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Letter to Editor

The Influence of Applying Purified Municipal Sewage on Nickel Content in Plants

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Abstract

This research evaluated the impact of purified municipal wastes from Lublin on nickel accumulation in tested plants due to varied rates of sewage. Moreover, the fodder value of some plants was estimated.

The experiment was localized in Bystrzyca river valley in 1996, covering an 8-hectare area. Studies were carried out on soils: (division) hydrogenic, (type) bog and bog-like, (sub-type) peat-bog and mineral-bog. The experimental field was divided into 7 blocks and each block into 3 quarters (a, b c). Sewage was applied at three rates under every cultivation: a – control; b – sewage rate optimum for a given plant (established on a base of N content and water demands); c – double optimum rate. Plant material was randomly collected in July and September 1997.

The ability for nickel accumulation in the investigated plants decreased along the sequence: grass mixtures > rape > hemp > maize > poplar (leaves) > willow (leaves).

Keywords: municipal sewage, nickel, plants

Introduction

Urbanization and industrialization of Poland made a great increase of sewage water amounts. Therefore, their purification became a very important problem, especially as regarding those associated with environmental protection [1]. Evident reduction of total sediments, BZT_5, CHZT, worm eggs, disease bacteria and heavy metals which accumulate in larger quantities in sewage sludge, can be observed in the way of waste utilization – mechanical-biological-combined purification – undertaken in our country. However, relatively high levels of nitrates and soluble phosphates that cause water eutrophization, still remain in purified sewage. Such waste utilization in agriculture is reasonable in a view of water and nutrients balance [2, 3]. Utilization of mechanically and biologically purified municipal sewage due to applying them for agrosystem irrigation is its third-level purification reducing biogenes amount to the level restricted by Polish and EU normatives [4].

Along with great amounts of biogenes introduction, there is the threat of introducing some heavy metals quantities. Nickel can be an example.

Organic matter binds nickel, mostly as mobile chelates, in the soil [5]. It is very important at sewage application as an unconventional fertilizer.

Nickel is concerned as an element playing no significant role in a plant, and at toxic level, it acts unfavorably, mainly because of the interaction with iron [6, 7]. On the other hand, the latest reports indicate its necessity as a microelement in plant production. Being a part of the urease enzyme, it enters for nitrogen management. Plants treated with nitrogen into leaves in a form of urea show elevated demands for nickel [8].

The aim of the research was to evaluate the impact of purified municipal wastes from Lublin on nickel accumulation in tested plants due to varied rates of sewage. Moreover, the fodder value of some plants was estimated.

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Table 1. Schedule of the experiment.

Tested Plants (Block)	Total dose (mm)			Disposable dose (mm)		Number of doses
	a	b	c	b	c	
1. Popolar	0	900	1800	75	150	12
2. Willow	0	900	1800	75	150	12
3. Maize	0	600	1200	50	100	12
4. Hemp	0	600	1200	50	100	12
5. Rape	0	400	800	40	80	10
6. Grass Mixture I	0	600	1200	60	120	10
7. Grass Mixture II	0	600	1200	60	120	10

(1) poplar – *Populus alba* and *Populus nigra*; (2) willow – *Salix americana* and *Salix viminalis* in two forms: "basket" and "protective"; (3) seeds of middle early maize hybrid varieties; (4) hemp (*Cannabis sativa* cv. Białobrzeskie); (5) rape (*Brassica napus* ssp. *oleifera* cv. Lisonne); (6) 6a, 6b and 6c quarters were sown with mixture more useful in wetter habitats with the majority of: timothy, cocksfoot, bluegrass and ryegrass; (7) 7a, 7b and 7c quarters were sown with mixture more useful in drier habitats with the majority of: fescue, timothy, cocksfoot, bluegrass and ryegrass.

Table 2. Nickel content (mg/kg) in plants from fields irrigated with municipal sewage.

I harvest						
Objects	Poplar (leaves)	Willow (leaves) S. viminalis	Willow (leaves) S. americana	Maize (flowering stage)	Hemp	Rape (flowering stage)
A	0.25	0.50	0.25	0.25	0.50	0.25
B	0.25	0.25	0.25	-	0.25	0.25
C	0.50	-	0.25	-	0.25	-

II harvest								
Object	Poplar (leaves)	Willow (leaves)	Willow (leaves)	Maize		Hemp (Konopie)	Rape (Rzepak)	
				Straw	Seeds		Straw	Seeds
A	0.50	-	0.25	0.25	0.25	1.25	0.25	2.25
B	0.25	0.25	0.25	-	0.50	1.50	-	1.50
C	0.50	0.25	0.25	0.50	-	1.25	0.50	1.00

"-" - lack of the plant samples

Materials and Methods

The experiment was localized in the Bystrzyca river valley in 1996. It covered an 8-hectare area. Studies were carried out on soils: (division) hydrogenic, (type) bog and bog-like, (sub-type) peat-bog and mineral-bog. The experimental field was divided into 7 blocks and each block into 3 quarters (a, b c). Sewage was applied at three rates under every cultivation: a – control; b – sewage rate optimum for a given plant (established on a base of N content and water demands); c – double optimum rate.

