Environment Protection Engineering

Vol. 30 2004 No. 4

Z. STĘPNIEWSKA*,**, A. SZAFRANEK*

CHANGES OF PHOSPHATE LEVEL IN SOME PEATS BEING TRANSFORMED IN DIFFERENT DEGREES

Based on an experimental model, a release of phosphorus from natural, renaturalized and drained peat soils in the conditions of flooding was investigated. The conditions in which that process proceeded were examined as well. Our investigations have been undertaken because a land being drained in 1960–1980 is intended for flooding again. It has been proven both that redox potential and Fe(II) affect significantly the release of $P–PO_4$ into the soil solution.

1. INTRODUCTION

Land being drained by peat degradation in anaerobic conditions loses its agricultural value. Because of the above it was decided to irrigate the land that had been drained. The process of renaturalisation can make iron(III) phosphates that precipitate in crystalline form in water available for plants, which leads to eutrophication of water [4]. When a soil is flooded with water, an availability of phosphorus increases indirectly by reduction of Fe(III) compounds [3]. Simultaneously with a decrease in redox potential (Eh) the solubility of phosphorus compounds changes which is caused by the transformation of such elements as iron, manganese and the changes in pH value. Reduction of iron(III) compounds is considered to be the main reason of phosphorus release [1]. The concentration of soluble phosphorus increases in anaerobic conditions, but when the value of redox potential (Eh) increases the precipitation of phosphorus chemically bonded to Al(III) and Fe(III) was observed. Readily soluble organic matter also contributes to phosphorus release because the higher its solubility in water, the higher the phosphate level in soil solution [2].

* Department of Biochemistry and Environmental Chemistry, Catholic University of Lublin, al. Kraśnicka 102, 20-718 Lublin, Poland, tel.: +48 (081) 445 46 15, e-mail: szafik@kul. lublin.pl.

** Institute of Agrophysics PAS, ul. Doświadczalna 4, 20-209 Lublin 27, Poland.

2. METHODS AND MATERIALS

2.1. LABORATORY EXPERIMENT

The samples of peat soils were taken in the area of the Pojezierze Łęczyńsko-Włodawskie from three sites:

- natural site, i.e. high peat-bog surrounded by swampy continental forest located nearby to the Moszne Lake whose average pH is 4.54 (site 1),
- renaturalized site in the neighbourhood of the Dziki and the Duża Zośka ponds flooded with precipitation water in 1994, after fire, an average pH is 7.16 (site 2),
- land being drained, i.e. degraded low peat-bog; since 1968 used as a meadow of pH 6.58 (site 3).

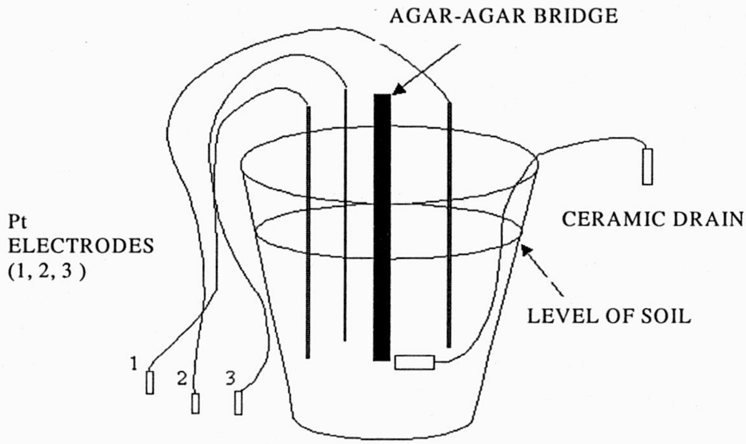

Fig. 1. Scheme of the test system

Soil samples from the depth of 0–20 cm were taken in triplicate and transferred to plastic containers. Three platinum electrodes were installed in each container in order to measure the redox potential (Eh). An agar bridge closing electric circuit between reference electrode and measuring electrode, the latter located in soil, and ceramic filter with an outlet pipe allowing us to take soil solution were installed (figure 1). Particular elements of measuring set were located at the same depth in the soil of each sample (20 cm from the bottom of the container). Containers filled with the soil were tightly closed and incubated in the conditions of complete saturation with water at the temperature of 18 °C. The concentration of P–PO_4 and Fe(II) ions, as well as Eh parameter were measured after every 7 days.

2.2. MEASUREMENT METHODS

2.2.1. CONCENTRATION OF P–PO$_4$ IONS

The concentration of P–PO$_4$ ions was determined by spectrophotometric method, which is based on colour reaction of ammonium molybdate with phosphates. Measurements were carried out at the wavelength λ = 690 nm. The solutions were filtered through paper filters, stabilized by a few drops of 1% solution of thymol in ethanol and then analysed.

