EFFECTS OF ADDED SEWAGE SLUDGE ON CONTAMINATION WITH CD BY WINTER WHEAT (TRITICUM AESTIVUM)

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Abstract

The accumulation and transfer of heavy metals along soil-plant at experimental field were investigated. The study was conducted in the north-east of Romania at the Ezăreni experimental farm of the University of Agricultural Sciences and Veterinary Medicine Iaşi, during 2007-2009, in a cropping systems, viz., rape - wheat (*Brasica napus – Triticum aestivum*).
One of the objectives of the study was to determine the risk of soil and plants contamination with heavy metals on applied sewage sludge (SS) as less expensive organic fertilizer. For assess the effect of this fertilization were applied two doses of sewage sludge (20 t/ha and 30 t/ha). The results show that cadmium concentration increased with the increasing fertilization level. On the second year, the applied of 30 t/ha sewage sludge determinate a cadmium concentration greater than safely concentration for wheat plants.

Key words: sewage sludge, cadmium, winter wheat.

In the last decade, one of the current agricultural priorities is to sustain and maintain fertility levels of soil without damaging the natural ecosystem. Various alternatives, including no-tillage management systems and organic byproducts application, such as sewage sludge, compost, crop residues, etc. to soil is a current environmental and agricultural practice for maintaining soil organic matter, reclaim degraded soils and supplying plants nutrients (Bayer, C. et al., 2002; Tejada M. and Gonzales J.L., 2004; García-Orenes F. et al., 2005; Gonzáles-Pérez Martha et al., 2006; Paramasivan S. et al., 2006; Alcantara S. et al., 2009). This is one of the bigger problems when we utilize sewage sludge.

Due to its high organic matter content, sewage sludge can improve physical, chemical, and biological properties of soil (Aggelides S.M. and Londra P.A., 2000; McBride M.B., 2003; Sanchéz-Monedero M.A., et al. 2004; Zhang H., et al., 2007; Gonzáles-Pérez Martha et al., 2006; Alcantara S. et al. 2009). Also sewage sludge cane the soils degraded with heavy metals contamination. Heavy metals in sewage sludge may enter the food chain through crops and affect human health (Su and Wong, 2003).

The preliminary study shows the need for further information on the soil fraction distribution of these metals to evaluate their mobility, bioavailability and transference processes (D'Amore, J.J. et al., 2005).

The objectives of this study were to determinate (i) the effect of sewage sludge application on heavy metal build-up in soil and winter wheat grain and leaves, and (ii) the effects of soil amendment with sewage sludge on the chemical properties of a Rumanian chambic chernozem.

MATERIAL AND METHOD

The study was carried out from August 2007 to August 2009 at the Didactic Station of the „Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine of Iasi, Ezareni Farm located in the East part of Romania (47°07´ N latitude, 27°30´ E longitude), on a chambic chernozem (SRTS – 2003, or haplic chernozems after WRB-SR, 1998) with a clay-loamy texture, 6.8 pH units, 3.7 % humus content and a medium level of fertilization. The soil has high clay content (38-43 %) and is difficult to till when soil moisture is close to the wilting point (12.2%). The experimental site has an annual average temperature of 9.40ºC and precipitation of 587 mm.

The location of the experiment was selected using the "method of subdivided plots" on a surface of 5670 m^2, for the plots with different fertilization doses each covered surface of 100 m^2, and for the plots untreated each 300 m^2, in each three different tillage systems. We have investigated two variants tillage systems (minimum tillage – Chisel (MT), no-tillage

(NT), and one classical soil tillage system – plough at depths of 20 cm (CT)) and three variants fertilization (chemical fertilization (CF), organic fertilization (OF) and organic and chemical fertilization (OCF)) in the crop rotation made of rape/wheat, with three replications with plots covered surface of 100 m^2.

