ON THE AGRICULTURAL USE OF SEWAGE SLUDGE IN ROMANIA

Marian BURDUCEA[1], Orest TROFIN[2,3], Toma STOLERU[1], Andrei LOBIUC[4], Gabriel Ciprian TELIBAN[5], Vasilica ONOFREI[5], Maria-Magdalena ZAMFIRACHE[1]

e-mail: marian.burducea@student.uaic.ro

Abstract

The construction of new waste water treatment facilities in Romania, especially in rural areas, increases the production of sewage sludge. European Commission recommends the reuse of wastes and since sewage sludge is a byproduct of waste water treatment, sustainable approach must be taken into consideration for the proper management and disposal. Sewage sludge contains high amounts of organic matter and nutrients and thus the reuse in agriculture is very important. This can be achieved following secondary treatment of the sewage sludge (biosolids) and depends also on the local conditions. Because the use of sewage sludge in agriculture is limited in Romania in accordance with its potential, the aim of the current paper is to emphasize the benefits of reusing this waste.

Key words: biosolids, reuse of waste, fertilizers

Sewage sludge results in the process of waste water treatment and is called biosolids when suffers a secondary treatment for sanitation (reduction of fermentation, moisture, macronutrients and pathogens). The most frequent methods for sanitation are aerobic and anaerobic fermentation, incineration, composting, sterilization or the use of lime. With the European Union (EU) legislation that aims the improvement of life quality especially in rural areas, in Romania, the number of wastewater treatment facilities is increasing. Moreover, the development of the collecting and treating systems of municipal wastewater resulting from domestic, economic or industrial activities, by a growing number of wastewater treatment plants is a reflection of welfare of the modern society.

Large amounts of sewage sludge are produced in EU, approx. 10 million tones dry solids (d.s.)a year and needs special measures for a sustainable management and disposal (Salado R., 2010; Kelessidis A., Stasinakis A.S., 2012). Biosolids contain high amounts of macronutrients and thus the use in agriculture is regarded as the most viable method of reusing this waste. The Sewage Sludge Directive 86/278/EEC regulate its use in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and men. Due to legislative restrains, that aim to ensure the safety of the citizens as well as to protect the environment, the methods used in the treatment of the wastewater lead to increasingly higher quality of sludge (Fytili D., Zabaniotou A., 2008; Smith B.R., 2009). However, in Romania, the use of biosolids in agriculture is still limited.

Most scientific papers shows positive effects of biosolids on plants by improving the yield because of the macro nutrient content (Cornfield A.H. *et al*, 1976; Vaca R. *et al*, 2011; Özyazıcı M.A., 2013; Chrysargyris A., Tzortzakis N., 2015) but also on the physico-chemical properties of soils on which they are used, by altering the bulk density of the soil, aeration and stabilization of eroded soils (Holz S.C. *et al*, 2000; Ros M. *et al*, 2003; Gu C. *et al*, 2013; Mihalache M. *et al*, 2014). There are also articles that shows some negative effects, concerning the increase in heavy metals in plants and soils, pathogens and esthetic alteration of environment through smell (Singh R.P., Agrawal M., 2007; Mazen A. *et al*, 2010; Vaitkute D. *et al*, 2010; Collivignarelli M.C. *et al*, 2015).

Considering the fact that production of biosolids will increase in Romania accordingly to the number of new wastewater treatment facilities, the aim of the current paper is to present an up to date comparative analyses concerning the production and disposal of sewage sludge in

[1] "Alexandru Ioan Cuza" University, Iasi
[2] " Gheorghe Asachi " Tehnical University, Iasi
[3] S.C. APAVITAL S.A. Iasi
[4] "Stefan cel Mare" University, Suceava
[5] "Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine, Iasi

Romania, with a special emphasis on the agricultural use.

