Influence of the Organic Fertilizer Condit on the Content of Heavy Metals and Soil Chemical Properties

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Summary

Effect of amendment Condit on the mobility and uptake of Cd, Pb and Ni by crops, such as peas, spring barley, carrot and red beet, and selected chemical soil properties was tested in a field trial in years 2006–2008. Experimental field was situated close by sources of pollution, chemical factory Chemko Strážske and waste dump. The soil at experimental area was highly contaminated mainly by Cd. Heavy metals content was tested in the following parts of the crops: pea seed, spring barley green mater, carrot root and red beet root. Heavy metals content in soil and plant samples was detected in 2M HNO_3 solution by the AAS method. It was found that Condit reduced Cd content in the soil under each cultivated crop. The most considerable Cd reducing (77.2%) was at treatment with pea. The reduction of Pb and Ni content in the soil after Condit application was markedly lower as in the case of Cd, in comparison with control treatment. Positive effect of tested amendment Condit on reduction of Cd uptake was found by all crops under test. The best effect of Condit was found in carrot. Content of Cd in the carrot root was lower for about 55% compared with control treatment without amendment. Soil organic carbon content was significantly higher at treatment with Condit in comparison with control treatment. Measured content of soil organic carbon was higher by 1.16 g kg^{-1}. The changes of soil carbon were insignificant at control treatment. Tested amendment Condit had significant impact on uptake of all measured heavy metals by plants. The result suggests that most significant impact had Condit on uptake of Cd. The measured amounts were the lowest of evaluated heavy metals.

Key words

soil contamination, amendment, cadmium, lead, nickel, immobilization

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Introduction

Pollution of agricultural soils with heavy metals such as cadmium (Cd), lead (Pb) and nickel (Ni) is still one of the most serious concerns for the functionality of ecosystems in the world. The risk associated with such sites depends on soil characteristics (e.g. content of clay, sesquioxides, organic matter and pH), climate factors (e.g. precipitation, winds and temperature) and environmental behaviours of the toxic contaminants (Filius et al., 1998; Danielovič et al., 2003; Zhou 2003).

This contamination with Cd, Pb and Ni is mainly caused by mining, smelting activities (Cang et al., 2004; Quartacci et al., 2006) power stations, heating systems, waste incinerators, urban traffic (Sanita di Toppi and Gabbrielli, 1999) and application of industrial effluents as water source for irrigation of crop plants (Rattan et al., 2005; Abbas et al., 2007). Accumulation of Cd, Pb and Ni in the soils has toxic effects on microorganisms, plants and ultimately on animals and human health via the food chain (Rulkens et al., 1998).

Increased Cd content up to 50 mg kg^{-1} in the soil is caused mainly by industrial development in the last decades (Adriano, 2001).

High concentrations of heavy metals in the environment can pose concerns for human health due to their persistence and carcinogenic and mutagenic effects (Turgut et al., 2004) and other heavy metals such as cadmium (Cd) and lead (Pb) have unknown biological functions (Kos and Lestan, 2004). Furthermore the uptake and accumulation of these metals in plants can cause adverse effects in terms of growth and biomass yield due to impairment of natural processes such as photosynthesis, respiration, and nitrogen assimilation (Sanita di Toppi and Gabbrielli, 1999).

Several physical, chemical, phyto, and engineering techniques have been used for the remediation of heavy metal-polluted soils (Mench et al., 1994; Shuman, 1999).

The application of soil amendments to immobilize heavy metals is a promising technology to meet the requirements for environmentally sound and cost-effective remediation (Gupta et al., 2007)

Soil amendments can help to: reduce labile contaminant pools, minimize organism exposure, promote plant development and limit migration to the groundwater (Kumpiene et al., 2008).

The chemical stabilization methods were considered to be the most cost-effective ways to immobilize heavy metals in the soils (Chen et al., 2000). The influence of organic substances on the availability of the heavy metals depends on the nature of these metals, soil types and the organic matter properties, particularly the degree of humification (Walker et al., 2004). Organic matter has a vital role in controlling the mobility of heavy metals in soils. It may decrease the available concentrations of heavy metals in soils by precipitation, adsorption, or complexion processes (Bernal et al., 2007).

