THE EFFECT OF SEWAGE SLUDGE ON YIELD AND QUALITY OF POTATOES

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Abstract- The main objective of the present study is the assessment of the effect gained by using sewage sludge on potatoes productivity and quality. With this regard, long-term field experiment with sewage sludge used on agricultural land was realized. The experiments were carried out in Covasna area, Covasna county, Romania. In order to identify the most suitable quantity concerning the used sewage sludge dose, soil chemical characterization was first realized. After, a practice-oriented experiment design was chosen and potato local plant specie was arranged in a Latin rectangle with five repetitions. In this way resulted different experimental field plots with distinctive doses concerning the used sewage sludge: 2.5 tonnes, 4 tonnes and 1 tonne. For one experimental filed plot no fertilizer was used, while for another one, chemical fertilizer was applied. The final results provide important evidence concerning the influence of sludge-fertilized treatments on potatoes productivity. Between all investigated scenarios, it was demonstrated that a dose of 25 t/ha sewage sludge used is ensuring the highest productivity level and the entire potatoes crop requirement of nitrogen.

Index Terms- quality, potatoes, productivity, sludge.

I. INTRODUCTION

The use of sewage sludge in agriculture is one alternative for the management of by-products from sewage treatment of industrial or municipal wastewater. This could be a proper solution as is already known their high content of organic matter, macro- and micro-nutrients. The process of recycling different types of waste materials by introducing in agriculture, needs a preparatory phase extremely important related to their sanitation, a scientific research objective important for community and practitioners, local administrators and for public bodies and institutions of environmental protection. On the other hand, studies on the environmental impact and human health risks of different strategies for the management of sewage sludge are more and more important for the public acceptability of the proposed alternatives [1].

II. REGULATIONS ON THE USE OF SEWAGE SLUDGE IN AGRICULTURE

The main EU Normative act, regulating the management of sewage sludge when it comes to their use in agriculture, is the Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment and in particular of the soil, when are is used the sludge from the wastewater treatment [2]. The Directive encourages and regulates the use of sewage sludge in agriculture, on the condition that the limit values for heavy metals is soils and sludge to be respected , so as to prevent harmful effects on soil, vegetation, animal and human health.

In Romania, the use of sewage sludge in agriculture is regulated by Order no. 344 of August 16th, 2004 approving the technical Regulations regarding the environmental protection with respect to the soil [3], in the case of using sewage sludge in agriculture which transposes the Directive 86/278 / EEC. The Order approves the technical regulations aimed at valorizing the agrochemical potential of the sewage sludge, preventing and reducing harmful effects on soil, water, vegetation, animals and population, so as to ensure a proper management of this sludge in agriculture. According to the Order, sludge from the wastewater treatment plants of localities and from other wastewater treatment plants with a composition similar to urban wastewater can be used in agriculture only if they comply with technical standards. In this regard, the Order establishes limit values of concentrations of heavy metals in soils on which sludge is applied; limit values for heavy metal concentrations in sludge and the maximum annual quantities of these heavy metals which can be placed in agricultural soils. Additionally, the use of sewage sludge in agriculture, should take into account the nutritional needs of plants, conservation of soil and surface water quality and maintenance of soil pH to values above 6.5. Specifically, in terms of type and characteristics of the sludge used in the experimental method of the study, is stated that they are in accordance with the technical regulations of the Ministry Order no. 344/2004 [3].

