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EFFECT OF SEWAGE SLUDGE AND FLOTATION LIME ON FORMATION OF AVAILABLE FORMS OF PHOSPHORUS, POTASSIUM AND MAGNESIUM IN SOIL

ODDZIAŁYWANIE OSADU ŚCIEKOWEGO I WAPNA POFLOTACYJNEGO NA KSZTAŁTOWANIE SIĘ PRZYSWAJALNYCH FORM FOSFORU, POTASU I MAGNEZU W GLEBIE

Abstract: The influence of sewage sludge and flotation lime applied on three levels on the changes in the content of available forms of P, K and Mg was evaluated in the light soil from the vicinity of a former sulphur mine. The two-year pot experiment, which was set up using complete randomization method, was conducted on soil material with the granulometric composition of light loamy sand. Oat and spring rape were the test plants in the experiment. Prior to the experiment the soil was characterized by a strong acid reaction, low content of available phosphorus and potassium and very low content of available magnesium.

Obtained results show that experimental factors clearly differentiated the content of available forms of phosphorus, potassium and magnesium in soil. The content of phosphorus and magnesium in the test soil increased as the result of sewage sludge application and an opposite effect was observed in case of available potassium. By optimization of soil reaction, liming indirectly affected soil fertility in the available forms of analyzed nutrients.

Keywords: sewage sludge, flotation lime, available phosphorus, available potassium, available magnesium

Sewage sludge constitutes a valuable source of nutrients [1–3] and organic matter [4, 5]. However, it involves many hazards in the form of increased content of heavy metals and organic pollutants [4]. The environmental application of municipal sewage sludge may lead to sanitary danger and may cause chemical and biological contamination of soils, surface waters and even plants grown in the areas fertilized with the sludge [6]. In

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spite of above contradictions, agricultural and natural application of sewage sludge seems to be a rational method of usage and utilization [7]. Under the conditions of the deficiency of natural fertilizers, sewage sludge should be applied, in particular, for fertilization and improvement of the properties of low-quality soils [8] and for the reclamation of degraded lands. In the reclamation of chemically degraded and strongly acidified soils, alkaline wastes from the mining industry (eg lime resulted from sulphur flotation) are also applied.

The aim of the performed experiment was to analyze the effect of sewage sludge and flotation lime on the changes in the content of available forms of phosphorus, potassium and magnesium in light soil, obtained from the vicinity of a sulphur mine.

Material and methods

The experiment was set up on the soil material obtained from the arable layer of soil with a granulometric composition of light loamy sand. Two-year pot experiment was carried out using complete randomization method in the years 2004–2005. Prior to the experiment the soil obtained from the vicinity of a former sulphur mine was characterized by a strong acid reaction, low content of available phosphorus and potassium and a very low content of available magnesium. Two variable factors were used in the experiment: a dose of sewage sludge and a dose of flotation lime. Both factors were applied on three levels, according to the following pattern:

1. Ss_0Ca_0 4. Ss_1Ca_0 7. Ss_2Ca_0
2. Ss_0Ca_1 5. Ss_1Ca_1 8. Ss_2Ca_1
3. Ss_0Ca_2 6. Ss_1Ca_2 9. Ss_2Ca_2,

where:

Ss_0 – without sewage sludge application;
Ss_1 – sewage sludge applied in the amount of 10 g · kg^{-1} soil;
Ss_2 – sewage sludge applied in the amount of 20 g · kg^{-1} soil;
Ca_0 – no liming;
Ca_1 – flotation lime in the amount of 3.096 g · kg^{-1} soil;
Ca_2 – flotation lime in the amount of 6.192 g · kg^{-1} soil.

The sewage sludge used in the experiment had been obtained from the communal sewage treatment plant in Hajdow near Lublin and subjected to hygienization and stabilization with CaO prior to its application. It was established that the sewage sludge contained 17.42 g P · kg^{-1} of total phosphorus and total content of calcium and magnesium amounted 112.21 g Ca + Mg · kg^{-1}.

Two test plants were cultivated on the analyzed soil: barley, 'Cwal' variety, in the year 2004 and spring rape, 'Mozart "00"' variety, in the year 2005. All experiment objects were also constantly fertilized with NPK and a microelement solution, in the amounts adjusted to the plants' nutritional needs.

After the completion of the experiment on the soil content of available phosphorus and potassium was determined using Egnera-Riehm DL method, whereas the content of available magnesium was determined using the Schachtschabel method.