Chemical amendments that form water soluble metal complexes, making metals more bioavailable for uptake by roots, have been identified as successful candidates to desorbs metals from the soil matrix (Schmidt, 2003). Chelating agents (Chiu et al., 2005; Kulli et al., 1999), organic acids (Chen et al., 2003; Evangelou et al., 2006), amino acids (Kerkeb and Kramer, 2003; Singer et al., 2007), synthetic and biosurfactants (Jordan et al., 2002; Mulligan, 2005), and inorganic ligands (Kayser et al., 2000; Puschenreiter et al., 2001) have been previously studied for enhancing bioavailability and metal accumulation in plant parts.

The effect of sorbents, such as zeolite and different calciferous compounds, on the content of Cd, Pb and Zn was observed by Castaldi et al. (2009) who found that these sorbents decreased the heavy metal content in wheat and peas. Similarly, the positive effect of liming on Cd content in spring wheat was found by Tlustoš et al. (2006). Kirkham (2006) stated that not only soil pH value but also soil organic matter content influence on Cd uptake by plants.

Greenhouse pot studies that tested methods to reverse or prevent Ni phytotoxicity (remediate) to sensitive crops (oat; red beet) were conducted on highly Ni contaminated soils from Port Colborne (Kukier and Chaney, 2000, 2001).

Fertilized but otherwise untreated soil caused significant Ni phytotoxicity to oats and red beet, but not to wheat, on both soils. Adding limestone reduced the concentration of Ni in shoots of all species and alleviated the symptoms specific to Ni phytotoxicity in oat. The experiment indicates that some combination of limestone and Fe oxides can readily remediate Ni phytotoxicity of the tested soils.

Liming like a means of eliminating the high Ni content in the soil and its phytotoxicity have observed also Siebelec et al. (2007). Phosphate application in hydroxyapatite form to Pb immobilization describes (Ma, 1996; Laperche et al., 1997). Geebelen et al. (2002) have observed at pot experiment impact of bentonite, zeolite, ash, compost, liming, steel slag and hydroxyapatite on Pb immobilization. The result was that the highest impact on Pb immobilization had a bentonite and steel slag.

The present study was conducted to reveal the effects of the organic fertilizer Condit on the mobility of heavy metals (Cd, Pb and Ni) and uptake by selected crops and on the selected chemical soil properties.

Material and methods

The study was conducted at farmer's field situated near by city Strážske. Strážske is located 17 km northerly of city Michalovce, Slovakia. Experimental field is situated close by sources of pollution, chemical factory Chemko Strážske and waste dump. The experiment was realized at Haplic Planosol (Dystric) with average content of clay particles between 30 and 40% (particles < 0.01 mm). The soil at experimental area was highly contaminated mainly by Cd. Measured content of Cd in the soil highly exceeded the content approved by the Slovak Law on Soil Protection No. 220/2004 and was in the range from 5.1 mg kg^{-1} to 12.9 mg kg^{-1}. Measured content of Pb was in the range from 25.0 mg kg^{-1} to 35.0 mg kg^{-1} and content of Ni was in the range from 5.0 mg kg^{-1} to 9.5 mg kg^{-1}. Soil acidity expressed as pH in KCl solution was 6.2 and the content of soil organic matter was 2.4%.

The experiment was conducted in a block design with four replicates for each treatment and was established during 2006 – 2008. Under conventional tillage 0.25 – 0.30 m deep mouldboard plough (tractor-driven) treatment was applied yearly in the autumn. Seeds were sown with a hand drill in the spring. To determine the impact of organic fertilizer Condit on the uptake

Cd, Pb and Ni by field pea, spring barley, carrot and red beet Condit was applied at level of 5 t ha^{-1}.