2.2.2.CONCENTRATION OF Fe(II) IONS

The concentration of Fe(II) ions was determined by sectrophotometric method after adding to each sample an α, α'-dipyridyl in the presence of acetate buffer. Measurements were carried out at the wavelength of 530 nm.

2.2.3. MEASUREMENT OF REDOX POTENTIAL (Eh)

Potential Eh was measured using platinum electrodes calibrated in the Michaelis buffer in the presence of calomel electrode as a reference electrode.

3. DISCUSSION

In each peat sample incubated in anaerobic conditions, a release of phosphorus to the soil solution was observed.

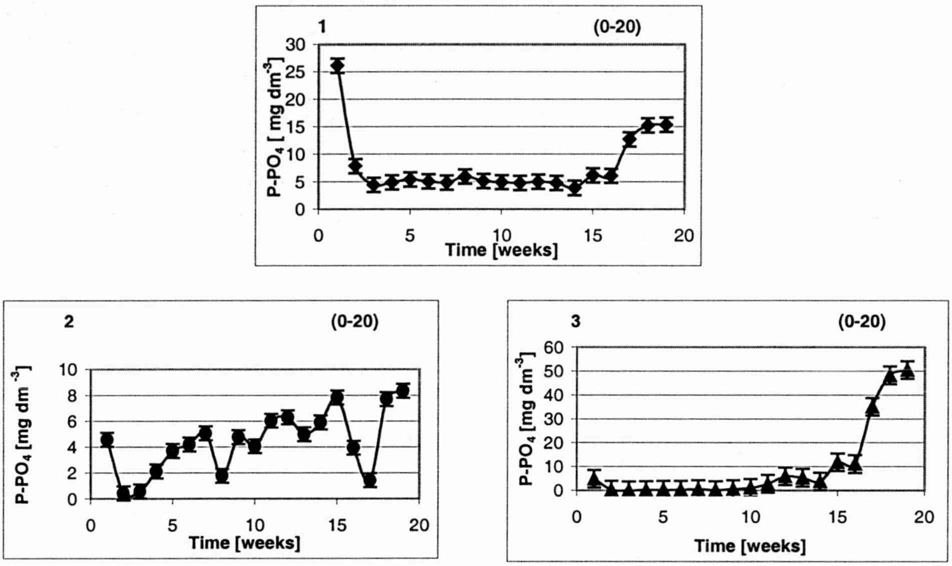

Fig. 2. Dynamics of the changes in phosphate concentration in the soil taken from: 1) natural peat-bog, 2) renaturalized area, 3) area being drained and flooded again

In the soil samples taken from a natural site, high content of P–PO_4 was observed as early as in the first day of incubation and it was equal to 26 mg dm^{-3}. Until the 15th week this content was on the level of 5 mg dm^{-3}, but from the 16th weak it increased and in the 18th week it reached to the value of 15 mg dm^{-3} (figure 2). Eh value decreased from 415 mV at the beginning of the experiment to –50 mV in its last day.

In the soil samples taken from a renaturalized area, an initial concentration of phosphates amounted to 5 mg dm^{-3}. In following weeks of incubation this concentration increased to 8 mg dm^{-3}, after 15 weeks it decreased to 1.5 mg dm^{-3}, and then increased to 8 mg dm^{-3} (figure 2). Eh value in that period decreased from 232 mV at the beginning of the experiment to –209 mV in its last day.

The concentration of phosphates in the samples from the land being drained was constant until the 10th week of incubation and equal to 1 mg dm^{-3}. Between the 10th and the 18th weeks of experiment it increased, finally reaching the value of 50 mg dm^{-3} (figure 2). At the same time, Eh potential ranged from 122 mV in the first week of incubation to –178 mV in the last week.

pH of soil material was in range from 4.54 to 7.16, which corresponded with an optimal pH range of phosphate solubility (from 4.5 to 7.1) [5].

In the first day of laboratory experiment, the level of P–PO_4 increased, which is in arrangement with the results of other authors [6]. It was found that P–PO_4 concentration increased with a decrease in Eh potential, which was also confirmed by other researchers [1]. This conclusions was drawn based on the analyses of the soil solutions taken from the renaturalized area and from area being drained. Such a tendency is represented by a negative correlation (figure 3). Soil at these places is characterized by a positive correlation between concentrations of P–PO_4 and Fe(II) (figure 4). There was no such a dependence for the samples taken from the natural site. During experiment the greatest release of P–PO_4 was found in the soil taken from the area being drained. Weekly it approached 9.8 mg dm^{-3} of P–PO_4. The smallest weekly release of P–PO_4 to the soil solution, i.e. about 4.5 mg dm^{-3}, was found in the soil samples taken from renaturalized area. This might be caused by small content of organic matter in that soil, as a result of fire, which damaged the area two years earlier.

