EFFECTS OF DIFFERENT APPLICATIONS OF SEWAGE SLUDGE ON HEALTH OF FOOD CROPS

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Because many of the soils have low organic matter content they are exposed to degradation, erosion and desertification through intensive cultivation, excessive ploughing, allied to years of unsuitable agricultural practices. These practices reduce the quantity of vegetal remains returned to the soil and accelerate the mineralization of whatever humus is in the soil. The inevitable result is a progressive decrease of the organic matter content and the negative consequences that this entails [10].Investigations were carried out in order to determine the effects of sewage sludge application on soil and plants. In the course, plots with an area of 100 m^2 were treated with different fertilization systems (mineral fertilization, organic fertilization, and mineral and organic fertilization). The effect of the tillage systems on the contents of these heavy metals, shows different results. A higher content of Cd in crops occurred in the no-tillage system and a higher content in Zn was found in crops of the minimal tillage system, excepting the content in Zn in rape seeds, where this higher Zn content occurs in crops of the conventional tillage system. A lesser content of Cd and Zn occurred generally in crops of the conventional tillage system.

***Key words**: fertilization, sewage sludge, heavy metals, food crops*

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, induce degraded soils and supplying plants nutrients [2, 9, 4, 5]. 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 [13, 1, 5].

The effects of sewage sludge on soil quality are twofold. On the one hand, sludge applications to soil increases the content of organic matter and plant nutrients, but on the other hand, sewage sludge coming from urban and industrial areas can be contaminated with appreciable amounts of toxic metals (Cu, Zn, Ni, Cd, Cr, Pb, Hg). Those metals are accumulated in soil, from where they can be absorbed by the plants and so those toxic metals arrive in to the human body through the foods [3, 6]. It is very important to know where the limit for fertilization whit sewage sludge is.

In the last years, the application of sewage sludge on agricultural land has become a common practice recently and it is accepted as inexpensive and easy to apply. Given the globalization in food production, we cannot do without the use of sewage sludge as supplementary fertilizer, as long sewage sludge is utilized in conformity with existing legislation [8, 5].

One of the purposes of this work is to investigate the transfer of heavy metals from the sewage sludge in to the soil, and after that in the plants and her seeds.

MATERIAL AND METHOD

The study was carried out from August 2007 to August 2008 at the experimental field of the Department of Soil Management, and initiated in the Student Research Station Ezareni of the University of Agricultural Sciences and Veterinary Medicine of Iasi – Experimental 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, a neuter to weakly acid reaction, circa 2.67 % humus content and a medium level of fertilization. An annual average, in the experimental site has a temperature of 9.4°C 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.

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	166,31	5629,7

Table 2

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

Heavy metals concentration is below the limits of European Community (86/278/CEE) legislation about agricultural use of sewage sludge.

Table 3

The essential nutrients of sewage sludge

N-total (%)	C-total (%)	P_2O_5 (mg/kg)	Na (mg/kg)	Mg (mg/kg)	K (mg/kg)	Ca (mg/kg)
1,396	12,81	10363,66	540,5	6210	3804,5	80999,5

Besides nutrition elements, in sewage sludge we can find also some heavy metals whit on toxic character (tab. 4).

Table 4

The heavy metals content in sewage sludge

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 experiment is of multiple factor type (A x B x C) where Factor A – soil tillage system, Factor B – crop rotation and Factor C – fertilization system.