Condit is an organic-biological fertilizer, which can be granulated or non-granulated (granulated form was used in this experiment), gray-black or black with soil-like odour and without any off-odours. Condit causes soil microbial activities, positively affects nutritional and health condition of plants as well as thermic, air and water regime of the soil. It also improves humus horizon for a longer time period and can be characterized as biological fertilizer. This fertilizer improves plant growth because of the optimization of soil conditions for soil microorganisms. It is assumed that this fertilizer potentially decreases the accumulation of heavy metals in the soil owing to their bonds to humic acids contained in the fertilizer. Additional characteristics are: dry matter (DM) 60 – 90%, ash content 10 – 20% in DM, N total 2 – 15% in DM, P as P_2O_5 0.4 – 0.6% in DM, K as K_2O 0.5 – 0.7% in DM; pH/H_2O 8.1 – 8.6, C:N ratio 5:1 – 18:1, total microorganism number 2.10^5, Cd total 0.3 mg kg^{-1} solids, Pb total 3 mg kg^{-1} solids, and Ni total 11 mg kg^{-1} solids.

Soil samples and also crop samples were collected from all four replicates and were analyzed for Cd, Pb and Ni content. The content in crops was measured in pea bean, spring barley green matter (total plant), carrot root and red beet root. In spring barley, we analyzed the whole plant due to low accumulation of heavy metals in grain (Adriano, 2001). Heavy metals content in soil and plant samples was detected in 2M HNO_3 solution by the AAS method.

The results were evaluated according to the Decision Slovak Republic No. 531/1994-540 even though the new Law No. 220/2004 (in Slovakia) is in use. We decided to use the mentioned Decision because the mobile and possibly mobile forms of heavy metals in the soil (2 M HNO_3) from the point of availability for plants are very important. The content of heavy metals in soil solution of aqua regia (Law No. 220/2004) is pseudototal content with limit value for Cd 0.4 – 1.0 mg kg^{-1}, for Pb 25 – 115 mg kg^{-1} and for Ni 40 – 60 mg kg^{-1}.

Soil samples were also analyzed for selected soil characteristics (organic carbon, soil exchange reaction, available phosphorus, and available potassium) and were collected at the beginning (year 2006) and at the end of experimental period (year 2008). The disturbed soil samples were analysed using well-known methodologies to determine the following chemical soil parameters: organic carbon by Tjurin method (Hraško, 1962), soil exchange reaction by potentiometric method (Fiala et al., 1999), and available phosphorus and potassium by Mehlich III method (Trávník et al., 1999).

Collected data were evaluated by Multi-factorial analysis of variance (ANOVA). Statistical analyses were performed using the Statgrafics software package. Simple linear regression analysis was also carried out. Correlation coefficient (r) was verified at $P \leq 0.005$ levels.

Results and discussion

Effect of organic amendment – Condit on selected heavy metals in the soil

Measured content of selected heavy metals in the soil for each experimental year are presented in the Table 1. Measured content of Cd was hazardous from the point of view of soil contamination consequently plant contamination, because it's content was several fold higher than the maximum allowed amount of Cd in the soil (by course of Law 220/2004). Measured average total contents of Cd were in the range from 7.04 mg kg^{-1} to 10.78 mg kg^{-1}. It was found that Condit reduced Cd content in the soil under each cultivated crop. The most considerable Cd reducing (77.2%) was at treatment with pea. The decline of Cd content, in this case mobile fraction (leaching by NH_4NO_3), after using of soil amendment (iron grit) was recorded also by Hanaeur et al. (2011).

It was found, that reduction of Pb and Ni content in the soil after Condit application was markedly lower as in the case of Cd, in comparison with control treatment. In terms of mobility Pb belongs to the least mobile chemical element, especially in the case of fixation by carbonates and sulphates. Lead can