III. EXPERIMENTAL RESEARCH

A. Soil analysis

In the present work, the quality indicators targeted for the laboratory analysis mainly focused on the content of heavy metals (lead and cadmium), PCBs, PAHs according the Ministry Order no. 344/2004 [3], but considering also the Ministry Order 756/1997 [4]; other investigated parameters were pH, humus, phosphorus, potassium and nitrogen. The soil samples were individuated from an experimental field in

Covasna area, Romania. The main physicochemical characteristics of native soil are presented in the table bellow:

Table I Soil characteristics from the experimental field [1]

Parameters	M.U.	Value measured
pH	-	6,56
Humus	%	2,63
P-Alc	ppm	39,5
K-Al	ppm	226
Ammonia nitrogen	mg/100g sol	3,661

Table II Soil chemical indicators and maximum admissible concentrations [1]

Chemical indicators	M.U.*	Value measured	Alert thresholds Sensitive use MO 756/1997	Intervention thresholds Sensitive use MO 756/1997	Maximum admissible concentrations according to MO 344/708/2008
Lead	mg/kg d.m.**	8,6	50	100	50
Cadmium	mg/kg d.m.	0,67	3	5	3
PAHs	mg/kg d.m.	<0,05	7,5	15	-
PCBs	mg/kg d.m.	<0,01	0,25	1	-

* M.U. - measurement unit
** d.m. – dry matter

Results presented in Table II indicate that Pb and Cd concentrations in soil not exceed the limit values according the Ministry Order no. 344/08/2004 [3] being almost six times lower than the admissible limit for Pb and about 4 times lower in case of Cd. As in case of the organic compounds the national regulation has no set maximum admissible concentrations in soils where the swage sludge is used, the reference levels were considered from the (Table II) MO756/1997 [4]. Also in this case (for PAHs and PCBs) values are found within the maximum allowed by law.

B. Sewage sludge analysis

Besides other important characteristics related to soil and sludge characteristics that must be considered when sludge is used in agriculture, the MO 344/08/2004 stipulates also the maximum admissible concentrations (MAC) in sludge for the contaminants of concern considered in the present as following:

Table III Sewage sludge chemical indicators and maximum admissible concentrations [1]

Chemical indicators	M.U.	Concentration level	Maximum admissible concentrations according to MO 344/2008
Lead	mg/kg d.m.	35,61	300
Cadmium	mg/kg d.m.	0,72	10
PAHs	mg/kg d.m.	3,37	5
PCBs	mg/kg d.m.	<0,01	0,8

Results presented in Table III indicate the possibility to use the investigated swage sludge in agriculture according to the national regulation. It could be observed that in case of every single investigated compound, the identified concentration level in swage sludge is lower than the maximum admissible concentration stipulated by the national regulation. The concentration level is closer to the maximum admissible concentration is with regard to PAHs, but also here is lower than the admitted concentration level (3,37 mg/kg$_{d.m.}$ respect to the admissible level of 5 mg/kg$_{d.m.}$).

C. The experimental field

In order to evaluate the influence of sewage sludge on productivity and quality of potatoes a long-term field experiment with sewage sludge used on agricultural land was developed. Therefore, a practice-oriented experiment design was chosen and potatoes local plant specie was arranged in a Latin rectangle with five repetitions. For the establishment of the optimal dose concerning the used sewage sludge, soil chemical characterization was done. In this way, different scenario resulted, as illustrated in Fig. 1: for 1, 2 and 3 experimental filed plots 2.5 t, 4 t and 1 t, respectively were used; for the experimental filed plot 4 no fertilizer was used, while for the last one chemical fertilizer was applied. The fertilizer used in the experimental field is sewage sludge from Sfantu Gheorghe wastewater treatment plant, Covasna County (non-fermented sewage sludge from the dewatering press).

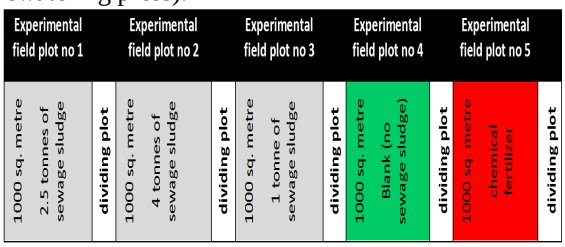


Fig. 1 Sewage sludge quantities used in the experimental field

IV. RESULTS AND DISCUSSION

The present study provides important evidence concerning the influence of sludge-fertilized treatments on potatoes productivity, but also on soil quality. According to the scenarios taken into account, Table IV is illustrating the main results gained in the framework of study, being illustrated the heavy metals (Cd and Pb), phosphorus (P) and potassium (K) concentration levels according to the doses of swage sludge applied on soil.