Factor A. **Tillage systems**

a_1 - conventional tillage system (CTS) (plowing at 20 cm depth, followed by a single pass of the mixing machine)

a_2 – minimal tillage system (MTS) (soil loosening without turning the furrow with the chisel, followed by a single pass of a complex aggregate formed by a rotary harrow with vertical rotors, field roller and field cultivators with disks and settling wheel)

a_3 – no-tillage system (NTS) (direct cultivation on the stubble field with a complex aggregate)

Factor B. Cultivated plant

a_1 – rape

a_2 – winter wheat

Factor C. Fertilization system

a_1 – chemical fertilization

Rape	Winter Wheat
V_1 – non-fertilized	V_1 – non-fertilized
V_2 - $N_{64}P_{50}K_{40}$	V_2 - $N_{32}P_{32}$
V_3 - $N_{96}P_{80}K_{60}$	V_3 - $N_{64}P_{64}$

a_2 – organic fertilization

Rape	Winter Wheat
V_1 – non-fertilized	V_1 – non-fertilized
V_2 – 20 t/ha	V_2 – 20 t/ha
V_3 – 30 t/ha	V_3 – 30 t/ha

a_3 – organic and chemical fertilization

Rape	Winter Wheat
V_1 – non-fertilized	V_1 – non-fertilized
V_2 – 20 t/ha + $N_{96}P_{80}K_{60}$	V_2 – 20t/ha + $N_{96}P_{96}$
V_3 – 30 t/ha + $N_{64}P_{50}K_{40}$	V_3 – 30 t/ha + $N_{64}P_{64}$

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 this 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 (25 June – winter wheat and 13 July - rape) 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 Zn and Cd content in plants were determined by the microwave extraction methods (according with the method describable by [7] 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 Cd and Zn in plants and seeds.

RESULTS AND DISCUSSIONS

Corresponding to Scheffer and Schachtschabel (1982) – after [6], the normal content for Zn in all the plants is between 10 – 100 mg/kg dry substance, and or Cd under 1,0 mg/kg dry substance. After studying the evolution of means values of the content at both metals we not found out significant negative effects. Though, it is true that after fertilization und tillage soil we can see differences between the untreated plots und the treated plots. Both study factors have on influence on the content for this 2 chemical element, and the results are very interesting.

If we analyses the result, we remark that on winter wheat the big Cd content was find in to the variants treated organically-chemical and organically. Below the average, the Cd content was finding on chemically and untreated plots.

The tillage systems have interesting influence. On the winter wheat the big Cd content is on the no-tillage variant (*fig. 1*) and the MTS has valor close by average.

These results are explained on the fact that the winter wheat take the nutrition elements which are on the arable horizon, and on CTS 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.

The effect of the sewage sludge on Zn content on the plants, showed that the higher Zn content in winter wheat plants was find on NTS (*fig. 2*). The loss Zn content by this crop result on the CTS.

The effect of fertilization systems on the Zn content was just like on the Cd content. A bigger content in Zn result in the variants which were with $N_{64}P_{64}$ + 30 t/ha treated and the loss on non-fertilizer variants.

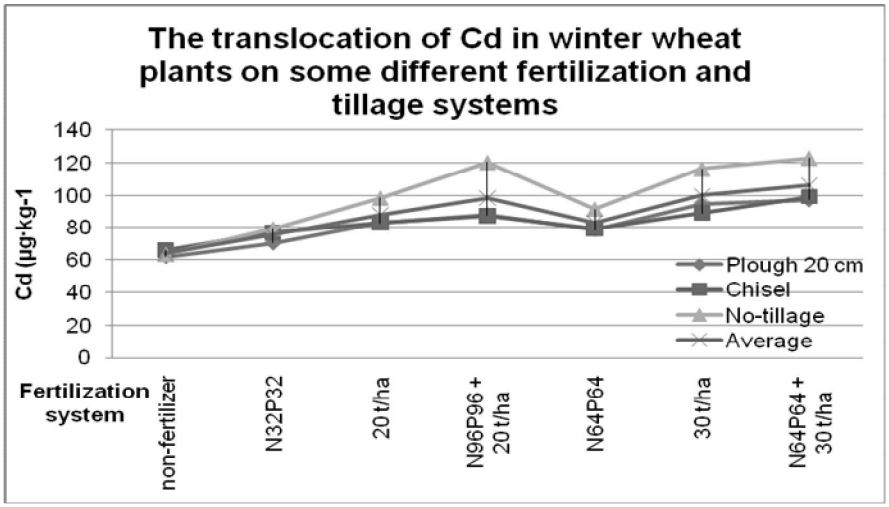

Figure 1 The translocation of Cd in winter wheat plants on some different fertilization and tillage systems

Under those 2 systems, the results are very interesting. The translocation of Zn is higher under all 3 tillage systems where was organically-chemical fertilization applied, but the content in decreased extender order: MTS – NTS – CTS, on but crops.

