The Potential of Use the Recyclable Organic Materials for Soil Fertilization

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Abstract

The decrease productivity of soils that occurs following an agricultural overproduction is manifested by insufficient of nutrients, nitrogen and phosphorus, by salinity increasing, humus deficiency, soil aggregation changing moisture content modified, etc, finally through undesirable phenomena of erosion. The uses of sewage sludge for fertilizing purposes of degraded soils remain a method of managing this recyclable waste. Sewage sludge anaerobically stabilized brings into soil an important input of nutrients (C, N, P), micronutrients and an significant settlement of compatible microorganisms with soil biocenosis. The potential hazards of sewage sludge due to pathogenic agents load is reduced by anaerobic stabilization. The potential of physicochemical contaminants is controlled by national legislation. Using a quantity of 40 $t \cdot ha^{-1}$ sewage sludge anaerobically stabilized for fertilization of cultivated soils with maize led to an increase of grain production of 12% over the amount harvested from a control field and with 5 % of the amount collected from a fertilized field with 40 $t \cdot ha^{-1}$ manure. In the aerial parts of the harvested plants from fertilized fields with the sewage sludge haven't accumulated toxic metals (Cd, Ni, Cr, Pb) in the detectable range, and the amount of Zn was according to the nutritional requirements.

Keywords: fertilization, maize, national legislation, recyclable waste, stabilized sewage sludge, toxic metals.

1. Introduction

Macro and micro nutrients are present in soil in greater or less amount-fertilizers role being to "cover" deficiencies soil. Using of manure to fertilize agricultural field for crop cultivation aims to improve soil characteristics due to lack of some components. Its absence leads to decreased soil fertility, erosion at lower yields and ultimately determines a disadvantageous economic balance [1, 2]. Fertilization aims to maintain or improve the soil chemical and physical characteristics and, on the other hand fertilizers role is to achieve higher yields as higher quality indexes. On the other hand, an excess of soil fertilizers used for fertilization has undesirable consequences both on plant health and environment. Washing soluble nutrient salts by precipitation or irrigation poses a big risk on their transport in surface water or groundwater migrating to deep canvases. Researcher's reports have shown that nitrogen containing fertilizers improve crop quality by increasing the protein content of wheat, corn, etc. and bioavailability phosphorus compounds lead to higher content of gluten [3].

Growing food needs in the last decades forced sustained concerns about ensuring adequate quality of soils leading to increased yields, higher quality without unintended consequences on human or animal health and without alteration of the environment. Until recently municipal sludge was stored to landfills or incinerated. Their use as fertilizers aimed recycling of organic carbon

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compounds based on macronutrients, nitrogen, phosphorus, etc or micronutrients as essential elements such as iron, zinc, etc. Land fertilization with municipal sludge (biosolids) is used in many countries [4, 5]. In USA, 60% of results biosolids are land application. In many countries of the world the use of town sludge as fertilizer was promoted [6].

The aim of the study is to determine: the influence of fertilizer, sewage sludge on the quality and quantity of maize crops and aerial parts for feed compared to the influence of fertilization with manure.

2. Materials and methods

Investigations were carried out on the farming land (lat +45^{o} 47$^{'}$3.33$^{''}$ N, long +21^{o} 12$^{'}$54.01$^{''}$ E), of the Department for Experimental Science, UASVM of Banat, Timisoara, Romania. Field experiment was conducted during the 17th of June 2013-the 29th of October 2014 with *Zea mays*, as selected plant species. The study was performed in three variants, in an experimental agricultural block. Each experimental variant occupies 12 m^2 (2 m x 6 m dimensions). The experimental variants used in this study were arranged in a completely randomized block design with three replicates, between the experimental variants a 0.5 m corridor was left so that each culture would be personalized and in order to avoid possible contaminations of the soil with microbes and leached micro and macro nutrients. The experimental variants have been prepared having the following characteristics: **M**-control variants without any fertilizer**;** **B**-fertilized **M** variants with 40 $t\cdot ha^{-1}$ manure, **N**-experimental variants, **M** variants fertilized with 40 $t\cdot ha^{-1}$ anaerobically stabilized sewage sludge. The experimental variants were prepared on April 2014. The treated soils were left for 60 days bio-geo-chemical stabilization. The fertilizer incorporation is done through agricultural works specific for cereal crops, at 30 cm depth. Sowed grain quantity was 20 $kg\cdot ha^{-1}$. Reference values for the indicators analyzed in sludge used for fertilizer in the U.S. are included in EPA Regulations under Title 40 Code of Federal Regulations Part 503 (40 CFR 503) and concern to pathogen and heavy metal content, application and other general safety regulations [6]. In Europe 34% of biosolids are applications [4]. Reference values in our country for the analyzed indicators in sludge for fertilization of agricultural land are required by MAPPM Order 756/1997 [7], regarding the quality and quantity of sludge that can be used for fertilization according to soil quality (*i.e.* heavy metals content). Spreading of sludge in the field and incorporating in the same day limits the dispersal of potential residual pathogens.

