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THE INFLUENCE OF SEWAGE SLUDGE OBTAINED BY NIJHUIS WATER METHOD ON THE YIELD OF RYEGRASS AND CHEMICAL COMPOSITION OF SOILS

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A b s t r a c t. Waste sludge separated from sewage containing blood, content of chicken stomach and other organic and mineral compounds produced in poultry processing plant 'Drosed' at Siedlce contained in per cent of dry matter: N-8.85, P-1.2, K-0.12 and small amounts of heavy metals. Fertilizing value of sludge was higher than FYM applicated in dose of 10 % in relation to dry matter of soil. The highest yield of ryegrass was obtained in combination with 15 % of sludge applied in relation to dry matter of soil. Increasing the dose of sludge up to 20 % of dry matter of soil decreased the yield of ryegrass dry matter. Sludge applied in doses from 2 to 20 % of soil dry matter increased the content of nitrogen and carbon in soils, available phosphorus and potassium as well as decreased the degree of saturation ratio of sorption complex by base exchange cations, what acidified the fertilized soils.

K e y w o r d s: sewage sludge, ryegrass, soils

INTRODUCTION

Significiant progress in the field of the technology of sewage purification caused that the problem of sludge treatment and utilization of waste activated sludges became the most important.

In Poland during last few years a lot of foreign firms appeared, which offer modern development technology in the field of dewatering of waste activated sludges. Utilization of centrifugers for the dewatering of sludges as well as polyelectrolites in connection with bell press caused the possibility to obtain sludges containing about 20-30 % of dry matter. Among the proposals for the dewatering of sludges is the method developed by the Duch firm Nijhuis Water, according to which liquid wastes containing chicken stomach, chicken blood and other organic and mineral components are treated with sulphate iron and polyelectrolyte and organic components are separated then from the effluent by pressing. Waste sludges obtained in this way are past over for the agricultural utilization or are stored on waste dumps.

MATERIALS AND METHODS

Pot experiment (pots contained 1.5 kg of dry soil) was carried out in completely randomized experimental design on the light (weak rye complex) and heavy loam soil (very good wheat complex). The following factors were investigated:

I. a) without liming;
   b) Ca in the form of $CaCO_3$ according to 1 unit of hydrolytic acidity.

II. Differentiated doses of sludges: 2, 5, 10, 15 and 20 % of dry matter of soils and cow farmyard manure having 21.4 % d.m., and N-2.4 %, P-0.59 %, and K-2.48 % d.m. Farmyard manure was applied in 10 % in relation to dry matter of soil. This combination was treated as standard.

Ryegrass (*Lolium multiflorum*) was used as test plant which was cut 4 times in vegetation period. Yield of dry matter of ryegrass was determined by drying of green mass in temperature 60 °C for 24 h.

In sludges the following were determined: total nitrogen by Kjeldahl method, total carbon by oxidation-reduction method, and ash by ashing of sludge dry matter in muffle oven in temperature 550 °C. Ash was dissolved in diluted (1:1) hydrochloric acid and in this solution some macro- and microelements were determined by ASA and ESA methods (Table 1).

In the soil, after ending the experiment the contents of following elements were determined: total nitrogen by Kjeldahl method, total carbon by oxidation-reduction method using potassium dichromate as oxidation reagent [3], available phosphorus and potassium by Egner-Riehm method, hydrolytic acidity, and the sum of the base exchangeable cations [5].

RESULTS AND DISCUSSION

Waste sludges separated from sewage produced in chicken processing plant 'DROSED' at Siedlce by Nijhuis Water method (Table 1) contained very high concentration of nitrogen (8.80 %) in dry matter as compared to other sludges and very low concentration of potassium (0.12 % d.m.). So high amount of nitrogen in investigated sludges results from the sewage purification technology. In this method sewage flows in the treatment sewage plant without biological pretreatment and after direct treatment of sewage with sulphate iron and coagulation of organic components containing soluble aminoacids and protein from blood and from chicken stomach, compounds which contain high concentration of nitrogen. Low concentration of potassium in investigated sludge is characteristic for sludges obtained in sewage treatment plants [4]. It results that potassium compounds of sludges are easily soluble in water. During all the operations connected with transport of sewage and sludges during their separation, potassium passes to the separated liquid phase (effluent) which flows over to the neighbouring region beside the sewage treatment plant. This is very important problem and from the environmental point of view it has not been solved up to now.

Table 1. Chemical composition of sewage sludge from chicken processing plant DROSED at Siedlce

Determined element	The content in % or mg kg^{-1} d.m.
1. Dry matter in %	9.65
2. Total nitrogen in % d.m.	8.89
a. Nitrogen of compounds	
dissolved in 0.25 M H_2SO_4	6.52
in % of total nitrogen	
b. Nitrogen of compounds	7.60
dissolved in 25 % H_2SO_4	52.00
in % of total nitrogen	
3. Total carbon in % d.m.	10.00
a. Carbon of compounds dissolved	
in 0.25 M H_2SO_4	13.80
in % of total carbon	5.85
b. Carbon of compounds dissolved	
in 25 % H_2SO_4	
in % of total carbon	
4. C/N ratio	
	% d.m.
5. Phosphorus	1.20
6. Potassium	0.12
7. Calcium	0.19
8. Sodium	0.09
9. Magnesium	0.03
	mg kg^{-1} d.m.
10. Iron	15.967
11. Zinc	213.70
12. Lead	3.00
13. Chromium	< 1.00
14. Nickel	< 0.60
15. Copper	54.60
16. Manganese	235.90
17. Cadmium	< 0.40
18. Cobalt	18.20

The C/N ratio in applied sludges is very low (5.8). This shows on the possibility of quick mineralization process of organic compounds of sludges after their application into soil and release of high amount of available nutrients to plants.