Table 1

The soil chemical characteristics

N-total (%)	C-total (%)	P_2O_5 (mg/kg)	Na (mg/kg)	Mg (mg/kg)	K-Al (mg/kg)	Ca (mg/kg)
0,19	1,83	39,4	128,9	6008,4	165	5629,7

Heavy metals (total forms)									
Cd (µg/kg)	Cr (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Co (mg/kg)	Ni (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Hg (mg/kg)	Pb (mg/kg)
118,6	35,36	784,4	27448,6	11,22	33,48	26,13	66,31	0,028	15,43

When we speak about characteristics of sewage sludge (SS), we report on the qualitative characteristics and also on the heavy metals content.

The main analytical data of sewage sludge are given in *table 2* and *table 3*. The sludge samples were collected from 10 points before the application. Heavy metals concentration is below the limits of European Community (86/278/CEE) legislation about agricultural use of sewage sludge.

Besides nutrition elements, in sewage sludge we can find also some heavy metals whit on toxic character (*table 3*).

Table 2

Nutrition elements content of sewage sludge

N-total (%)	C-total (%)	P_2O_5 (mg/kg)	Na (mg/kg)	Mg (mg/kg)	K-AL (mg/kg)	Ca (mg/kg)
1,396	12,81	10363,66	540,5	6210	441,5	80999,5

Table 3

Heavy metals content of sewage sludge (total forms)

Cd (µg/kg)	Cr (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Co (mg/kg)	Ni (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Hg (mg/kg)	Pb (mg/kg)
1219,5	87,91	456	32039,5	9,14	36,96	160,7	7551	1,825	156,55

The mineral fertilization shall use both classic products, intensively used by the local producers, and other imported fertilizers, newly introduced on the domestic market. The application of the sewage sludge shall be made only in the initial experimental year. The residual effects of the sewage sludge shall be monitored during the following experimental year. The application time for sewage sludge was before effectuation the soil tillage. The chemical fertilization was realize in two time 2/3 in the same time whit sewage sludge application and 1/3 am 20 February, in snow must time.

Plants and seeds sampling were collected from each crops plot on getting time in three replications. After drying, plants and seeds sampling were minced to pass a 2-mm sieve and stored in polyethylene (plastic) bottle in a dry place until chemical analysis.

The cadmium content in plants were determined by the microwave extraction methods (according with the method describable by Hoß T., 2007) and Atomic Absorption Spectrophotometry (AAS).

Data were statistical processing by means of the analysis of variance, and treatments means were compare using the data from literature. Multiple linear regression analysis on standardized data was conducted to search for linear correlation between those 2 experimental factors, fertilization systems and tillage systems, on total amount cadmium and Zn in plants and seeds.

RESULTS AND DISCUSSIONS

The extractability and plant availability of cadmium were affected by the additions of sewage sludge but also by tillage system. The results obtained for winter wheat grains and leaves according to the tillage systems and types and doses of fertilization variants are presented on the next data. Cadmium content was higher with intensely mobilization on soil surface (0-10 cm depth) and with the sewage sludge dose.

Comparing with the results obtain on the first analysis year, on the next year the concentration of cadmium was different. If on the plants analysis the cadmium content has a negative development, even if in 2008 cadmium as in the 50 t ha^{-1} treatment the significantly higher than the control, on grain cadmium concentration was higher on the second year.

Tillage system has affected the cadmium concentration from winter wheat, on plants and also on grain, through depth and intensity of soil work. On the winter wheat plant the lower quantity of cadmium was induced on classical tillage system, and higher on NT. These results are explained on the fact that the winter wheat take the nutrition elements which are on the arable horizon, and on CT the soil horizons are turn down, so

fertilization applied are underground. The no-tillage system work only the superficial horizon and so fertilization remain on the surface, and the winter wheat cane easy take. MT was also favorable for cadmium accumulation for plants, comparing with CT, but the difference was not significant.