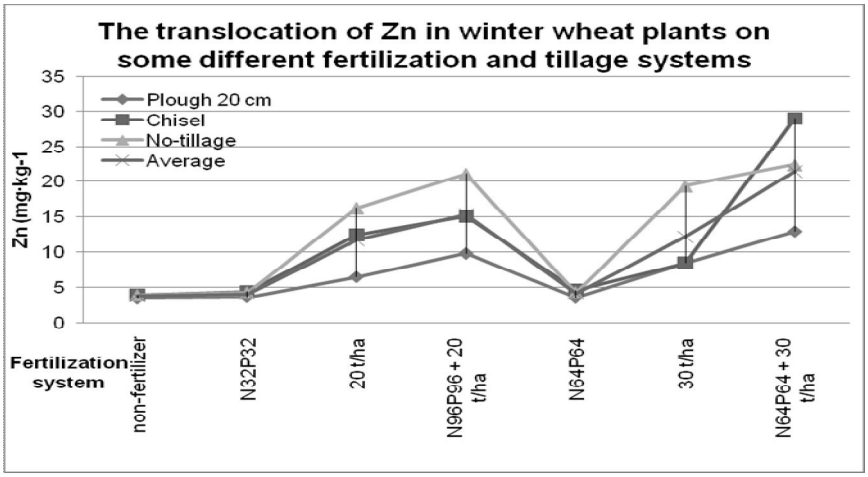

Figure 2 The translocation of Zn in winter wheat plants on somedifferent fertilization systems and tillage systems

By winter wheat can by remark that a similar evolution like the translocation of Cd in to the plants, saving-that the difference are not anymore so significant. Though, the big Cd content was finding in variants treated with $N_{64}P_{64}$ + 30 t/ha, and the lower, deservedly in to the variants without fertilization (*fig. 3*).

If we correlate the effect of those 2 factors (fertilization system and tillage system) the result show something different. The extended order for the transfer of Cd in to the winter wheat is influence by tillage system is CTS – NTS – MTS, and the high content in both chemical elements was finding on the treatment organically-chemical.

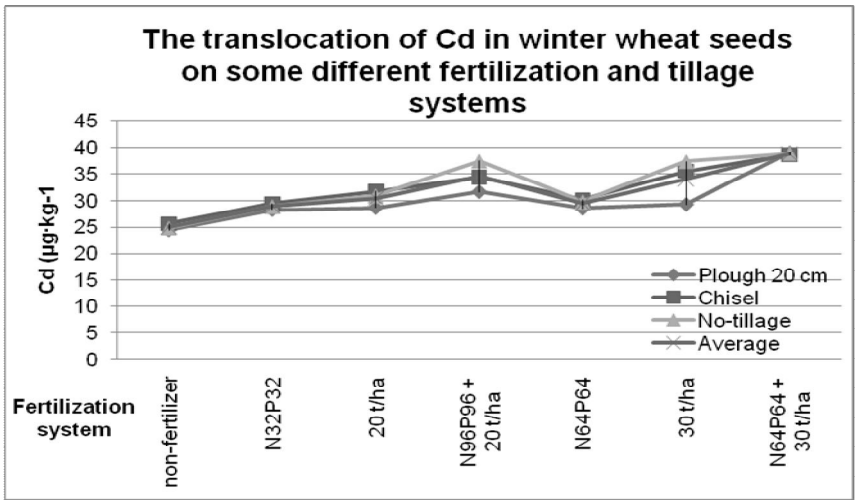

Figure 3 The translocation of Cd in winter wheat seeds on some different fertilization and tillage systems

The increases of transfer Cd on the winter wheat plants was favor by the NTS (*fig. 4*). Under average, it was canned valor on CTS.