Plant material was randomly collected in July and September 1997.

Scheme of the experiment was shown in Table 1.

Before experiment setting, the soil was characterized by the following parameters: pH 7.3, C_{org} – 18.7%, very high level of available phosphorus and very low contents of potassium and magnesium. Nickel content oscillated around 5.49 mg/kg of soil. No additional mineral fertilization was applied during the experiment.

Initially dried plants were digested at 500°C with NH_4NO_3 addition to accelerate the process [9]. The ash obtained was dissolved in HCl (spectral grade) in re-distilled water solution (1:1). Nickel was complexed using ammonium pyrolydinedithiocarbamate (APDC) and then analyzed in methylisobutyl ketone (MIBC). Nickel content was recorded by means of AAS technique using Perkin-Elmer 1100B device.

Results and Discussion

Application of purified sewage and different plant species affected the differentiation of nickel content in plants used for the experiment (Tables 2, 3).

The highest amounts of nickel were observed in grass mixtures. However, wastes significantly decreased the nickel accumulation in the 2nd and 3rd cut as compared to the control (Table 3). The ability for taking relatively great amounts of heavy metals by grasses, in comparison to other irrigated species, can be associated with their genetical features [6, 10].

Table 3. Nickel content (mg/kg) in grass mixtures from fields irrigated with municipal sewage.

Objects	Mixture I			Mixture II		
	I cut	II cut	III cut	I cut	II cut	III cut
A	1.25	2.00	1.75	1.00	1.30	2.25
B	1.25	1.75	1.50	0.50	0.75	1.50
C	1.25	1.00	0.75	1.00	1.25	1.00

Similarly as for grasses the decrease of nickel amount under the influence of wastes application was observed in rape seeds. Nickel is concerned to be one of the small heavy metals having the ability to accumulate in generative plant organs at high concentrations. Nickel level in rape seeds was close to that found in areas with no direct environment pollution threats [6].

Maize and poplar leaves were those where elevated nickel contents due to sewage application were found as compared to the control (Table 3). In a case of the latter plant, only a double sewage rate caused the increase of nickel level. It similarly affected the nickel content in rape straw. Willow appeared to be the most resistant to nickel accumulation due to irrigation with purified wastes (Table 2).

The plant species was the factor most determining nickel level in plants. Similar dependencies were found for other heavy metals, whose concentrations were studied in the same experiment [11]. The ability for nickel accumulation decreases along the sequence: grass mixtures > rape > hemp > maize > poplar (leaves) > willow (leaves).

In the opinion of Kabata-Pendias *et al*. [12], nickel concentration limit in plants for fodder utilization amounts to 30 mg/kg and did not exceed that value by any root species in the experiment (Tables 2, 3).

Soil and waste properties were other factors determining nickel content in plants. The soil reaction mostly determines nickel mobility [13]. According to Kabata-Pendias [6], nickel solubility increases below pH 6.0. In the present study, high pH value (about 7.3) and quite great organic matter percentage points to decreased nickel mobility.

Nickel content in purified sewage, taking into account Polish normatives [Order of Ministry for Natural Environmental Protection and Forestry, 1991], did not exceed the limit of 0.2 mg/dm^3 relating to its agricultural usage from the beginning of sewage plant functioning (Fig. 1). Thus, the factor did not significantly influence the increase of nickel availability by plants under study.

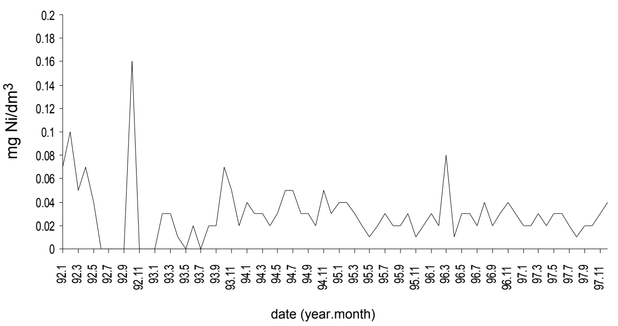

Fig. 1. Nickel content in purified municipial sewage from Lublin (MPWiK data 1998).

Conclusions

Field irrigation with purified sewage affected the different nickel accumulation in tested plants. The ability for nickel accumulation in the investigated plants decreased along the sequence: grass mixtures > rape > hemp > maize > poplar (leaves) > willow (leaves).

The highest nickel levels were found in grass mixtures, but the element content did not exceed the limits for plants utilized as fodder.

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