Table IV Soil characterization after the sludge-fertilized treatment

Sewage sludge quantity	tonnes/ha	Blank (no sewage sludge)	10	25	40
Chemical indicators	M.U.				
Lead	mg/kg d.m.	8,6	9,1	11,6	13,4
Cadmium	mg/kg d.m.	0,67	0,71	0,82	0,95
P	d.m. g%	22	44,7	51,3	57,5
K	d.m. g%	201	256	277	293

From Table IV could be observed that the pollutants concentration level is increasing once that the sewage sludge quantities were increased; this trend is maintained in case of both analyzed heavy metals. On the other hand, the application of sewage sludge in different quantities has highly significant positive effects for phosphorus and potassium contents in soil. Another important objective of the present research study was to assess the influence of sewage sludge on productivity and quality of potatoes. The study provides important evidence concerning the influence of sludge-fertilized treatments on potatoes productivity. Between all scenarios, as it can be observed from the results presented in Fig. 2, it was demonstrated that dose of 25 t/ha sewage sludge used is ensuring the highest potatoes crop productivity. On the other hand, also the potatoes quality was investigated as illustrated in Table V.

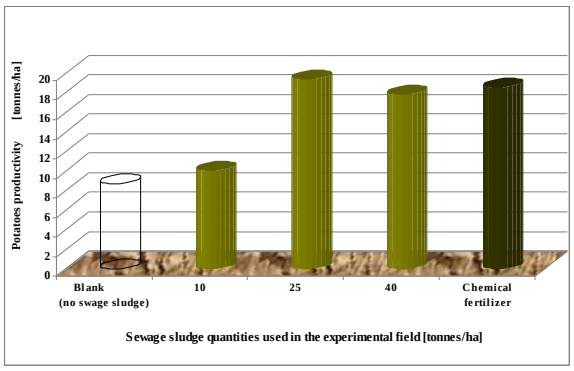


Fig. 2 The influence of sludge-fertilized treatments on potatoes productivity

Table V Potato quality after harvesting

Quality indicators	M.U.	Identified valued	The analytical method
Humidity	mg/kg d.m.	83,54	SR 3787/99 [5]
Protein	mg/kg d.m.	22,66	SR 3787/99 [5]
P	d.m. g%	0,85	SR 3787/99 [5]
K	d.m. g%	227,53	SR EN 14082/2003 [6]
aerobic NTG	Ufc/ml,g	-	SR EN ISO 4833/2003 [7]
coliform bacteria	Ufc/ml,g	-	SR ISO 4831/2009 [8]
Escherichia coli	Ufc/ml,g	-	SR ISO 16649-2/2007 [9]
Salmonella/25g	Ufc/ml,g	-	SR EN ISO 6579/2003/AC/2006 [10]
Detecting the presence of residues	Ufc/ml,g	n.d.	Met. Pt. Det. Rey. Prod. Fito.-ed.79 Ceres

Additionally, for potatoes from the land where a dose of 25 t/ha sewage sludge was applied, the concentration level of Cd and Pb in potatoes was also assessed. The obtained results were compared with maximum allowed level of concentrations for Cd and Pb in potatoes according to the European Regulation in force: Regulation (EC) No 853/2004 [11] (Fig. 3). The potatoes were analyzed according to SR EN 14083:2003 [12] for both metals (Cd and Pb). The identified concentration levels in potatoes are under the maximum values allowed by the regulation with regard to Cd presence in the foodstuff as potatoes and four times higher for Pb respect to the maximum level.

