taken from six sites where various phases of moorshing process could have been easily visually assessed. Selected physical and chemical properties of the investigated soils are in other paper [2]. The studied materials represent weakly (sample No. 12), medium (sample No. 1), strongly (sample Nos 13 and 9) and very strongly (sample Nos 4 and 5) secondary transformed peats. Water holding capacity expressed by $W_1$ index was used in this study for quantification of the secondary transformation degree of the studied materials. It is the ratio of centrifuged moisture equivalent (at 1000 g) after predrying at 105 $^{o}$C and one week rewetting to that of a fresh sample.

Indices of secondary transformation were determined according to the Gawlik's method [1]. For the peat formations weakly secondary transformed, the range of $W_1$ values is 0.41-0.50; for medium secondary transformed, $W_1$ ranges from 0.51 to 0.60; for strongly secondary transformed from 0.61-0.70; and $W_1$>0.8 for the degraded peats.

Dissolubility of organic matter in static conditions was studied. 10 g (dry mass basis) portions of each soil were placed into plastic bottles and simultaneously shaken with water in the proportion of 1 part of solid to 5 parts of water at two temperature levels (20 and 90 $^{o}$C) for 15, 30, 60, 90 min and so on. Deionized water was used for the release experiments as deionized water had only small amount of cations. Hence, ion exchange was of minor importance. After this process, the aliquot was passed through a glass filter (G4) and collected to clean and dry glass containers without washing.

To determine concentration of DOM in the sample solutions, the measurements of optical absorbance [5,6] were made with visible spectrophotometer (SPEKOL, Carl Zeiss), pH of aliquots were adjusted to 7 by adding a few drops of 1M NaOH. Organic matter released by water has the largest specific visible absorbance at 465 nm. It was experimentally determined in accordance with all the analytical rules. A standard curve, using a series of 10 sodium humate solutions (Aldrich H1, 675-2) was plotted. Concentration of C in the standards from 0.005 to 0.15 mg $ml^{-1}$ has a range of absorbance between 0.4 and 0.03. Next, the curves of DOM c (mg $ml^{-1}$) concentration as a function of the shaking time were plotted.

## RESULTS AND DISCUSSION

Figures 1 and 2 show the amounts of the dissolved organic matter (c (mg $ml^{-1}$)) against the time of shaking at 20 and 90 °C for all studied samples. Our studies have shown that time and temperature are important factors for releasing organic components from peat-moorsh soil. The time of equilibrium settlement was about 90 min at 20 °C (Fig. 1) for all the samples except No. 12. For this sample DOM concentration is constant after 120 min. At 90 °C this process lasted longer. The results show that after about 180 min DOM concentration was constant for all the soils (Fig. 2). The time of equilibrium settlement depends on temperature: for 20 and 90 °C it was respectively, 90 and 180 min. Longer periods of equilibrium at higher temperatures is contrary to what had been expected.

DOM concentrations measured colorimetrically after equilibrium settlements are shown in Fig. 3. These values for 20 °C range from 0.025 mg $ml^{-1}$ for the soil No. 5 to 0.09 mg $ml^{-1}$ for No. 12. After the releasing experiment conducted at 90 °C these values range from 0.03 mg $ml^{-1}$ for the soil No. 5 to 0.12 for No. 12. As can be seen, the amount of DOM released at 90 °C is higher than that at 20 °C. It is in good agreement with our expectations.

Our data show that time and temperature has strong influence on the amount and probably also the nature of organic matter released from the studied soils.