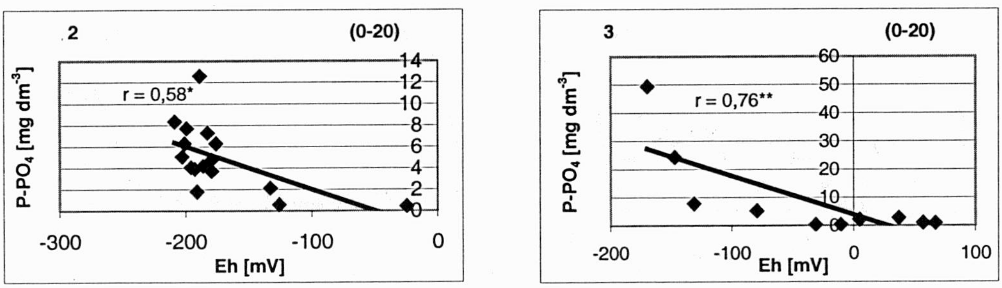

Fig. 3. Phosphate concentration versus Eh value in the soil taken from:
2) renaturalized area, 3) area being drained and flooded again

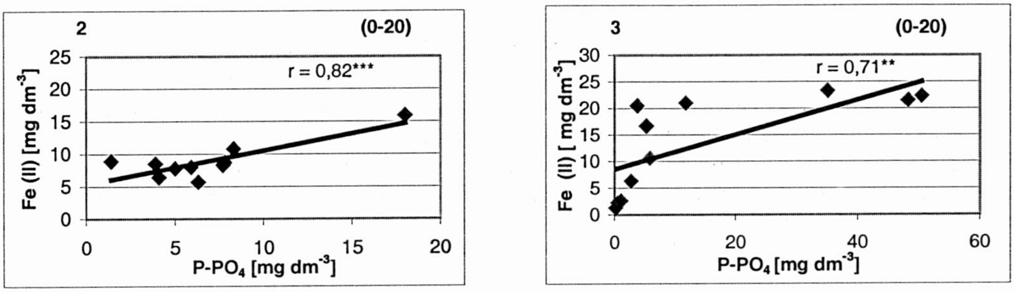

Fig. 4. Phosphate concentration versus iron(II) concentration in the soil from: 2) renaturalized area, 3) area being drained and flooded again

4. CONCLUSIONS

The results obtained indicate that phosphorus was released from the soil flooded with water in each variant of the experiment. A negative linear correlation between the concentration of phosphates in the soil solution and the Eh value and a positive correlation between the concentration of P–PO$_4$ and the concentration of Fe(II) (places 2, 3) were found. In the case of soil samples taken from natural area, such correlations were not detected. When we intend to irrigate peat soils being drained in the past, we should remember that this allows a release of phosphates which can reach a level of 50 mg dm^{-3} in three months.

REFERENCES

[1] ANN Y., REDDY K.R., DELFINO J.J., *Influence of redox potential on phosphorus solubility in chemically amended wetland organic soil*, Ecological Engineering, 2000, 14, 169–180.

[2] CROSS A.F., SCHLESIGER W.H., *A literature review and evaluation of the Hedley fractionation: applications to the biogeochemical cycle of soil phosphorus in natural ecosystems*, Geoderma, 1995, 64, 197–214.

[3] GARDNER C.M.K., COOPER P.M., HUGHES S., *Phosphorus in soils and field drainage water in the Thames catchment*, UK, The Science of the Total Environment, 2002, 282–283, 253–268.

[4] LEINWEBER P., MEISSNER R., ECKHARDT K.U., SEEGER J., *Management effects on forms of phosphorus in soil and leaching losses*, European Journal of Soil Science, September 1999, 50, 413–424.

[5] Van LOON G.W., DUFFY S.J., *Environmental chemistry*, Oxford, 2003, 295–298.

[6] De MELLO J.W.V, BARRON V., TORRENT J., *Phosphorus and iron mobilization in flooded soils from Brazil*, Soil Science, February 1998, 122–132.

ZMIANY POZIOMU FOSFORANÓW W TORFACH O RÓŻNYM STOPNIU PRZEKSZTAŁCENIA

W doświadczeniu modelowym badano uruchamianie fosforu w naturalnych, zrenaturalizowanych i osuszonych glebach torfowych poddanych nawodnieniu, a także określono warunki, w jakich ten proces zachodzi. Badania podjęto w związku z planami ponownego nawodnienia terenów osuszonych w latach 1960–1980. Przeprowadzone badania wskazują na istotny wpływ potencjału Eh oraz Fe(II) na uwalnianie P–PO_4 do roztworu glebowego.