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INFLUENCE OF SEWAGE ON THE CONTENT OF TRACE ELEMENTS IN THE SOILS OF VARIOUS EROSION ZONES

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A b s t r a c t. Lublin municipal waste water effluent treated in two stages (mechanical and biological) was used in the monoliths filled with loess soil of an undisturbed structure taken from different erosion zones: W - top (grey-brown podzolic soil): D - bottom of the valley (deluvial soil); N - northern slope (brown soil - weakly eroded), S - southern slope (calcareous soil - strongly eroded). Control objects were the monoliths treated with equal amounts of water and nutrients: N, P, K, Mg. In the soils treated with sewage and water and mineral salts, a similar increase in the content of soluble metal forms (Zn, Cu, Mn, Pb, Cd, Ni) was observed.

K e y w o r d s: sewage, heavy metals, eroded soils.

INTRODUCTION

Using sewage in agriculture is one of the best ways of its utilization and is well justified in terms of water balance and recycling of plant nutrients [2]. However, sewage, contains not only macro- and microelements necessary for plants, but also harmful heavy metals, which may cause many unfavourable changes in living organisms when introduced to the food chain. Using sewage could also cause periodical soil hypoxia caused by excess humidity. Reduction processes, which occur in the soils flooded with sewage, are very important for the effective usage of nutrients by plants, including the uptake of toxic heavy metals.

The aim of the present research was to evaluate the influence of post-sewage waters from the city of Lublin after a two-stage treatment (mechanical-biological) on the content of soluble forms of metals (zinc, copper, manganese, lead, cadmium, and nickel) in the soils in different stages of deformation caused by surface water erosion.

MATERIALS AND METHODS

The present research was carried out on the soils derived from loess. They represented four erosion zones: grey-brown podzolic soil from the top (which was not subjected to erosion), brown soil from the northern slope (weakly eroded), deluvial soil from the bottom of the valley, and calcareous soil from the southern slope (strongly eroded).

In 1989, the soils were placed in plastic pipes - 50 cm high, called monoliths. Four monoliths from each erosion zone were put in the ground, 50 cm deep next to one another on a flat area. This way erosion pressure characteristic of the areas with strong relief, and microclimate differences were eliminated.

The following fertilizers were used under plants cultivated in the monoliths (rape, sunflower, and cocksfoot) in 1996, 1997, and 1998: treated Lublin sewage - in two monoliths of each zone; an equal amount of plant nutrients in the form of mineral salts - in the other two. During three vegetation seasons, total amount of nutrients used was as follows (values given in g/monolith): N - 4.5; P - 0.96; K - 3.72; Mg - 1.50.

In each vegetation season, 50 portions containing 1 dm^3 of sewage per a monolith or 50 portions containing 1 dm^3 of distilled water plus mineral salts with N, P, K, and Mg were used. In the soil samples taken prior to sewage application and after two years of its application, the following parameters were determined: pH_{KCl} - using a potentiometer; hydrolytic acidity (Hh) - using the Kappen's method; content and saturation of the sorptive complex with basic cations: K^+, Na^+, Ca^{2+}, and Mg^{2+}. Content of trace elements soluble in the 1 mol solution of HCl/dm^3 (ratio of soil to solution 1:10; time of extraction - 1 hour of shaking) was evaluated by the method of atomic absorption spectrometry using a HITACHI-2200 apparatus. Contents of Zn, Mn, Cu, and Pb was determined using the AAS flame apparatus, while Cd and Ni were measured flamelessly in a graphite burner.

The treated sewage used in the experiment contained the following amounts of metals (an average in g/m^3): Zn - 1.80; Mn - 12.40; Cu - 0.45; Pb - 0.38; Cd - 0.07; Ni - 0.24.

RESULTS AND DISCUSSION

Sewage caused an increase in the amount of basic cations, which means a decrease in the value of hydrolytic acidity and increase in pH_{KCl} (Table 1). Those changes occurred in comparison with the initial values prior to sewage application, as well as in comparison to the monoliths treated with mineral salts with N, P, K, Mg and distilled water. The smallest changes occurred in the monoliths with the

Table 1. pH_{KCl}, hydrolytic acidity (Hh), and sum of bases (mmol(+)/kg)

Object	Soil	pH		Hh		Sum of bases (s)	
		Before experiment 1996	After experiment 1998	Before experiment 1996	After experiment 1998	Before experiment 1996	After experiment 1998
Sewage	W	5.6	6.3	24.0	12.0	60.9	69.5
	N	5.1	5.3	34.1	20.0	62.6	83.7
	D	6.0	6.4	12.1	9.4	86.2	91.9
	S	7.1	7.3	4.4	3.7	232.6	210.6
Mineral salts	W	5.6	4.5	24.0	32.6	60.9	40.7
	N	5.1	4.1	34.1	41.6	62.6	62.0
	D	6.0	4.9	12.1	25.5	86.2	69.3
	S	7.1	7.2	4.4	4.1	232.6	211.2