Table 5

The influence of „tillage system" on cadmium content from winter wheat plant and grain – mean values 2007 - 2009 (µg/kg)

Agricultural year	Analysis sampling					
	Plant			Grain		
	Plough 20 cm	Chisel	Direct drilling	Plough 20 cm	Chisel	Direct drilling
2007-2008	80,93	83,03	98,91^{xx}	29,95^{o}	32,16	32,56
2008-2009	68,81^{oo}	72,10^{oo}	85,53^{x}	32,48	36,14	37,52^{x}
Statistic analysis	LSD $_{5\%}$= 3,72 µg/kg	LSD $_{1\%}$ = 8,60 µg/kg	LSD $_{0,1\%}$ = 27,37 g/kg	LSD $_{5\%}$= 3,72 µg/kg	LSD $_{1\%}$ = 8,59 µg/kg	LSD $_{0,1\%}$ = 27,33 µg/kg

Control – mean value of Cd content for experimental time

In order to evaluate the relation between plant absorption of cadmium and fertilization system a statistic analysis was made.

The results shown that the transfer of this element is determinate not only by of different doses sewage sludge applied but also by mineral fertilization. To associate the mineral fertilization with organic fertilization induced on winter wheat plants and grain o higher concentration of cadmium, but the administration of sewage sludge has a big part.

To applied o bigger dose of SS induce o existence of higher cadmium content on the soil, and also o higher absorption for plants for this element.

On the plants, on the first study year, cadmium content was higher that on the next year, but on the grain the results are different. The decomposition of SS applied in august 2007 determinate o increase for cadmium, even over admissible limits, special on the plots where was 30 t ha^{-1} SS.

Table 6

The influence of „fertilization system" on cadmium content from winter wheat plant and grain – mean values 2007-2009 (µg/kg)

Fertilization system	Analysis sampling					
	Plant			Grain		
	2007-2008		2008-2009	2007-2008		2008-2009
Non-fertilization	63,82^{o}		49,22^{ooo}	24,98^{oo}		26,33^{o}
$N_{32}P_{32}$	70,53		67,33^{o}	26,47^{o}		31,56
20 t/ha SS	90,9		74,44	32,40		39,00
$N_{96}P_{96}$ + 20 t/ha SS	98,51^{x}		87,45	34,43		40,89
$N_{64}P_{64}$	78,26		71,34	26,86^{o}		34,11
30 t/ha SS	104,90^{xx}		80,89	36,51		46,22^{xx}
$N_{64}P_{64}$ + 30 t/ha SS	106,42^{xx}		97,67^{x}	39,27		52,89^{xxx}
Statistic analysis	LSD $_{5\%}$= 11,95 µg/kg	LSD $_{1\%}$ = 18,10 µg/kg	LSD $_{0,1\%}$ = 29,07 g/kg	LSD $_{5\%}$= 6,60 µg/kg	LSD $_{1\%}$ = 9,99 µg/kg	LSD $_{0,1\%}$ = 16,06 g/kg

Control – mean value of Cd content for experimental time

The interaction of this two factors (soil tillage systems and fertilization systems) manifest on a quantitative growth of cadmium, indifferent which sampling is analysis, with reduce on work depth and with the growth of SS dose applied.

The extended order for the transfer of cadmium in to the winter wheat is CTS – NTS – MTS, and for the fertilization systems hereupon was the OCF-OF-MF-NF.

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Table 7

The influence of "tillage system x fertilization level" on cadmium content from winter wheat plant – mean values 2007-2009 (µg/kg)