Table 1. Content of Cd, Pb and Ni in the soil after crops harvesting

Treatment	Cd [mg kg-1]				Pb [mg kg-1]				Ni [mg kg-1]			
	2006	2007	2008	Average	2006	2007	2008	Average	2006	2007	2008	Average
A_1B_1	9.52 (1.06)	12.15 (1.15)	10.68 (0.96)	10.78	33.59 (1.87)	32.04 (1.53)	29.68 (2.06)	31.77	6.69 (0.76)	7.74 (0.66)	8.1 (0.81)	7.53
A_1B_2	2.21 (0.26)	1.61 (0.12)	3.56 (0.36)	2.46	29.65 (1.76)	31.47 (2.44)	28.54 (1.95)	29.89	6.11 (0.81)	7.52 (0.59)	7.49 (0.56)	7.04
A_2B_1	8.59 (0.76)	10.85 (0.92)	9.26 (1.60)	9.57	38.54 (2.46)	39.36 (2.39)	37.86 (2.18)	38.59	8.14 (0.58)	8.86 (0.69)	9.22 (0.73)	8.74
A_2B_2	4.5 (0.43)	3.72 (0.29)	3.25 (0.31)	3.82	35.55 (1.95)	36.69 (2.87)	35.24 (1.77)	35.83	8.02 (0.55)	8.82 (0.71)	8.56 (0.68)	8.47
A_3B_1	7.16 (0.69)	6.53 (0.60)	7.42 (0.81)	7.04	34.59 (2.56)	32.7 (1.95)	30.74 (1.86)	32.68	5.99 (1.06)	7.66 (1.06)	6.98 (1.06)	6.88
A_3B_2	2.02 (0.16)	1.71 (0.12)	2.99 (0.36)	2.24	30.12 (2.51)	29.46 (1.84)	27.88 (1.79)	29.15	5.29 (0.49)	7.58 (0.71)	6.54 (0.66)	6.47
A_4B_1	7.85 (0.83)	9.58 (0.99)	8.51 (0.92)	8.65	33.69 (2.51)	34.29 (1.91)	33.25 (2.16)	33.74	7.36 (0.61)	8.14 (0.86)	7.88 (0.73)	7.79
A_4B_2	4.59 (0.56)	6.11 (0.61)	7.11 (0.78)	5.94	32.11 (2.22)	30.11 (2.01)	32.11 (2.17)	31.44	7.01 (0.59)	6.66 (0.49)	6.56 (0.51)	6.74

Values in parenthesis indicate standard errors of the mean, n=3; A_1 – peas; A_2 – spring barley; A_3 – carrot; A_4 – red beet; B_1 – control; B_2 – Condit be fixating in the soil not only by organic fractions but also by clay minerals. Experiment was realized at loamy soil with higher content of clay particles. Alloway (1995) found that especially Pb, in clay soils is immobilized into soil solids, but its behavior changes extremely under anthropogenic influence. Similar conclusions were made by Palmrothl et al. (2006) in a study with Pb, Zn and Cu, where Pb reduction in the soil was not significant (P<0.05), regardless of amendments and type of extraction.

Tested amendment Condit didn't increase content of Cd, Pb and Ni in the soil under all treatments. Several authors have reported increased heavy metals availability after soil fertilization with composted biosolids, although in spite of low total of heavy metal amounts in it (Plauquart et al., 1999; Illera et al., 2000). Mentioned tendency wasn't confirmed at our experiment. We incline to the opinion that organic amendments (with lower and the lowest content of heavy metals) had reduced content of available forms of metals, rather than to the opinion that organic amendments had increased content of available forms of metals. Heavy metal mobility can be reduced by vegetation and organic amendments in the case of fresh contamination (Clemente et al., 2006). Mentioned trend is confirmed also by Friesl et al. (2006). Authors tested five different amendments in order to reduce the mobile fractions and plant uptake (using *Hordeum vulgare* L.) of As, Cd, Pb and Zn in pot and field experiments. The best results were obtained by adding 3% amendments (2.5% gravel sludge and 0.5% ferrihydrite) to decrease the mobile fractions (e.g. Cd by 41% in pot and 96% in field experiments) as well as the plant uptake (e.g. Cd by 62%) compared to the control.