Moreover, it is worth noticing that two shapes of kinetic curves were obtained. The course of the curves of organic matter released at 90 °C obtained for all the samples except No. 5 are as follows: in the first part the relation between concentration and time of shaking is approximately linear. Concentration is going up to the very maximum, then a little fall is noticed. Next, after about 180 min the amount of DOM measured in the aliquots is almost constant. A similar shape of kinetic curves was obtained at 20 °C for the sample No. 12. In the domaining cases, the shape is typical. We speculate that these unusual kinetic curves are the consequence of predrying of the peat material. Samples taken for the experiment were preliminarily air dried at room temperature. Decreasing concentration after the maximum was reached may reflect aggregation process, which at that moment was dominant for some organic compounds released earlier. In particular, this is observed for weakly and medium secondary transformed samples (Nos 1,12 and 13) shaken with water at 90 °C and for the sample No. 12 shaken at 20 °C. Our results

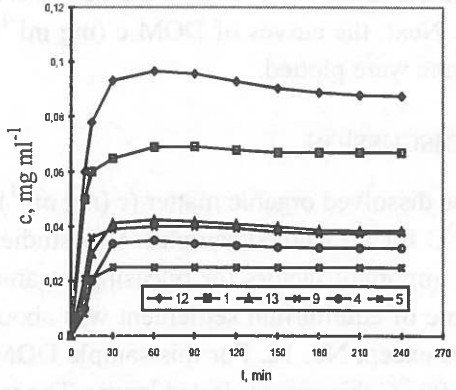


**Fig. 1.** Concentration in the organic matter released at 20°C against the time of shaking.

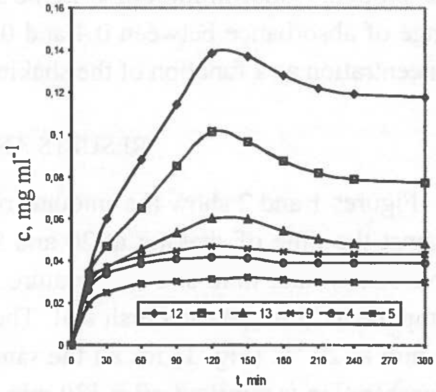


**Fig. 2.** Concentration in the organic matter released at 90°C against the time of shaking.

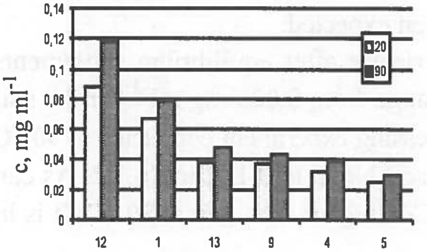


**Fig. 3.** Amount of organic matter released at 20 and 90 °C.

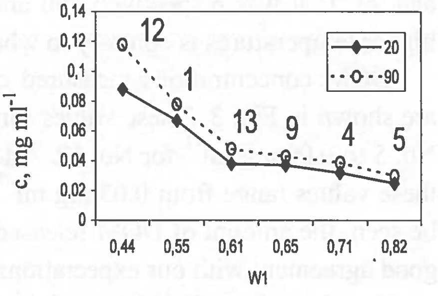


**Fig. 4.** Concentration c in the organic matter released at 20 and 90 °C against the value of $W_I$ index.

may indicate that strongly and very strongly transformed samples (Nos 4,5 and 9) are less subjected to drying and the curves obtained are typical.

To sum up, for strongly and very strongly secondary transformed samples the obtained curves are typical. For weakly and medium mucked samples that were shaken at 90 °C, the maximum of the kinetic curves is observed. Their shape is probably the consequence of taking air-dried samples for the experiment.

An attempt to find some relationships between the amount of DOM released and the state of secondary transformation was performed. Generally, the soils investigated were similar in respect to their ash content (under 25 %) and other physico-chemical properties [2]. They are mainly different in the state of secondary transformation. A correlation was found between DOM concentration and degree of secondary transformation as determined by $W_I$ index. The amount of the