Table 1

Sewage sludge production and utilization in Romania (thousands tones dry solids)

Time	Total production	Landfill	Other	Compost and other applications	Agricultural use	Incineration
2005	67.8	55.9	6.6	4.7	0.7	0
2006	225.6	145.4	6.7	3.9	0.4	:
2007	99.6	44.4	7.7	2.7	0.7	:
2008	79.2	36	1.2	2	0.5	:
2009	120.5	58.1	:	15.8	0.1	0
2010	82.1	40.5	1.7	1.3	1.9	0
2011	114.1	53.9	1.5	0.2	1.8	0
2012	85.4	43	1.4	1.3	2.2	0.4
2013	172.8	117.7	46.5	0.3	8	:

MATERIAL AND METHOD

The methods used employed the survey of literature mainly from the last 10 years. The dataset used for statistical calculations was obtained from EUROSTAT which is the official website responsible for presenting statistics of economical indices in EU. The statistical calculations for the period 2005 - 2013 for the selected indices was performed using Microsoft® Excel® software.

RESULTS AND DISCUSSION

According to Eurostat (2016), in Romania, land fill is the most used method of sewage sludge disposal while agricultural use and incineration are the last (*table 1*). However, in EU there are countries in which the greatest percentage of the produced sludge is used in agriculture. For example, in 2012, Spain, Germany and United Kingdom were the largest sewage sludge producers with 2577.2, 1844.4 and 1078 thousands tones d.s. respectively of which 74.5%, 29.3% and 78.2% were use in agriculture. In other countries such as Hungary, Greece and Romania, despite the fact that they produce considerably amounts of sludge, its utilization in agriculture is limited (157.7, 118.6, 48.4, thousands tones d.s. total production of which 9.5%, 11.8% and 4.1% are used in agriculture). Even though in 2013 the total production of sludge increased in Romania to 172.8 thousands tones d.s. only 8 thousands tones (4.65%) d.s. were used in agriculture (Eurostat, 2016). The percentage of biosolids used in Romania is very low when compared to the one of the average EU of the 28 countries (*figure 1*). Some of the reasons why in Romania the agricultural use of biosolids is still limited are: the lack of awareness about its benefits as a fertilizer, fear of contaminating the land with heavy metals, the costs of sludge transport on agricultural land and the costs for monitoring the environmental impact.

In Romania, the legislation that regulates the use of biosolids in agriculture is the MO 344/2004 regarding the technical normative for environmental protection and especially soils when sewage sludge is used in agriculture. MO 344/2004 focuses on the content of heavy metals that are present in sewage sludge and in soil. Even though this law is built to encourage the use of biosolids in agriculture, it contain a paragraph that is ambiguous, Ch. 2, paragraph 9, the producer is responsible for the quality, quantity, transport, application of sludge on the agricultural land and also for any effects on environment and human health that may arise from sludge utilization. It is not clear what are the thresholds that may be used to define an effect and therefore the producers are discouraged to use biosolids in agriculture.

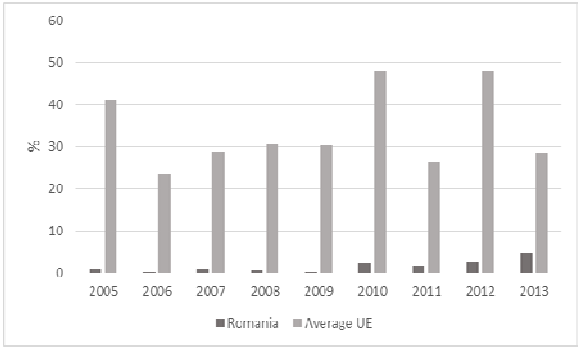

Figure 1 **Sewage sludge use in agriculture in Romania and average of 28 EU countries**

Research regarding the beneficial effects of utilizing sewage sludge for the crops fertilization in Romania, sustain its usefulness especially for the high amounts of macronutrients which improves soil quality that leads to greater yields. For instance, in a two year study, 1994-1996, at the University of Agricultural Sciences and

Veterinary Medicine, Bucharest, 10% sludge compost amendment to soil lead to an increased yield of maize with up to 199.9% (Stan V., 1996). Also, in a five year-crop rotation experiment with winter rape – wheat – maize – sunflower and wheat, at Podu-Iloaiei Agricultural Research Station, Iaşi County, the use of 40 tones/ha of sludge increased the yield of winter rape by 187% (Ailincai C. *et al*, 2011). Our previous work regarding the cultivation of *Ocimum basilicum* on an eroded soil amended with 15% biosolids from Iasi wastewater treatment plant, lead to an increase with up to 520% of *herba* yield (Burducea M. *et al*, 2016). Thus, the sewage sludge from Romania waste water treatment plants can be used, with very good performances, for the fertilization and soil conditioner for the land with agricultural purposes, especially for the growth of higher crops but also for some medicinal plants like basil, that are cultivated for the production of the essential oils.