Explanations: W - top - grey-brown podzolic soil; N - northern slpe - brown soil, weakly eroded; D - bottom of the valley - deluvial soil; S - southern slope - calcareous soil, strongly eroded.

soil taken from the strongly eroded, southern slope, where a high content of calcium carbonate $CaCO_3$ caused several times higher contents of basic cations (S) and low concentration of protons. Great buffering abilities of that soil (calcareous soil) blocked acidifying activity of the used mineral salts and alkalizing activity of the sewage. An increasing content of basic cations in the soils hydrated with sewage is, first of all, caused by an increased amount of exchangeable sodium (Na). However, in the long run, we did not observe any significant increase in the ratios of Na:K, Na:Mg, Na:Ca due to a relatively easy washout of Na from the soil profile [1].

Changes in the degree of acidification and cation saturation in the sorptive complex of the soils hydrated with sewage, could have also affected the amount of soluble forms of trace elements. Table 2 shows contents of microelements: copper (Cu), zinc (Zn), and manganese (Mn) in the soils from different erosion zones, on which sewage and equal amounts of nitrogen, phosphorus, potassium, and magnesium in the form of mineral salts was applied. In both groups of monoliths, hydrated with sewage and hydrated with distilled water, a clear increase in the content of the investigated microelements was observed after two years. Such tendency occurred with similar intensity in the soils from particular erosion zones. In most cases, after two years of application of sewage and mineral salts and distilled water, the content of microelements increased over two times. Research of Łabuda [3] proved that sewage application did not influence either a significant decrease or increase in the content of microelements in the soils. Other authors [6] proved a significant growth of the content of microelements in the soils hydrated with sewage.

Table 2. Content of microelements soluble in 1 M HCl/dm^3 in soils (mg/kg)

Object	Soil	Cu		Zn		Mn	
		Before experiment 1996	After experiment 1998	Before experiment 1996	After experiment 1998	Before experiment 1996	After experiment 1998
Sewage	W	1.3	2.4	7.5	14.9	60.0	146.5
	N	1.1	2.2	4.4	9.7	38.5	103.7
	D	1.5	3.3	7.8	15.9	72.0	164.0
	S	1.6	2.9	8.7	15.3	66.8	162.6
Mineral salts	W	1.0	2.3	5.6	17.2	53.5	139.5
	N	1.1	2.4	4.7	9.9	41.5	95.5
	D	1.5	3.2	6.7	14.5	69.1	161.5
	S	1.6	3.1	8.7	14.5	66.7	164.5

Explanations as in Table 1.

Table 3. Content of heavy metals soluble in 1 M HCl/dm^3 in soils (mg/kg)

Object	Soil	Pb		Cd		Ni	
		Before experiment 1996	After experiment 1998	Before experiment 1996	After experiment 1998	Before experiment 1996	After experiment 1998
Sewage	W	4.3	10.8	0.107	0.199	0.5	1.3
	N	4.0	8.0	0.091	0.150	0.5	1.1
	D	4.4	10.5	0.128	0.236	0.9	1.9
	S	3.7	8.5	0.140	0.253	0.8	1.9
Mineral salts	W	3.8	10.4	0.098	0.196	0.4	1.4
	N	3.6	8.7	0.098	0.156	0.5	1.2
	D	4.4	10.2	0.127	0.229	0.5	2.0
	S	3.7	9.1	0.137	0.262	0.8	1.9

Explanations as in Table 1.

A similar growth after sewage application was observed in the case of heavy metals: lead (Pb), cadmium (Cd), and nickel (Ni). An increased concentration of heavy metals in the soil surface layer could result from bioaccumulation and anthropopressure with dust deposits, sewage and waste application [4,7].

Generally, it can be stated that sewage application caused a significant growth of the content of the investigated trace elements soluble in the 1 M HCl solution in the soils. That growth was observed both in the microelement (Zn, Cu, and Mn) content and the content of toxic heavy metals (Pb, Cd, and Ni). Since similar growth in the content of soluble trace elements was observed in the monoliths treated with water containing mineral salts, it can be suspected that it was caused not so much by the introduction of elements together with the sewage, but rather their mobilization from the soil reserves.

CONCLUSIONS

The present research on the effect of sewage on the content of trace elements in the loess soils of various erosion zones allowed to draw the following conclusions:

1. After two years of sewage application and application of equal amounts of salts containing nitrogen, phosphorus, potassium, and magnesium and distilled water, similar, easy-to-notice growth in the content of soluble microelements, such as copper (Cu), zinc (Zn), and manganese (Mn), as well as the content of heavy metals: lead (Pb), cadmium (Cd), and nickel (Ni) was observed in the loess soils from various erosion zones.

2. Similar tendencies towards changes in the content of the investigated elements in the soils hydrated with sewage and distilled water, and those fertilized with equal amounts of mineral salts, allow to state that the increase in the element concentration was caused not so much by the introduction of these elements with the sewage, as by their mobilization from the soil reserves.

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