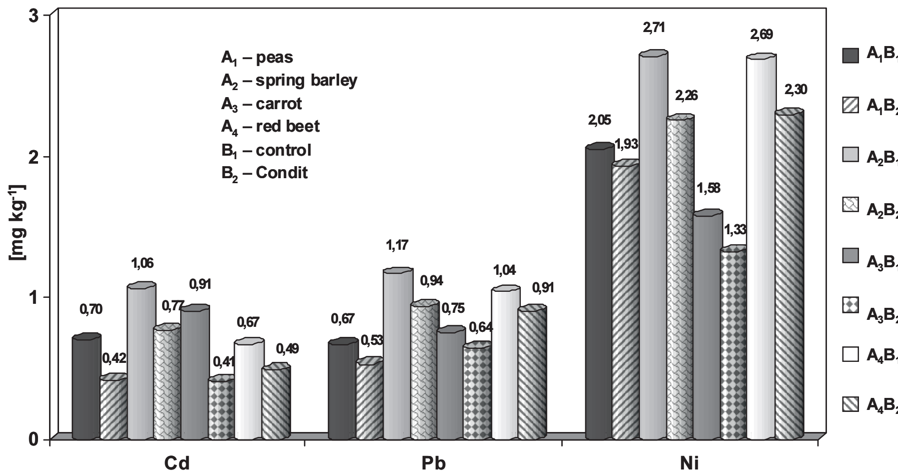

Figure 1. The average content of Cd, Pb and Ni in the crops (2006-2008)

Effect of organic amendment – Condit on selected heavy metals in plants

The higher average content of Cd in the soil, which was severalfold higher than the maximum allowed amount of Cd in the soil, resulted in overloaded content in the pea and carrot. Positive effect of tested amendment Condit on Cd uptake was found at all crops under test. The best effect of Condit was found at carrot. Content of Cd in the carrot root was lower for about 55% in comparison with control treatment without amendment (Figure 1).

Gaj and Schnug (2002) found, that soya and wheat had cumulated higher amounts of Cd at contaminated treatment in comparison with control treatment without Cd application. Content of Cd at contaminated treatment was 3 mg per kilogram of soil. Authors also found that uptake of Cd by the wheat plants was reduced by 35% and by the soya plants by 52% after the application of organic fertilizers. Favourable effect of organic amendments on Cd uptake (but also of mineral amendments) was found also by Keller et al. (2005).

Effect of Condit on the Pb and Ni uptake was less clear than in the case of Cd uptake. Probable cause of weaker effect was the lower content of Pb and Ni in the soil, which doesn't overload maximum allowed amounts. The positive fact is that Condit didn't increase content of above mentioned heavy metals compared to control treatment. Keller et al. (2005) similarly found that organic amendments had no significant effect on Pb concentrations in tobacco leaves. Ambiguous effect of sorbents and amendments on Pb concentrations in crops found also Tlustoš et al. (1997) and Geebelen et al. (2003).

No significant effect of organic amendments (bio sludge) on the uptake by plants was also found in the case of Ni (Tóth et al., 2010). Tlustoš et al. (1997) found ambiguous effect of sorbents also on Ni concentrations, not only on Pb concentrations.

For evaluation of the relationship of Ni a pH it is true that solubility of Ni is inversely proportional to pH. Nickel is the most soluble in soil with pH from 6.5 to 7.5. Similarly, the Ni is accessible on poorly drained soils (Tóth, 2007). It was found in our treatment that soil reaction was slightly acidic and did not exceed value 6.5. Nickel uptake by plants was regular without major differences between tested treatments.

Effect of year, treatment of immobilization and crop on heavy metals content in the plants was significant, it emerged from analysis of variance (Table 2). Significant effect of year found also Steinnes et al. (1997). Increasing sum of precipitation had reduced Cd content in tested crops. The effect of rising air temperature was adverse to effect of increasing precipitation. The content of Cd in the plants increased with increasing air temperature. Mentioned general impact of sum of precipitation and air temperature become evident in the case of Cd.

Tested amendment Condit had significant impact on uptake of all measured heavy metals by plants. The best results were found at Cd uptake, it's immobilization in the soil was the greatest. Content of Cd in the carrot root was lower by 55%, in the pea seed by 40%, in the barley plants by 28%, and in the red beet by 26% in comparison with the control treatment. Significant reduction of Cd content in the plants after organic amendments application had also found Gaj and Schung (2002).