The fertilization with sewage sludge induced significant increases of Zn content, on variants organically-chemical. From this result we cane concluded that the content on Zn, increased with doses of fertilization, and more then that a fertilization organically-chemical induce a big transfer for Zn in seeds than a one only with sewage sludge.

Total metals were determined after digestion of soil samples with HNO_3 and H_2O_2 circa 1 hour in Microwave, and after that though AAS. It was three digestion steps, respectively at 38.24 and 38 %, of 250, 700 and 500 W power, were performed or 12.8 and 12 min. Available fraction of metals were extracted from circa 0.5 g plants probe and 0,8 g seeds probe, with 50 ml extracting solution (HNO_3 65 %, H_2O_2 32 %), according to [7] procedure. Total amount metals were determinate using an AAS.

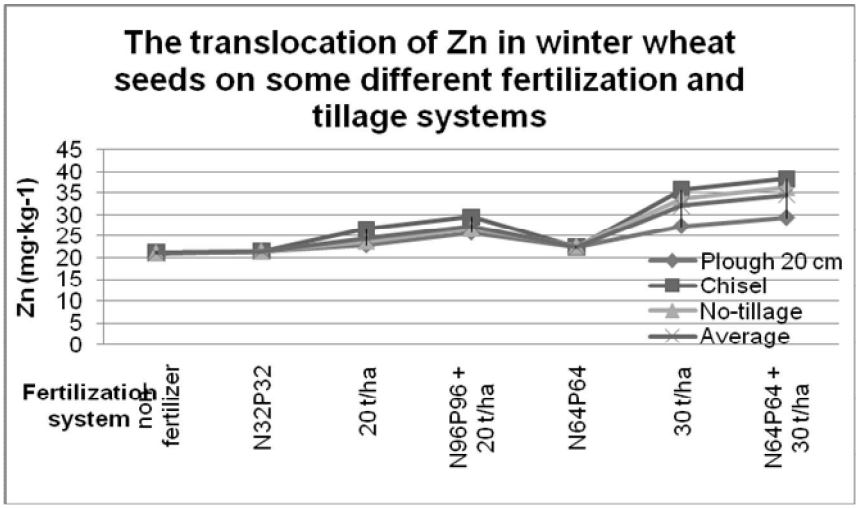

Figure 4 The translocation of Zn in winter wheat seeds on some different fertilization systems and tillage systems

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 total amount of those 2 heavy metals in winter wheat was in the range of non-sludge Romanian clay-loamy soils.

The results obtain showed that after one year of sewage sludge application, we didn´t notice any significant negative effects on the food crops, but we notice significant change in total content of the heavy metals between the treatments.

The results obtained from the factorial analysis indicated that the content in Cd and Zn is a result of correlation between fertilization doses and tillage system using.

In this experiment the application of sewage sludge increased the content in Cd and Zn, but without negative effects. The increased of those 2 important heavy metals are direct proportional to the amount of fertilization doses, special sewage sludge dozes, added to the soil.

The effects of the second one experiment factor, the tillage systems, on this 2 heavy metals showed that the Zn transfer was favored by the MTS by both crops. Cd content is different from one crop to the other. By winter wheat the transfer is higher on the NTS, while by rape on both unconventional tillage systems (MTS and NTS).

However, by the correlation between those 2 experimental factors we find that by both crops the higher transfer was realize more on the minimal tillage system when was applied $N_{64}P_{50}K_{40}$ + 30 t/ha, and 30 t/ha sewage sludge.

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