Biosolids implementing benefits resulted from: cost reduction of crops supplemental nutrients, increased crops by natural nutrients, long time soil productivity, environmental, etc. Plant tissues were thoroughly washed with deionised water to remove any soil particles attached to plant surfaces. The tissues were dried (105°C) to a constant weight. Plant samples with constant weight are then brought to 550°C; to the residual materials 5 ml of concentrated hydrochloric acid are added, samples are maintained 30 minutes on the dry sand bath. After filtering those in a paper filter with small porosity, they were taken to a calibrated flask with hydrochloric acid 1:1 solution. Plant extracts analysis was done using a spectrophotometer, Atomic Absorption Spectrophotometer, GBC Avanta AAS, GBC Scientific Equipment Ltd. Company. The detection limit of the device is 0.02 $mg\cdot L^{-1}$ for Cd, 0.05 $mg\cdot L^{-1}$for Cr, Cu, Fe, Mn, and Zn, 0.10 $mg\cdot L^{-1}$ for Ni and 0.20 $mg\cdot L^{-1}$ for Pb.

3. Results and discussion

Table 1 shows the quantities of metals determined in sewage sludge used to fertilize experimental variants compared with reference literature values in our country for agricultural soils, MAPPM Order 756/1997 [7].

Table 2 shows the nutrient content of fertilizer agents used for experimental variants fertilization.

Sewage sludge used was richer in nutrients than manure, so it contains more nitrogen with 61.4% and 36.1% more phosphorus than manure. According to the quality of soil and sewage sludge qualities used in the experiment, a fertilizer agent dose of 40 kg ha^{-1} sewage sludge was established. The same doses were established using manure as fertilizer.

Table 1. The amount of metals determined in sewage sludge and reference values for agricultural soils according to MAPPM Order 756/1997 [7]

No	Fertilizer type	Content of metals in sewage sludge (mg kg D.M.)							
		Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
1	Biosolids *	2.7	26.0	8.3	533.0	1248.3	14.7	23.6	233.0
2	Normal values MAPPM Order 756/1997 [7]	1.0	30.0	20.0	-	900.0	20.0	20.0	100.0

*mean values

Table 2. Nutrient content of fertilizer agents used for experimental variants fertilization

No	Fertilizer agents type	The nutrient content of fertilizer agents (mg kg D.M.)			
		pH *	Humidity (%)	Total nitrogen (%)	Total Phosphorus (%)
1	Sewage sludge	8.5	91.5	1.14	1.11
2	Manure	7.1	67.86	0.75	0.40

*mean values

In Table 3 are presented the amounts of corn grain harvested from the experimental variants studied. It can be observed in the table that fertilization with manure increased grain yield by 7.9% and fertilization with sewage sludge increased the harvest by 13.8% compared to the unfertilized maize crop.

Table 3. The amounts of corn harvested on experimental variants

No	Variants	The amount of corn grains*	
		Harvest (kg)	The percent of harvest increasing vs. control harvest (%)
1	**M**	4.1	-
2	**B**	4.45	7.9
4	**N**	4.75	13.8

*mean values

Table 4 shows the quantities of bioaccumulate metals in different aerial parts of maize plants collected from the experimental variations studied. Note that the aerial plant tissue did not accumulate any heavy metals such as Cr, Cd, Pb, Ni. Instead it was accumulated various amounts of metals Cu, Fe, Mn and Zn. Thus the amount of Zn accumulated in different parts of the plant is below the permissible values for feed. It is observed that the addition of fertilizer significantly reduced the bioaccumulated Zn content toward the Zn content in plant parts grown on unfertilized variant.

Table 4. The quantities of metals in various aerial parts of plants of corn harvested from the experimental variants

No	Variant	Aerial part of plant	Heavy metal content (mean values) (mg/kg D.M.)			
			Cu	Fe	Mn	Zn
1	**M** unfertilized	Leafs	10.5	214.9	46.1	115.3
		Cobs	4.7	30.9	11.3	41.7
		Corn husks	3.9	28.9	16.3	24.5
		Grains	5.2	48.1	3.3	8.3
2	**B** manure fertilizer	Leafs	37.5	1115.0	315.9	58.5
		Cobs	3.5	26.9	8.8	28.6
		Corn husks	4.5	62.0	16.0	46.5
		Grains	0.5	48.0	Sld.	46.5
3	**N** sewage sludge fertilizer	Leafs	8.0	165.8	47.9	59.4
		Cobs	2.2	71.9	7.1	51.5
		Corn husks	8.3	46.1	20.2	61.3
		Grains	1.9	27.75	4.4	29.3

The addition of sewage sludge determined the lowest quantities of the other metals analyzed. Fertilization with sewage sludge resulted in the accumulation of small amounts of Cu or similar in leaves, cobs and kernels vs. other variants.

