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INFLUENCE OF SLUDGE ON THE CONTENT OF MAGNESIUM AND POTASIUM IN SOIL UNDER WILLOW CULTIVATION

Abstract. According to Rule accepted on the 10th of July 2007 on fertilizers and fertilization, sewage sludge is a substance that contains appreciable substances for normal growth and development of plants therefore improves chemical, physical and biological properties of soils. Addition of sewage sludge changes the content of these elements in soil and are taken up by willow. Next to nutritional value of sludge it comprises harmful elements such organic contaminants: PAH (Polycyclic Aromatic Hydrocarbons), polychlorinated biphenyls, polyphenols, polychlorinated dibenzodioxins and heavy metals which delimit its using in agriculture. The research with willow and sewage was conducted at the Experimental Station in Pawlowice in years 2008-2010. The experiment was established using split-plot method with two changeable factors in three repetitions: various doses of sewage sludge: 75 and 150 fresh mass $t \cdot ha^{-1}$and selected clones of *Salix viminalis* L. Research showed significant impact of doses of sewage sludge and various depth of soil on the content of magnesium and potassium. The aim of research was to determine content of Mg and K under willow cultivation and the presence of sewage sludge in soil.

Keywords: magnesium, potassium, sewage sludge, willow.

INTRODUCTION

Sewage sludge is a waste but bearing in mind its organic matter and other nutrients content are taken up plants in the process of their growth and development. The high nutrient content makes it an excellent fertilizer. Sludge contains in great quantity nitrogen, phosphorus, calcium and potassium. Nutrients needed in large amount by plants are referred to as macro-nutrients and include nitrogen (N), phosphorus (P), and potassium (K), calcium (Ca), magnesium (Mg) and Sulfur (S) therefore their content in the soil and the their form in the soil decides about their availability. Potassium (K) is one of essential elements for plants, and plant growth is severely restrained when it is insufficient in soils. The availability of K is affected by soil processes including physical, chemical, and biological ones. According to Oleszek-Kudlak [2002] the content of potassium and magnesium compared to nitrogen and phosphorus is low.

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The amount of magnesium is about 0,54% and modest amount of potassium. The content of these elements in sewage decides about its value and makes them highly useful in fertilization and irrigation [Bauman-Kaszubska i Sikorski 2011, Krzywy and Iżewska 2004, Mazur 1996, Ralph 1996, Mazur and Mokra 2011]. The content of dry mass fluctuates from 16,2 to 48,7%. These differences are the results of technology of sewage treatment. The sludge with higher dry mass is stored for longer time on compost heap. Those sludge may be treated as an organic fertilizer because of high content of organic matter (54,2%) and organic carbon (31,5%) [Kalembasa and others 1999, Czekała 1999, 2004].

Willow is an energetic plant that take up macronutrients from sewage sludge easily especially in the period of the greatest biomass production (June-August): nitrogen, phosphorus and potassium. This plant takes up better these elements compared to other plants. Production of willow is projected to be an important source of renewable energy in the coming decades. The average annual willow biomass is estimated from 10 to 15 $Mg \cdot ha^{-1}$ [Adegbidi and others 2001, Lazadina al. 2007].

METHODS

Field experiment with two factors was carried out as split-plot method in the years 2008-2010. The first factor comprised two doses of sewage sludge against control: 75 and 150 $t \cdot ha^{-1}$ fresh mass of sewage sludge (14,3 and 25,8 $t \cdot ha^{-1}$ d.m.).The second factor was four selected clones of *Salix viminalis*: 1001 (*Salix viminalis dasycladis ss Baltica),* 1047 (*Salix viminalis var gigantea),* 1053 (*Orm Valne)*, 1054 *(Salix viminalis* 082). Sewage sludge characterized by high alkaline reaction, high content of macronutrients and low content of heavy metals that didn't exceed permissible concentrations included in polish ordinance connected to using sewage sludge. The aim of research was to determine the amount Mg and K in the soil on various depths with various doses of sludge. Sewage sludge was coming from Wastewater Treatment Plant Janówek and was spread once on the surface of the soil in 2008. The content of dry mass of sewage sludge was 19%. We applied the same sewage on the field. Sewage sludge characterized by high alkaline reaction, high content of macronutrients and low content of heavy metals that didn't exceed permissible (tab.1).