**T a b l e 1.** Physical and chemical properties of the investigated soils

| No. of soil | $W_1$ | Kind of moorsh | Ash content % d.m. | Bulk density g cm$^{-3}$ | Total porosity vol. % | pH | | mg/100 g of soil | | | | | mg/1000 g of soil | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $H_2O$ | 1N KCl | $P_2O_5$ | $K_2O$ | Mg | $NH_4$ | N-$NO_3$ | B | Cr | Zn |
| 12 | 0.44 | $Z_1$ | 22.69 | 0.21 | 88.5 | 5.13 | 4.54 | 26.0 | 16.9 | 30.0 | 7.31 | 23.34 | 4.4 | 4.0 | 83.5 |
| 1 | 0.55 | $Z_1$ | 17.56 | 0.25 | 84.6 | 5.48 | 5.18 | 60.0 | 19.3 | 60.0 | 1.07 | 37.76 | 8.0 | 50 | 33.0 |
| 13 | 0.61 | $Z_1$ | 15.14 | 0.24 | 85.2 | 5.84 | 5.33 | 41.0 | 8.4 | 7.0 | 1.67 | 14.23 | 7.1 | 0.5 | 8.5 |
| 9 | 0.65 | $Z_3$ | 18.94 | 0.31 | 80.9 | 5.45 | 4.97 | 34.0 | 9.6 | 8.0 | 2.75 | 17.39 | 3.4 | 3.5 | 18.0 |
| 4 | 0.71 | $Z_3$ | 15.80 | 0.31 | 80.9 | 5.70 | 5.32 | 46.0 | 15.7 | 30.0 | 2.67 | 24.22 | 6.8 | 5.0 | 16.5 |
| 5 | 0.82 | $Z_3$ | 22.27 | 0.39 | 78.7 | 5.54 | 5.00 | 37.0 | 9.6 | 40.0 | 0.16 | 13.69 | 6.6 | 4.0 | 25.0 |

$W_1$ - index of secondary transformation of moorsh material, $Z_1$ - peaty moorsh, $Z_3$ - proper moorsh.

released organic matter decreases with an increase in the value of $W_1$ index. It is well illustrated in Fig. 4.

## CONCLUSIONS

1. Time of equilibrium settlement of organic components releasing from peat-moorsh soils depends on temperature: for 20 and 90 °C it was, respectively, 90 and 180 min.

2. For weakly and medium transformed samples that were shaken at 90 °C, the maxima of the kinetic curves are observed. Their shape is probably a consequence of taking preliminarily dried samples for the experiment.

3. For strongly and very strongly secondary transformed samples the curves obtained have classical shapes.

4. A correlation between DOM concentration and degree of secondary transformation as determined by $W_1$ index was found. The amount of the released organic matter decreases with the increasing value of $W_1$ index.

To explain longer time of equilibrium settlement at higher temperature levels more detailed studies should be carried out. Application of a standard curve determined by using solutions of other substances (for example fulvic acid) may be useful. Obviously, to explain the unusual shape of kinetic curves obtained for weakly and medium secondary transformed soils, further investigations, and especially qualitative analysis of the released organic matter, should be done.

## REFERENCES


1. **Gawlik J.:** Water holding capacity of peat formations as an index of the state of their secondary transformation. Polish J. Soil Sci., 25, 121-126, 1992.
2. **Gawlik J., Harkot W.:** Influence of the kind of moorsh and the state of its transformation on the germination and growth of *Lolium perenne* in the pot plant experiment during spring - summer cycle. Acta Agrophysica, 26, 25-40, 2000.

3. **McCarthy J.F., Zachara J.M.:** Subsurface transport of contaminants: mobile colloids in the subsurface environment may alter the transport of contaminants. Environmental Science and Technology, 23, 496-502, 1989.
4. **McDowell W.H., Wood T.:** Podzolization: soil processes control dissolved organic carbon concentrations in stream water, Soil Science, 137, 23-32, 1984.
5. **Reemstsma T., Bredow A., Gehring M.:** The nature and kinetics of organic matter released from soil by salt solutions. European J. Soil Sci., 50, 53-64, 1999.
6. **Scott M.J., Jones M.N., Woof C., Tipping E.:** Concentrations and fluxes of dissolved organic carbon in drainage water from an upland peat system. Environment International, 24, 537-546, 1998.
7. **Sposito G.:** The Chemistry of Soils: Soil Organic Matter. NY, Oxford, Oxford University Press, 42-65,1989.