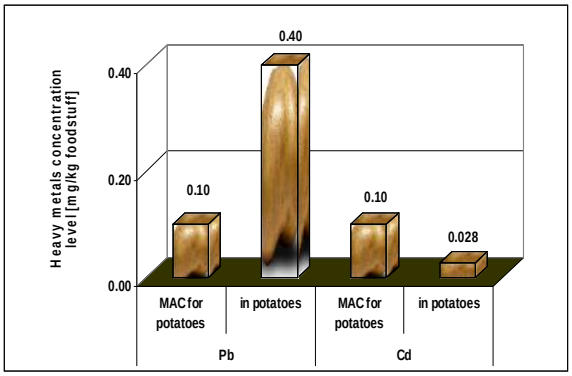


Fig. 3 Pb and Cd concentration levels in potatoes and allowed limits

CONCLUSION

The results from the research study demonstrate how the sludge application to the soil is effective in improving crop productivity as it happened in case of cultivated potatoes. The results obtained showed how for a certain amount of sewage sludge on land (25 t/ha), the potatoes production significantly increased in sludge-fertilized treatments as compared to the other quantities or using the chemical fertilizer. In the same time, it was showed that the concentration levels of heavy metals in soil (after that the sewage sludge was applied on land) did not overcome the maximum values stipulated by the national regulation even that concentration of Cd and Pb in soil increased according to the quantity of sewage sludge applied. These results indicated the possibility to use the investigated swage sludge in agriculture according to the national regulation, but a special attention must be focused on the heavy metals content in the cultivated vegetable products.

REFERENCES

[1]. D. M. Cocârță, V. Ruxandu Subțirelu, A. Badea, "The effect of sewage sludge on wheat productivity and quality and implications on human health", Proceedings of the International Conference on energy and environment, CIEM, Iasi, Romania, 22-23 October 2015, Ed. POLITEHNICA PRESS/ISSN 20670893.

[2]. Council Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture, CELEX-EUR Official Journal L 181, 4 July 1986, pp. 6-12.

[3]. Order No. 344/708 of 16th August 2004 on the approval of the technical Norms for the environmental protection and, especially, for soil protection, when using wastewater treatment sludge in agriculture.

[4]. Ordin Nr. 756 din 3 noiembrie 1997 pentru aprobarea Reglementării privind evaluarea poluării mediului. (Ministry Order No. 756 from November 3, 1997 for approval of Regulation concerning environmental pollution assessment), published in Official Monitor No 303/6 November 1997.

[5]. SR 3787/99 - Ware potatoes.

[6]. BS EN 14082/2003 - Foodstuffs. Determination of trace elements. Determination of lead, cadmium, zinc, copper, iron and chromium by atomic absorption spectrometry (AAS) after ash drying.

[7]. SR EN ISO 4833/2003 ISO 4833:2003 – replaced by SR EN ISO 4833/2014 - Microbiology of food and animal feeding

stuffs - Horizontal method for the enumeration of microorganisms - Colony-count technique at 30 degrees C.
[8]. SR ISO 4831/2009Microbiology of food and animal feeding stuffs -- Horizontal method for the detection and enumeration of coliforms - Most probable number technique.
[9]. SR ISO 16649-2/2007 Microbiology of food and animal feeding stuffs -- Horizontal method for the enumeration of beta-glucuronidase-positive Escherichia coli -- Part 2: Colony-count technique at 44 degrees C using 5-bromo-4-chloro-3-indolyl beta-D-glucuronide.
[10]. SR EN ISO 6579/2003/AC/2006 - Microbiology of food and animal feeding stuffs - Horizontal method for the detection of Salmonella spp. - Amendment 1: Annex D: Detection of Salmonella spp. in animal faeces and in environmental samples from the primary production stage (ISO 6579:2002/Amd 1:2007.
[11]. COMMISSION REGULATION (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs.
[12]. SR EN 14083:2003 - Foodstuffs. Determination of trace elements. Determination of lead, cadmium, chromium and molybdenum by graphite furnace atomic absorption spectrometry (GFAAS) after pressure digestion.

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