The samples were collected at the end of growing season each year. The samples were sampled with three depths: 0-5 cm, 5-15 cm and 15-30 cm from each combination. They were sieved, dried and mixed to obtain homogenous material. Chemical analysis comprised:

- the Egner-Riehm colorimetric method for available potassium
- Schachtschabel metod for available magnesium

All data were analyzed statistically by analysis of variance AWA.

Table 1. The content of nutrients and heavy metals in communal sewage sludge

Specification	Unit	Sewage sludge
Reaction	–	12
Dry mass	$g \cdot kg^{-1}$	220
Organic matter	$g \cdot kg^{-1}$	450
N (general form)	$g \cdot kg^{-1}$	36
P	$g \cdot kg^{-1}$	28
Ca	$g \cdot kg^{-1}$	100
Mg	$g \cdot kg^{-1}$	7.0
Pb	$mg \cdot kg^{-1}$	59
Cd	$mg \cdot kg^{-1}$	2.0
Cr	$mg \cdot kg^{-1}$	108
Cu	$mg \cdot kg^{-1}$	415
Ni	$mg \cdot kg^{-1}$	50
Hg	$mg \cdot kg^{-1}$	0.05

RESULTS

The analysis showed significant influence of various doses of sewage sludge, weather conditions in the years of experiment and various depth of soil on content of magnesium and potassium. Weather conditions didn't have an impact on the amount of magnesium in soil. The highest concentration was observed in the third year of research as a result as sewage sludge fertilization and its disintegration (Fig. 1). First year was treated as a year of its beginning of the processes.

Sewage sludge modified significantly the content of magnesium. Single and double dose of sludge increased the concentration of magnesium in soil what was statistically proved (Fig. 2).

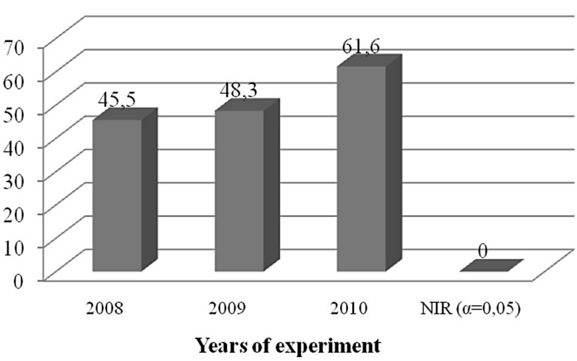

Fig. 1. The influence of sewage sludge on the content of magnesium in the soil in years 2008-2010 ($mg \cdot kg^{-1}$)

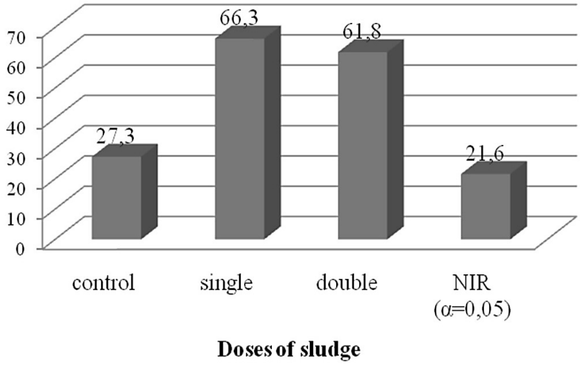

Fig. 2. The influance of various doses of sewage sludge on the content of magnesium in the soil (mg.kg^{-1})

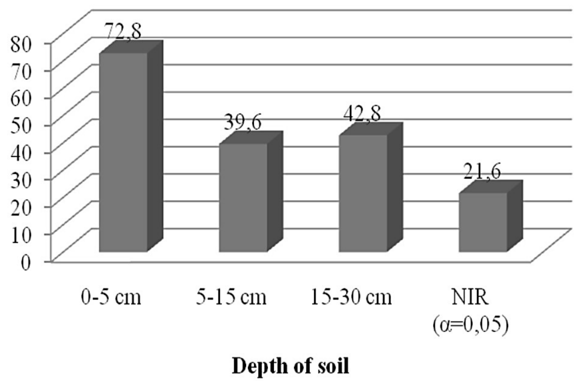

Fig. 3. The influence of sewage sludge on the content of magnesium in various depth of soil in (mg.kg^{-1})