The sewage sludge may be used in different scenarios, such as land spreading, incineration, landfilling, forestry or land reclamation. Each of the above directions has advantages and disadvantages, and the method to use for sludge disposal should consider the characteristics of the sludge and their compatibility with the environmental and geographical particularities and regulations of each country. Incineration of sludge may lead to release of gases such as N_2O and NO_x and toxic particles in the atmosphere, while landfilling may generate odor and vegetation disturbance (Przewrocki P. *et al*, 2004; Werther J., Ogada T., 1999). Some promising reusable methods are the biological ones, such as bacterial transformation of sludge to biocombustible (Angerbauer C. *et al*, 2008) or stabilization through the vermicomposting technique (Gupta R., Garg V.K, 2008). Land spreading may be a favored method, as the high levels of nutrients in sludge generate adequate levels of fertilization for soils and may also improve the physical characteristics of soils.

Usage of sludge as fertiliser in agriculture must however be carefully applied, as sludge contains not only elements needed for plant growth, but also numerous microorganisms, including pathogens (Arthurson V., 2008) organic pollutants and toxic metals (Hanay O. *et al*, 2008). These are the main reasons for which sludge is limited in agricultural use by regulations in many countries. In deciding if the sludge can safely be used in crops for fodder or human consumption, some aspects should be considered, such as the fact that the sludge characteristics vary significantly with its origin, with higher concentrations of pollutants in industrialized areas and with the type of treatments applied, but some of the data available is dated. The development of modern treatment stations lead to much improved sludge characteristics, and pollutants are, often, within regulatory values (Grøn C., 2007; Smith S.R., 2009).

CONCLUSIONS

The quality of the wastewater and especially the industrial wastewater will influence the quality of the sludge, even if now it is conform to standard requirements, this could be changed in the future and will restrict the alternatives of sludge disposal. The valorization and reuse of biosolids is however dependent to the local conditions, local availabilities of farmland and crops suitable for sludge use. Local authorities and sludge producers should rise awareness and information campaigns for farmers and civil society on the benefits of using sludge in agriculture. Academia, sewage sludge producers and farmers should be brought together for exchanges of good practices. The MO 344/2004 should be amended in order to eliminate the ambiguity of some paragraphs with a more specific ones.

REFERENCES

Salado R., 2010 - *Environmental, economic and social impacts of the use of sewage sludge on land, report prepared by RPA.* Milieu Ltd and WRC for the European Commission, Milieu Ltd., Belgium.

Kelessidis A., Stasinakis A. S., 2012 - *Comparative study of the methods used for treatment and final disposal of sewage sludge in European countries*. Waste Management 32:1186–1195.

Fytili D., Zabaniotou A., 2008 - *Utilization of sewage sludge in EU application of old and new methods—A review.* Renewable and Sustainable Energy Reviews, 12:116–140.

Smith B. R., 2009 - *Organic contaminants in sewage sludge (biosolids) and their significance for agricultural recycling.* Phil. Trans. R. Soc. A., 367:4005–4041.

Cornfield A.H., Beckett P.H.T., Davis R.D., 1976 - *Effect of sewage sludge on mineralisation of organic carbon in soil.* Nature, 260:518 – 520.

Özyazıcı M. A., 2013 - *Effects of sewage sludge on the yield of plants in the rotation system of wheat-white head cabbage-tomato.* Eurasian Journal of Soil Science, 2:35–44.

Chrysargyris A, Tzortzakis N, 2015 - *Municipal solid wastes and mineral fertilizer as an eggplant transplant medium.* Journal of Soil Science and Plant Nutrition, 15:11-23.

Holz S.C., Ingelo F., Canet R., 2000 - *Long term effect of the application of sewage sludge and vegetal cover on some physical and physiochemical*

properties of a degraded soil. Agrochimica, 44(3-4):132-139.

Ros M., Hernandez M.T., García C., 2003 - *Bioremediation of soil degraded by sewage sludge: effects on soil properties and erosion losses.* Environ Manage 31(6):741-747.