It was also found that content of heavy metals in the plants was significantly influenced by cultivated crops (Table 2) and was not related with content in the soil. Correlation analysis showed, that all tested correlations between soil and plant heavy metals content were nonsignificant. Eight correlations were antithetical and sixteen were direct. The highest value of correlation coefficient was found at spring barley. Estimated ratio r =

Table 2. Analysis of variance and multiplied test ($LSD_{0,05}$) of heavy metals content in the crops

Metal	Source of variability		d.f.	F-ratio	MS	Count	Mean content	Homogenous group			
		2006					0.63	x			
	Year	2008	2	4.08	0.046	32	0.69		x		
		2007					0.70		x		
	Treatment	B_2	1	201.78	2.300	48	0.52	x			
		B_1					0.83		x		
Cd		A_1					0.56	x			
	Crop	A_4	3	55.73	0.635	24	0.91	x			
		A_3					0.66		x		
		A_2					0.57			x	
	Residual		86								
	Total		95								
		2007					0.80	x			
	Year	2006	2	4.82	0.054	32	0.82	x			
		2008					0.87		x		
	Treatment	B_2	1	48.64	0.552	48	0.75	x			
		B_1					0.90		x		
Pb		A_1					0.60	x			
	Crop	A_3	3	99.66	1.130	24	0.69		x		
		A_4					0.97			x	
		A_2					1.05				x
	Residual		86								
	Total		95								
		2006					1.92	x			
	Year	2007	2	31.88	0.95	32	2.13		x		
		2008					2.26			x	
	Treatment	B_2	1	73.99	2.22	48	1.95	x			
		B_1					2.25		x		
Ni		A_3					1.45	x			
	Crop	A_1	3	197.49	5.92	24	1.98		x		
		A_2					2.48			x	
		A_4					2.49			x	
	Residual		86								
	Total		95								

A_1 – peas; A_2 – spring barley; A_3 – carrot; A_4 – red beet; B_1 – control; B_2 – Condit

Table 3. Average content of selected soil properties at the beginning (2006) and at the end of experiment (2008)

Treatment	$C_{ox.}$ [g kg^{-1}]			P [mg kg^{-1}]			K [mg kg^{-1}]			pH/KCl		
	2006	2008	08-06	2006	2008	08-06	2006	2008	08-06	2006	2008	08-06
A_1B_1	15.42	14.74	-0.67	52.4	78.1	25.7	260.4	259.0	-1.4	6.37	6.35	-0.02
A_1B_2	14.55	16.85	2.29	88.6	229.8	141.2	282.2	399.5	117.3	6.40	6.34	-0.06
A_2B_1	14.90	14.00	-0.90	71.9	89.5	17.6	274.3	307.2	32.9	6.12	6.24	0.12
A_2B_2	15.27	15.95	0.67	82.4	149.9	67.5	290.3	367.4	77.1	6.16	6.14	-0.02
A_3B_1	13.32	14.45	1.13	44.3	59.1	14.8	241.5	308.0	66.5	6.16	6.01	-0.15
A_3B_2	13.17	14.16	0.99	49.1	49.1	0.0	223.2	301.0	77.8	6.06	5.90	-0.16
A_4B_1	12.95	13.03	0.08	42.0	65.8	23.8	210.3	247.1	36.8	6.29	6.36	0.07
A_4B_2	13.55	14.22	0.67	67.6	68.1	0.5	253.5	309.9	56.4	6.37	6.34	-0.03
B_1	14.15	14.06	-0.09	52.7	73.1	20.5	246.6	280.3	33.7	6.24	6.24	0.01
B_2	14.14	15.30	1.16	71.9	124.2	52.3	262.3	344.5	82.2	6.25	6.18	-0.07

$C_{ox.}$ – soil organic carbon; P – available phosphorus; K – available potassium; A_1 – peas; A_2 – spring barley; A_3 – carrot; A_4 – red beet; B_1 – control; B_2 – Condit

0.992 and r = 0.987 were nearly significant. Le Coultre (2001) summarized the results of 31 studies that dealt with heavy metal uptake by vegetables cultivated in the soils with different level of contamination and concluded that the relation between the heavy metal content in the soils and in vegetables was statistically nonsignificant.

We can established that there was found tendency in the course of Cd uptake. Impact of amendment Condit was more remarkable (higher reduction of Cd content) at seed crops than at root crops. It should be kept in mind that crop species ability to heavy metals accumulation is generally different. Differences between the crop species in light of heavy metals content support also Turan and Esringü (2007).