Agricultural year	Tillage system	Fertilization system							Mean values
		Non-fertilization	$N_{32}P_{32}$	20 t/ha SS	$N_{96}P_{96}$ + 20 t/ha SS	$N_{64}P_{64}$	30 t/ha SS	$N_{64}P_{64}$ + 30 t/ha SS	
007-2008	ough 20 cm	61,87^{ooo}	65,27^{ooo}	81,27^{ooo}	87,82	73,67^{ooo}	99,36^{xxx}	97,24^{xxx}	80,93
	hisel	66,12^{ooo}	71,93^{ooo}	88,04^{ooo}	87,41	74,54^{ooo}	94,00^{xx}	99,13^{xxx}	83,03
	irect drilling	63,47^{ooo}	74,40^{ooo}	103,39^{xxx}	120,30^{xxx}	86,57^{xxx}	121,35^{xxx}	122,90^{xxx}	98,91
	ean values	63,82	70,53	90,9	98,51	78,26	104,90	106,42	87,62
	SD $_{5\%}$= 0,6 µg/kg			SD $_{1\%}$ = 1,0 µg/kg			SD $_{0,1\%}$ = 1,8 µg/kg		
008-2009	ough 20 cm	45,33^{ooo}	56,67^{ooo}	67,33^{oo}	81,00	59,67^{ooo}	75,00	99,67^{xxx}	69,24
	hisel	46,00^{ooo}	68,33^{oo}	73,00	83,67^{xx}	71,67	74,67	87,33^{xxx}	72,10
	irect drilling	56,33^{ooo}	77,00	83,00^{x}	97,67^{xxx}	82,67^{x}	93,00^{xxx}	109,00^{xxx}	85,52
	ean values	49,22	67,33	74,44	87,45	71,34	80,89	98,67	75,62
	SD $_{5\%}$= 5,8 µg/kg			SD $_{1\%}$ = 7,7 µg/kg			SD $_{0,1\%}$ = 10,2 µg/kg		

Control – mean value of Cd content for experimental time

Table 8

The influence of "tillage system x fertilization level" on cadmium content from winter wheat grain – mean values 2007-2009 (µg/kg)

Agricultura l year	Tillage system	Fertilization system							Mean values
		Non-fertilization	$N_{32}P_{32}$	20 t/ha SS	$N_{96}P_{96}$ + 20 t/ha SS	$N_{64}P_{64}$	30 t/ha SS	$N_{64}P_{64}$ + 30 t/ha SS	
2007-2008	Plough 20 cm	24,42^{ooo}	25,53^{ooo}	30,64^{ooo}	31,60	26,26^{ooo}	32,24^{ooo}	38,97^{xxx}	29,95
	Chisel	25,65^{ooo}	27,12^{ooo}	33,69	34,30^{xxx}	27,41^{ooo}	38,44^{xxx}	38,54^{xxx}	32,16
	Direct drilling	24,87^{ooo}	26,77^{ooo}	32,88^{ooo}	37,38^{xxx}	26,90^{ooo}	38,86^{xxx}	40,29^{xxx}	32,56
	Mean values	24,98	26,47	32,40	34,43	26,86	36,51	39,27	31,56
	LSD $_{5\%}$= 0,2 µg/kg			LSD $_{1\%}$ = 0,3 µg/kg			LSD $_{0,1\%}$ = 0,4 µg/kg		
2008-2009	Plough 20 cm	17,67^{ooo}	28,00^{o}	32,67	35,33	28,67^{o}	39,33	45,67^{xxx}	32,48
	Chisel	24,00^{ooo}	28,00^{o}	37,33	38,67	29,00^{o}	43,67^{xx}	52,33^{xxx}	36,14
	Direct drilling	27,33^{oo}	28,67^{o}	37,00	38,67	34,67	45,67^{xxx}	50,67^{xxx}	37,52
	Mean values	23,00	28,22	35,67	37,56	30,78	42,89	49,56	35,38
	LSD $_{5\%}$= 5,6 µg/kg			LSD $_{1\%}$ = 7,5 µg/kg			LSD $_{0,1\%}$ = 9,9 µg/kg		

Martor – valoarea medie a indicatorilor pentru toate variantele corespunzătoare fiecărui an agricol

CONCLUSIONS

The heavy metals have an important role in possibility to can utilize the sewage sludge in crops fertilization. It is important to know the direct influence on heavy metals from soils, and indirect influence on crops composition, qualitative composition respective.

The results obtained here confirm previous conclusions about the importance of determinate the effect of SS application on heavy metals accumulation on plants and grain. Also the results show that the winter wheat absorbs a wide range of heavy metals in different amendments.

Is have to make attention on the results obtain on winter wheat grain, on the second experimental year, when concentration of this element was over the assurance food interval on the variants fertilized with 30 t ha^{-1} SS, alone or associate with mineral fertilization, and worked with conservative tillage systems.

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