Results and discussion

The soil from the control series (Ss_0Ca_0) collected after the rape harvest in the flowering phase was characterized by the highest content of available forms of P, K and Mg (Table 1). In comparison with the status prior to the experiment set up, the phosphorus content was 2 times higher, potassium level was 4 times higher and magnesium content was nearly 5 times higher. This can be explained by the fact that the soil used in the experiment was not suitable for test plant cultivation, especially for rape – a plant with high requirements towards soil reaction [9]. The seed yields of this plant amounted to 0.27 g · pot^{-1}, and of straw was 0.74 g · pot^{-1}. Consequently, almost total inhibition in rape grown was accompanied by low uptake of the analyzed nutrients [10].

Table 1

The effect of sewage sludge and flotation lime on the soil content of available forms of phosphorus, potassium and magnesium

Determination / Object	Available P	Available K	Available Mg
	[mg · kg^{-1}]		
Before the experiment	34.04	41.51	8.35
Soil after rape harvest in the flowering phase			
Ss_0Ca_0	67.39	166.34	40.38
Ss_0Ca_1	47.42	27.56	16.79
Ss_0Ca_2	61.20	22.48	22.46
Ss_1Ca_0	59.01	56.22	32.22
Ss_1Ca_1	57.14	25.75	23.15
Ss_1Ca_2	64.89	27.51	27.53
Ss_2Ca_0	58.86	44.42	42.99
Ss_2Ca_1	56.67	31.33	27.03
Ss_2Ca_2	72.35	25.14	30.63
Soil after rape harvest in the full maturity phase			
Ss_0Ca_0	65.12	91.82	27.58
Ss_0Ca_1	41.25	22.54	10.07
Ss_0Ca_2	43.43	18.94	13.41
Ss_1Ca_0	61.91	26.63	27.86
Ss_1Ca_1	47.08	16.75	13.44
Ss_1Ca_2	50.33	17.81	13.44
Ss_2Ca_0	61.59	19.48	28.02
Ss_2Ca_1	51.74	17.86	17.27
Ss_2Ca_2	61.59	16.43	18.35

The application of flotation lime – especially in series without sludge – was connected with an observable decrease in phosphorus, potassium and magnesium content in soil after the end of the experiment. The liming applied in the lower dose caused on average 1.26 times decrease in phosphorus content, 2.73 times decrease in

potassium content and 1.97 times decrease in magnesium content, in comparison with their levels in the objects without liming. After the application of the higher lime dose, the corresponding values amounted to 1.19, 3.13 and 1.67, respectively. The decrease in the analyzed elements in soil results, to a large degree, from the yield-forming influence of lime, which was accompanied by the increase in plant uptake of the analyzed elements [10]. The decrease in available magnesium content in the soil might have also been influenced by liming, as it was in research carried out by Labuda et al [11] and Labetowicz and Szulc [12]. It can be caused by antagonism occurrence between Mg^{2+} and Ca^{2+} ions, which in consequence leads to the decrease in magnesium availability for plants [13].

The influence of sewage sludge on the level of analyzed elements in the soil – in comparison with flotation lime – was more differentiated and multidirectional. The direction and range of changes in these elements content were determined by the kind of examined cation, the timing of soil sample collection, sludge dose and lime application. The multidirectional character of this influence on the one hand was also connected with the fact that sewage sludge is the source of all the analyzed elements, especially of phosphorus [14], and on the other one this waste distinctly affected the increase of plant yields [10].

The sludge application in series without liming was connected with the decrease in available phosphorus content in soil. On the other hand, in limed series – as reported by other authors [7, 15] – the sludge caused the increase in this element in soil. This increase, according to the dose of sludge, reached on average 1.14–1.26 times, in comparison with the contents in the objects without sludge.

In most of the objects, the sewage sludge application affected the decrease in available forms of potassium content in the test soil. Similar connections were also observed by Grzywnowicz and Strutynski [16] and by Krzywy et al [17] in their researches. The decrease amounted on average 1.65 and 2.72 times, in series Ss_1 and Ss_2, respectively, in comparison with the values from control objects. It must be added that the greater decrease in the content of available potassium in soil was observed in objects with sludge, where liming was not applied at the same time. In the soil from under the plants harvested in the flowering phase, in objects Ss_1Ca_2, Ss_2Ca_1 and Ss_2Ca_2 the minor increase of available phosphorus was noticed, in comparison with the contents in control objects Ss_0Ca_0.

The content of available magnesium in soil as the result of sewage sludge application visibly increased. This increase – in comparison with the values from control objects without sludge – equaled on average 1.19 times with application of the lower dose of sewage sludge and 1.36 times with the higher one. The greater increase of magnesium in soil was noticed in limed series with double dose of sewage sludge. The obtained data are comparable to the results of Baran et al [15] and Krzywy and co-authors [17].