The affluence of magnesium in the soil was stated as high and was dependent on the sewage sludge fertilization. Under the influence of sewage sludge the increase of magnesium was observed. The greatest amount of magnesium stated on the surface of soil (Fig. 3). In vertical profile there showed the decrease of magnesium apart from the object with double dose of sludge at the depth 5-15 cm.

Fertilization with sewage sludge modified the content of available potassium. Under the influence of sewage sludge there showed slight decrease of the content of potassium. The highest concentration of potassium was observed on the control object. Neither single nor double dose caused the increase of potassium content in soil. The smallest concentration of potassium was observed on the variant without sewage sludge (Fig. 5). There was showed the decrease content of it in the years of research. It was caused by taking up potassium by willow. The highest amount of potassium was in the first year of research (Fig. 4). The highest amount of K was at the level 0-5cm. The more deep level, the less amount of K was observed (Fig. 6).

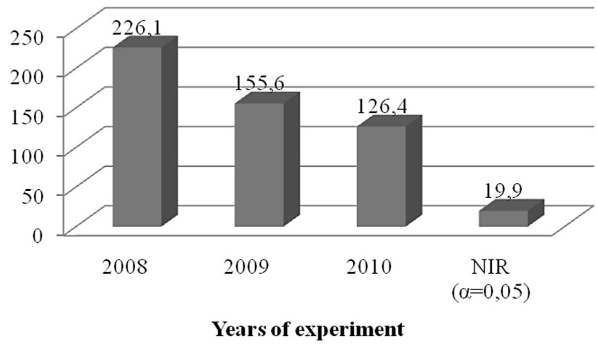

Fig. 4. The influence of sewage sludge on the content of potassium in soil in years 2008-2009 (mg⋅kg^{-1})

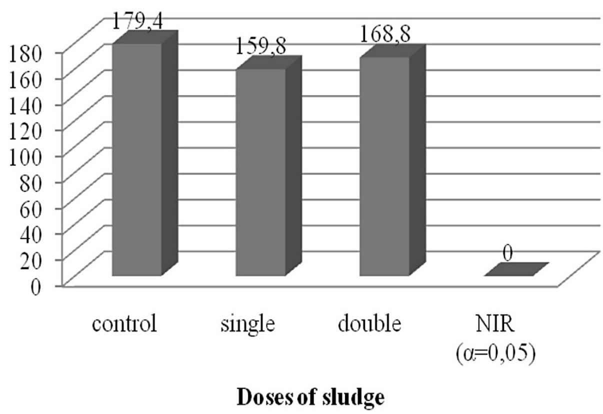

Fig. 5. The influance of various doses of sewage sludge on the content of potasium in the soil (mg⋅kg^{-1})

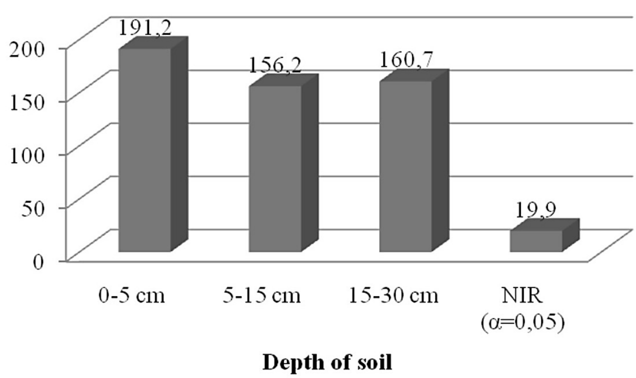

Fig. 6. The influence of sewage sludge on the content of potassium in various depth of soil in (mg⋅kg^{-1})

Interaction between years and depth of soil indicated that weather conditions influenced on amount of potassium . The highest concentration of potassium was observed in the depth 0-5 cm in the first year of experiment. The highest amount of potassium was in first year of research and was decreased in second and third year. Obviously the highest concentration of potassium was in shallow depth of soil. The deeper depth, the lesser amount of potassium (tab. 2).