The content of heavy metals - elements which limitate agricultural utilization of sludge - in investigated sludge was very low in comparison to standards proposed in this field [7].

Yield (g/pot) of dry matter of ryegrass (Table 2) as the sum of 4 cuts was significantly

Table 2. The yield (g/pot) of ryegrass dry matter

Kind of soil	Light			Heavy loam		
	0	Ca = $1H_h$	Means	0	Ca = $1H_h$	Means
Without fertilizers	6.0	7.2	6.6	8.1	8.7	8.4
FYM 10 %	10.5	9.5	10.0	9.1	10.8	9.9
Sludge 2 %	11.0	14.2	12.0	13.5	14.0	13.7
Sludge 5 %	14.8	12.6	13.7	16.7	11.7	14.2
Sludge 10 %	18.8	19.2	19.0	20.1	16.2	18.1
Sludge 15 %	19.5	29.5	24.5	21.8	22.2	22.0
Sludge 20 %	14.6	18.9	16.7	13.2	21.5	17.3
Means	13.6	15.9	14.7	14.6	15.0	14.8
LSD p = 0.05 for: liming			1.2			n.s
doses of sludge			2.1			1.7
liming doses x sludge		1.2	0.7		1.4	0.9

differentiated under the influence of investigated factors.

Liming on the light soil significantly increased the yield of ryegrass dry matter without any influence on loamy heavy soil. Farmyard and sludge applied on light soil significantly increased the yield but on loamy heavy soil only sludge significantly increased the yield of ryegrass. On the both soils the highest yield of ryegrass was obtained in the combination with sludge applied in a dose of 15 % in relation to dry matter of soils and these yields were from 2-3 times higher in comparison to yield obtained in the combination with farmyard manure.

Interaction of liming and sludge doses on the light soil was specifically high when sludge was applied in the dose of 15 % in relation to the dry matter of soil. In this combination liming increased the yield 51 % but on the loamy soil liming significantly decreased the yield at the 5 % dose of sludge more than 30 %.

The content of nitrogen and carbon in soils (Table 3) after ending the pot experiment significantly increased under the influence of the application of different doses of sludge. That results from the application of big amounts of these elements in sludge. Similar relationships were observed in other investigations [1,3]. The influence of liming on the content of mentioned elements was negligible.

The content of available phosphorus and potassium in soils (mg/100 g of soil) after ending the experiment (Table 4) in both soils increased under the influence of the applied doses of sludge. The content of the available phosphorus and potassium in the light soil under the influence of liming slightly increased, but in the loamy heavy soil the changes were not so regular. In the light soil liming usually increases the content of these elements but in the loamy heavy soils the amount of these elements decreases whereas phosphorus partly precipitate. The decreasing amount of potassium is the effect of antagonism between potassium and calcium [2].

Hydrolytic acidity (Table 5) in both soils increased under the influence of sludge application. Sum of the base exchangeable cations in the light soil decreased but on loamy heavy soil slightly increased, what is connected with the capacity of absorbing complex. Degree of saturation of soil by basic cations (V %) under the influence of the sludge application slightly decreased in the both soils. Acidification process in the light soil was higher than in the loamy heavy one and had the following values: 11 and 8 % without liming, respectively whereas 8 and 4 % in series with liming.

CONCLUSIONS

1. Chemical composition of sludge produced in chicken processing plant at Siedlce according to Nijhuis Water method shows the possibility of their agricultural utilization.

Table 3. The content (%) of nitrogen and carbon in soils

Liming	0			Ca = 1 H_h		
Determined elements	N	C	C/N	N	C	C/N
			Light soil			
Without fertilizers	0.06	0.06	10.0	0.07	0.71	10.0
FYM 10 %	0.08	0.63	7.9	0.07	0.73	10.4
Sludge 2 %	0.08	0.66	7.9	0.07	0.74	10.5
Sludge 5 %	0.09	0.66	7.3	0.09	0.80	8.8
Sludge 10 %	0.10	0.95	9.5	0.08	0.85	10.6
Sludge 15 %	0.10	0.85	8.5	0.14	0.85	6.0
Sludge 20 %	0.12	0.91	7.6	0.12	0.85	7.0
Means	0.09	0.75	8.3	0.09	0.79	8.7
			Loamy heavy soil			
Without fertilizers	0.32	2.00	6.2	0.28	2.03	7.2
FYM 10 %	0.36	2.05	5.6	0.36	2.29	6.4
Sludge 2 %	0.35	2.09	5.9	0.40	2.28	5.7
Sludge 5 %	0.36	2.06	5.7	0.32	2.46	7.7
Sludge 10 %	0.36	2.65	7.3	0.41	2.13	5.2
Sludge 15 %	0.42	2.32	5.5	0.41	2.13	5.2
Sludge 20 %	0.48	3.43	7.1	0.41	2.76	6.7
Means	0.37	2.37	6.4	0.37	2.29	6.2