Organic amendment Condit influenced not only heavy metal uptake by plants but also some chemical soil properties (El-Shakweera et al., 1998; Gondek and Filipek-Mazur, 2005). The influence of Condit on soil chemical properties is shown in Table 3. Soil organic carbon content was significantly higher at

Table 4. Analysis of variance and multiplied test ($LSD_{0.05}$) of selected soil properties

Soil properties	Source of variability		d.f.	F-ratio	MS	Count	Mean content	Homogenous group		
$C_{ox.}$	Year	2006	1	10.42	4.56	32	14.14	x		
		2008					14.68		x	
	Treatment	B_1	1	13.78	6.03	32	14.10	x		
		B_2					14.72		x	
	Crop	A_4	3	32.84	14.37	16	13.44	x		
		A_3					13.78	x		
		A_2					15.03		x	
		A_1					15.39		x	
	Residual		55							
	Total		63							
P	Year	2006	1	22.06	21180	32	62.3	x		
		2008					98.7		x	
	Treatment	B_1	1	20.64	19818	32	62.9	x		
		B_2					98.1		x	
	Crop	A_3	3	14.54	13965	16	50.4	x		
		A_4					60.9	x		
		A_2					98.4		x	
		A_1					112.2		x	
	Residual		55							
	Total		63							
K	Year	2006	1	77.18	53685	32	254.5	x		
		2008					312.4		x	
	Treatment	B_1	1	36.62	25472	32	263.5	x		
		B_2					303.4		x	
	Crop	A_4	3	15.34	10673	16	255.2	x		
		A_3					268.4	x		
		A_1					300.3		x	
		A_2					309.8		x	
	Residual		55							
	Total		63							
pH/KCl	Year	2008	1	0.81	0.02	32	6.21	x		
		2006					6.24	x		
	Treatment	B_2	1	0.47	0.01	32	6.21	x		
		B_1					6.24	x		
	Crop	A_3	3	20.26	0.39	16	6.03	x		
		A_2					6.17		x	
		A_4					6.34			x
		A_1					6.37			x
	Residual		55							
	Total		63							

treatment with Condit in comparison with control treatment. Measured content of soil organic carbon was higher by 1.16 mg kg^{-1}. Higher content of organic carbon after organic fertilizers application found also Raju and Reddy (2000), Soumare et al. (2003), and Cogger et al. (2008). Milosevic and Milosevic (2010) found that increase of soil carbon after organic fertilizers may be no significant. No significant change of soil carbon was found only at control treatment in our experiment.

Contents of available nutrients are very variable, it was confirmed by experiment. It was found that average content of available phosphorus at control treatment increased by 20.5 mg kg^{-1} and of available potassium by 33.7 mg kg^{-1} (Table 3) at the end of experiment (difference between 2006 and 2008). Organic fertilizers are dominant source of nutrients and have impact on reserves in the soil (Ellmer et al., 2000; Yang et al., 2007; Morari et al., 2008; Milosevic and Milosevic, 2010). It was found that Condit had significantly increased available phosphorus by 52.3 mg kg^{-1} and available potassium by 82.2mg kg^{-1}. Organic matter application into the soil had also economic effect, because of reduction of fertilizers rate (phosphorus and potassium) as a result of increasing content of available nutrients (Petrus et al., 2010).

Soil reaction is less variable soil property. There was found no significant effect of amendment and experimental year on soil reaction (Table 4).

Obtained data presented in the Tables 3 and 4 are pointing out that content of soil organic carbon, available phosphorus and available potassium and soil reaction were influenced by crops.

There was found direct correlation between soil organic matter and available phosphorus (ratio 0.779) and available potassium (ratio 0.814) on the basis of obtained data. Findings are in compliance with Wang et al. (2010) conclusions.

Conclusion

The use of the organic fertilizers enriched by some supplemental stuff with heavy metal immobilization effects is relatively simple and effective way of achievement of safe farming in contaminated soils. According to Chen et al. (2000), the application of chemical amendments alleviated the phytotoxicity of heavy metals and had beneficial effects on plant growth.

Obtained data demonstrated the effects of Condit on bioavailability of heavy metals (Cd, Pb and Ni) and their transfer to selected crops. The lower transfer of heavy metals in to the plants after Condit application was found at all tested heavy metals. The result suggests that most significant impact had Condit on Cd uptake by plants. The measured amounts were the lowest of evaluated heavy metals.

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