Conclusions

1. Sewage sludge and floatation lime application have distinctly differentiated the content of available forms of phosphorus, potassium and magnesium content in soil.

2. The content of available forms of the analyzed elements in the limed soil was lower than in the soil of control objects. This testifies to the increasing availability of the analyzed elements and their use by the test plants, under conditions of varying soil reaction.

3. In most of the objects, the application of sewage sludge has resulted in an increase in the soil content of available forms of phosphorus and magnesium and a decrease in the content of the available forms of potassium.

References

[1] Jakubus M.: Fol. Univ. Agric. Stetin., 244, Agricultura 2005, **99**, 73–82.
[2] Jakubus M.: Zesz. Probl. Post. Nauk Rol. 2006, **512**, 209–219.
[3] Krzywy E., Iżewska A. and Wołoszyk Cz.: Zesz. Probl. Post. Nauk Rol. 2004, **499**, 165–171.
[4] Speir T.W., Schaik van A.P., Lloyd-Jones A.R. and Kettles H.A.: Biol. Fertil. Soils 2003, **38**, 377–385.
[5] Veeresh H., Tripathy S., Chaudhuri D., Ghosh B.C., Hart B.R. and Powell M.A.: Environ. Geol. 2003, **43**, 513–520.
[6] Paluch J., Pulikowski K. and Wardecka L.: Acta Agrophys. 2006, **8**(1), 191–203.
[7] Drab M., Węclewski S. and Długosz A.: Zesz. Probl. Post. Nauk Rol. 2004, **499**, 69–77.
[8] Baran St.: Zesz. Probl. Post. Nauk Rol. 2004, **499**, 15–20.
[9] Wielebski F.: Aktualne problemy nawożenia rzepaku w Polsce, [in:] Zbilansowane nawożenie rzepaku (Aktualne problemy), W. Grzebisz (ed.), AR, Poznań 2000, 261–276.
[10] Paul G.: Rola osadów ściekowych i wapna poflotacyjnego w zagospodarowaniu gruntów z okolic kopalni siarki. PhD thesis, maszynopis, Lublin 2008.
[11] Łabuda S., Filipek T. and Dechnik I.: Rocz. Glebozn. 1992, **43**(3–4), 29–36.
[12] Łabętowicz J. and Szulc W.: Zesz. Probl. Post. Nauk Rol. 1999, **456**, 403–409.
[13] Kotowska J. and Maciejewska M.: Chem. Inż. Ekol. 1998, **5**(4), 309–313.
[14] Sapek A. and Sapek B.: Fol. Univ. Agric. Stetin., 200, Agricultura 1999, **77**, 331–336.
[15] Baran St., Wójcikowska-Kapusta A. and Żukowska G.: Rocz. Glebozn. 2006, **57** (1–2), 21–31.
[16] Grzywnowicz I. and Strutyński J.: Zesz. Probl. Post. Nauk Rol. 1999, **467**, 299–306.
[17] Krzywy E., Iżewska A. and Jeżowski S.: Zesz. Probl. Post. Nauk Rol. 2003, **494**, 215–223.

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Abstrakt: Oceniono wpływ osadu ściekowego oraz wapna poflotacyjnego, zastosowanych na trzech poziomach, na zmiany zawartości przyswajalnych form P, K i Mg w glebie lekkiej pochodzącej z okolic byłej kopalni siarki. Przeprowadzono dwuletni eksperyment wazonowy założony na materiale glebowym o składzie granulometrycznym piasku gliniastego, metodą kompletnej randomizacji. W doświadczeniu roślinami testowymi były owies i rzepak jary. Gleba przed doświadczeniem charakteryzowała się bardzo kwaśnym odczynem, małą zawartością przyswajalnego fosforu i potasu oraz bardzo małą zawartością przyswajalnego magnezu.

Uzyskane wyniki wskazują, że czynniki doświadczalne widocznie zróżnicowały zawartość przyswajalnych form fosforu, potasu i magnezu w glebie. W efekcie stosowania osadu, zwiększyła się zawartość fosforu i magnezu w glebie testowej, a przeciwny skutek obserwowano w przypadku potasu. Wapnowanie, poprzez optymalizację odczynu gleby, wpływało pośrednio na jej zasobność w przyswajalne formy analizowanych składników pokarmowych.

Słowa kluczowe: osad ściekowy, wapno poflotacyjne, fosfor przyswajalny, potas przyswajalny, magnez przyswajalny