Table 4. The content of available phosphorus and potassium

Kind of soil	Light		Loamy heavy	
Liming	0	Ca = 1H_h	0	Ca = 1H_h
		P_2O_5 (mg/100 g soil)		
Without fertilizers	16.6	17.6	15.6	16.6
FYM 10 %	16.0	22.0	16.6	15.6
Sludge 2 %	22.4	23.6	19.4	17.2
Sludge 5 %	18.4	18.4	20.8	20.0
Sludge 10 %	15.6	22.0	24.0	16.6
Sludge 15 %	20.0	22.0	22.0	20.8
Sludge 20 %	20.4	21.4	24.8	28.0
Means	18.5	21.0	20.4	19.2
		K_2O (mg/100 g soil)		
Without fertilizers	14.1	16.9	5.6	11.3
FYM 10 %	22.5	19.7	11.3	19.7
Sludge 2 %	22.5	16.9	28.2	14.1
Sludge 5 %	14.1	22.5	11.2	11.2
Sludge 10 %	16.9	16.9	16.9	11.2
Sludge 15 %	16.9	19.7	11.2	14.0
Sludge 20 %	16.9	16.9	11.2	14.0
Means	17.7	18.5	13.6	13.6

Table 5. Selected elements of sorption properties of soil

Liming	0				Ca = 1 H_h			
Sorption properties	mmol H^+/100 g of soil			V %	mmol H^+/100 g of soil			V %
	H_h	S	T		H_h	S	T	
				Light soil				
Without fertilizers	1.05	9.9	11.4	86	0.98	10.2	11.2	91
FYM 10 %	0.90	9.5	10.4	91	0.75	9.7	10.2	95
Sludge 2 %	0.60	10.8	11.4	95	1.05	11.3	12.3	92
Sludge 5 %	1.20	12.0	13.2	91	0.83	12.1	12.9	94
Sludge 10 %	0.83	9.5	10.3	92	0.90	10.0	10.9	92
Sludge 15 %	1.23	6.8	8.0	85	1.23	8.0	9.2	87
Sludge 20 %	1.43	7.3	8.7	84	1.43	8.7	10.1	86
Means	1.03	9.4	10.4	89	1.20	10.0	11.0	91
				Loamy heavy soil				
Without fertilizers	1.50	20.3	21.8	93	1.05	20.5	21.5	95
FYM 10 %	1.43	20.1	21.5	93	0.98	20.9	21.9	95
Sludge 2 %	0.98	21.8	22.8	96	0.98	22.1	23.1	96
Sludge 5 %	1.58	24.9	26.5	94	0.90	26.8	27.7	96
Sludge 10 %	1.50	29.5	31.0	95	1.43	30.2	31.6	95
Sludge 15 %	1.95	25.5	27.5	92	0.98	26.0	27.0	96
Sludge 20 %	2.03	22.2	24.2	91	1.80	22.8	24.6	92
Means	1.56	23.4	24.2	93	1.16	24.2	25.3	92

2. The highest yield of ryegrass was obtained when sludge was applied in dose of 15 % in relation to the dry matter of soil. Independent of soils the yield was two fold higher than the yield obtained in the combination with farmyard manure applied in dose 10 % of dry matter of fertilized soil.

3. The content of total nitrogen and organic carbon in soils after ending the pot experiment increased under the influence of sludge application.

4. Application of sludge increased acidity of soils proportionally to the applied doses of sludge.

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WPŁYW OSADÓW ŚCIEKOWYCH UZYSKANYCH METODĄ NIJHUIS WATER NA PLON RAJGRASU WŁOSKIEGO I SKŁAD CHEMICZNY GLEBY

Osad ściekowy wydzielony ze ścieków surowych zawierających krew drobiu, treści żołądków oraz innych związków organicznych i mineralnych Siedleckich Zakładów Drobiarskich 'DROSED' zawierał w suchej masie 8.85 %-N, 1.2 %-P, 0.12 %-K oraz nieznaczne ilości metali ciężkich. Wartość nawozowa osadu była wyższa niż obornika bydlęcego stosowanego w ilości 10 % w stosunku do masy gleby. Najwyższe plony rajgrasu włoskiego uzyskano na dawce 15 % osadu w stosunku do masy gleby. Zwiększenie dawki do 20 % powodowało obniżenie plonu suchej masy rajgrasu. Osad stosowany w dawkach od 2 do 20 % w stosunku do masy gleby powodował zwiększenie zawartości azotu i węgla oraz przyswajalnego fosforu i potasu w glebie oraz zmniejszenie stopnia wysycenia gleb zasadami co spowodowało zakwaszenie gleb.

Słowa kluczowe: osady ściekowe, rajgras włoski, gleby.