Gu C., Bai Y., Tao T., Chen G., Shan Y., 2013 - *Effect of sewage sludge amendment on heavy metal uptake and yield of ryegrass seedling in a mudflat soil.* J Environ Qual. 42(2):421-8.

Mihalache M., ,Ilie L., Madjar R., 2014 - *Translocation of heavy metals from sewage sludge amended soil to plant. Rev. Roum. Chim.* 59(2):81-89.

Singh R.P., Agrawal M., 2007 - *Effects of sewage sludge amendment on heavy metal accumulation and consequent responses of Beta vulgaris plants*. Chemosphere, 67:2229–2240.

Mazen A., Faheed F.A., Ahmed A.F., 2010 - *Study of potential impacts of using sewage sludge in the amendment of desert reclaimed soil on wheat and jews mallow plants*. Braz. arch. biol. Technol., 53(4):917-930.

Vaitkutė D., Baltrėnaitė E., Booth C.A., Fullen M.A., 2010 - *Does sewage sludge amendment to soil enhance the development of Silver birch and Scots pine?* Hungarian Geographical Bulletin, 59 (4):393–410.

Collivignarelli M.C., Abbà A., Padovani S., Frascarolo M., Sciunnach D., Turconi M., Orlando M., 2015 - *Recovery of sewage sludge on agricultural land in Lombardy: current issues and regulatory scenarios.* Environmental Engineering and Management Journal, 14 (7):1477-1486.

Eurostat, 2016, - Sewage sludge production and disposal,http://ec.europa.eu/eurostat/web/products-datasets/-/env_ww_spd, accesed on 22.10.2016.

Stan V., 1996 - *PhD Thesis, Contributii la valorificarea Agricola nepoluanta a unor reziduri de gospodarie oraseneasca*. University of Agricultural Sciences and Veterinary Medicine, Bucharest, Romania.

Ailincăi C., Jităreanu G., Bucur D., Ailincăi D., 2012 - *Soil quality and crop yields, after utilization of sewage sludge on agricultural land, in the Moldavian plain, Romania.* Cercetări Agronomice în Moldova, 45(1):5-18.

Burducea M., Lobiuc A., Jigau G., Pintilie C., Virgolici M., Burducea I., Trofin O., Zamfirache M.M., 2016 – *Municipal sludge amendments effects on growth and physiological parameters of Ocimum basilicum L. plants.* Proceedings of International conference Sludge Management, Palace of the Parliament, Buchares, Romania, 291-299.

Przewrocki P., Kulczycka J., Wzorek Z., Kowalski Z., Gorazda K., Jodko M., 2004 - *Risk Analysis of Sewage Sludge - Poland and EU Comparative Approach*. Polish Journal of Environmental Studies, 13(2):237-244.

Werther J. and Ogada T., 1999 - *Sewage sludge combustion*. Progress in Energy and Combustion Science, 25(1):55–116.

Angerbauer C., Siebenhofer M., Mittelbach M., Guebitz G.M., 2008 - *Conversion of sewage sludge into lipids by Lipomyces starkeyi for biodiesel production*. Bioresource Technology, 99(8):3051–3056.

Gupta R. and. Garg V.K, 2008 - *Stabilization of primary sewage sludge during vermicomposting*. Journal of Hazardous Materials, 153(3): 1023–1030.

Arthurson V., 2008 - *Proper Sanitization of Sewage Sludge: a Critical Issue for a Sustainable Society.* Applied and Environmental Microbiology, 5267–5275.

Hanay O., Hasar H., Kocer N.N., Aslan S., 2008 - *Evaluation for Agricultural Usage with Speciation of Heavy Metals in a Municipal Sewage Sludge.* Article in Bulletin of Environmental Contamination and Toxicology, 81(1):42-6.

Grøn C., 2007 - *Organic Contaminants from Sewage Sludge Applied to Agricultural* Soils. False Alarm Regarding Possible Problems for Food Safety? Environmental Science and Pollution Research, 14(1): 53–60.

Smith S. R., 2009 - *Organic contaminants in sewage sludge (biosolids) and their significance for agricultural recycling.* Phil. Trans. R. Soc. A, 367:4005–4041.