Table 2. The content of potasium in various depth of soil in years of research 2008-2010 ($mg{\cdot}kg^{-1}$)

Year	Depth of soil		
	0–5 cm	5–15 cm	15–30 cm
2008	275.5	202.7	200.2
2009	164.7	144.1	158.1
2010	133.3	121.9	124.0
NIR (α = 0.05)	34.60		

DISCUSSION

Sewage sludge caused the changes in macro-and micronutrients in soil what is proved by numerous research (Baran i in. 1996a, 1996b,Furczak and others 2002). The fertilization with sewage sludge caused the decrease the concentration of potassium in soil compared to soil covered with sludge. It is proved by Krzywy and others (2003). There is no much publication related to the reaction of potassium and magnesium in soil under willow cultivation and addition of sewage sludge. Addition of sewage sludge caused changes in concentration of macronutrients. Decreasing of potassium and magnesium testified about uptaking these elements by willow to growth and development. The following research affirmed this thesis. In the growing season willow takes up the biggest amount of macronutrients especially nitrogen and phosphorus from sewage sludge (Mai-July) – in the period of the biggest development of biomass (Kaniuczak and others 2001, Perrtu 1993).

CONCLUSIONS

1. The content of available magnesium and potassium is strongly dependent on doses of sewage sludge and differentiated. The differentiation is caused by the properties of sewage sludge.
2. The highest amount of magnesium is seen on the object with sewage sludge and potassium on the control object.
3. The highest amount of magnesium is seen on the object with sewage sludge in the third year and decrease in the first and second year. The research showed the

decrease the amount of potassium within the years of experiment. It was cased by taking up by willow. The same tendency concerned the content of potassium.

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WPŁYW KOMUNALNYCH OSADÓW ŚCIEKOWYCH NA ZAWARTOŚĆ MAGNEZU I POTASU W GLEBIE POD UPRAWĄ WIERZBY

Streszczenie

Zgodnie z ustawą o nawozach i nawożeniu z dnia 10 lipca 2007 roku, osad ściekowy definiowany jest jako środek poprawiający właściwości fizyczne, chemiczne, fizykochemiczne i biologiczne gleby. Zasobność osadów ściekowych w makro- i mikroelementy ma istotny wpływ na wzrost i rozwój roślin. Wprowadzenie do gleby osadów ściekowych powoduje zmiany zasobności gleby w makro- i mikroskładniki, które są pobierane przez wierzbę. Oprócz substancji biogennych zawiera także substancje niepożądane: WWA, polifenole, dioksyny, a także związki ograniczające ich wartość w rolnictwie – metale ciężkie. W pracy przedstawiono wyniki dotyczące wpływu komunalnych osadów ściekowych na zawartość magnezu i potasu w glebie na różnych głębokościach gleby pod uprawą wierzby. Doświadczenie z klonami wierzby krzewiastej założono w 2003 roku, natomiast z osadem ściekowym w latach 2008-2010 w Stacji Badawczo-Dydaktycznej Uniwersytetu Przyrodniczego we Wrocławiu. Eksperyment został założony metodą split -plot z dwoma czynnikami zmiennymi: pierwszym czynnikiem były dwie dawki osadu ściekowego na tle kontroli: 14,3 $Mg \cdot ha^{-1}$ i 28,5 $Mg \cdot ha^{-1}$ s.m , a drugim czynnikiem były cztery klony wierzby krzewiastej. Analiza wariancji wykazała istotny wpływ badanych dawek osadów ściekowych oraz zróżnicowanie głębokości gleby na zawartość magnezu i potasu w glebie. Celem pracy było określenie zawartości magnezu i potasu w glebie pod uprawą wierzby i obecności osadów ściekowych.

Słowa kluczowe: osad ściekowy, magnez, potas, wierzba.