It is also noted a greater accumulation of iron in leaves tissues and grains grown on fertilized with manure or fertilized toward to tissue bioaccumulation of plants harvested on other variants.

In Figure 1 the bioaccumulation of metals in the plant basal node is presented.

Note that the metals Fe and Zn were accumulated in higher amounts than Cu and Mn. The largest amounts were determined in the basal node of the plants harvested from soil fertilized with slurry of 64.8 mg/kg DM for Fe and 35.6 mg/kg DM for Zn. Note that the metals Cu and Mn accumulated in smaller amounts, lowest amounts were determined in the basal node of the plants harvested from soil fertilized with sewage sludge 7.0-9.3 mg/kg DM for Cu and 17.0 mg/kg D.M. for Mn in the basal node of the plants grown in soil fertilized with manure.

The degree of access of metals in different parts of the plant air parts depends primarily on how these metals are accessed in roots are stored in basal nodes and secondary of plant metabolism which will differently assimilate these metals in different parts air and will be stored preferential.

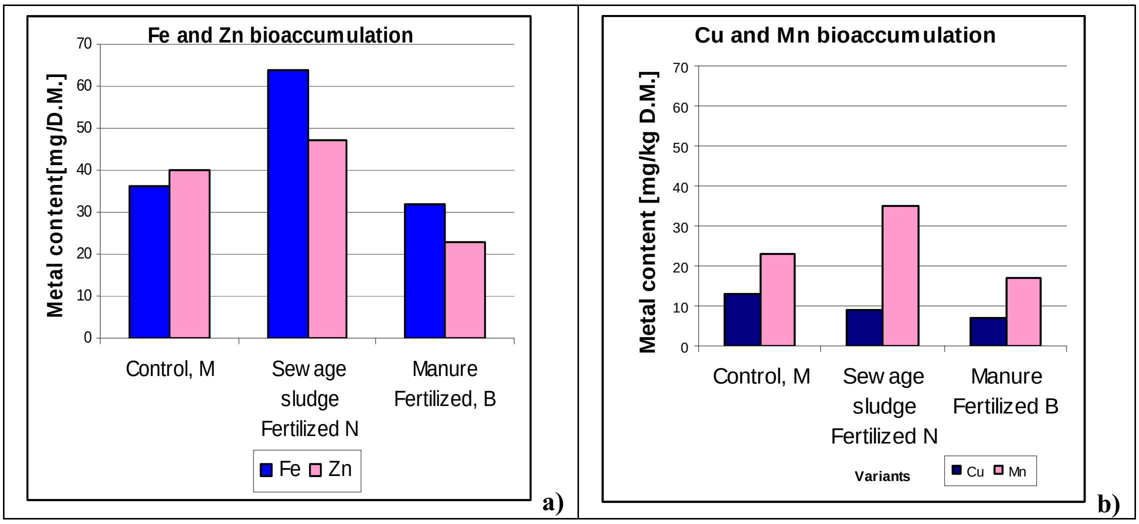

Figure 1. Bioaccumulation of metals in the basal node of the corn harvested
a) Fe and Zn bioaccumulation; b) Cu and Mn bioaccumulation

The quantities of heavy bioaccumulate studied metals were included in the relationship:

$$Fe > Zn \geq Mn > Cu$$

The relationship shows validity for the studied aerial parts: leaves, cobs, husk, grain and basal node. In additional in all studied cases the quantities of heavy bioaccumulate metals in grain were lower than other part of plants *i.e.* leafs, cobs, corn husks and basal node. In all studied cases the quantities of heavy metals were mostly bioaccumulated in the leaves of harvest plants.

4. Conclusions

Using a quantity of 40 $t \cdot ha^{-1}$ sewage sludge anaerobically stabilized for fertilization of cultivated soils with maize led to an increase of grain production of 13.8% over the amount harvested from a control field and with 7.9% of the amount collected from a fertilized field with 40 $t \cdot ha^{-1}$ manure. In the aerial parts of the harvested plants from fertilized fields with the sewage sludge haven't accumulated toxic metals (Cd, Ni, Cr, Pb) in the detectable range, and the amount of Zn was according to the nutritional requirements. For other metals analyzed, the organic matter added as fertilizer caused a modification in solubility of metals in the soil so that the amount bioaccumulated in different parts of the plant varied within wide limits.

The degree of various heavy metals bioaccumulation of the following relationship was established:

$$Fe > Zn \geq Mn > Cu$$

The relationship shows validity for the studied aerial parts: leaves, cobs, husk, grain and basal node Furthermore in all studied cases the quantities of heavy bioaccumulate metals in grain were lower than other part of plants *i.e.* leafs, cobs, corn husks and basal node. In all studied cases the quantities of heavy metals were mostly bioaccumulated in the leaves of harvest plants.

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