Current trends for the use of sludge from urban treatment plants in agriculture

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Abstract

One of the main environmental problems of the existence and development of modern citieis the recycling of domestic and industrial wastewater. Sewage sludge accumulates on the territory of the treatment plant, which is a multicomponent mixture of substances mainly of organomineral origin.

This article provides a brief summary analysis of current trends in the utilization of sludge from urban wastewater treatment plants in agriculture. The main directives and regulations related to the use of sludge in agriculture in the European Union and Bulgaria are presented. Data on the sludge used in agriculture in European countries are presented. The benefits and risks of introducing sediments into the soil and their impact on soil microflora are analyzed.

Key words*:* sludges from treatment plants; soil; agriculture; pollutants; legislation

INTRODUKTION

The problem with sediments treatment and utilization of the waste content from the purification plants is an issue with a decades-long history. Their treatment and disposal is an expensive and ecologically sensitive problem. Until recently this issue has had only ecological and economical dimensions, connected with the pollution of the environment and with the expenses for utilization and recultivation of the repositories for storage of these wastes (Badmanev & Doroshkevich, 2006). In the same time, according to numerous data, the sediments contain big quantity of organic substances (up to 45.60%), nitrogen (up to 6%), phosphorus (up to 2,5-3,0% P_2O_5), potassium (up to 0,3-0,5%), microelements and they can be used as a fertilizer for the crops (Vinokurova, 1999; Zakharov, 2004). Over the recent decades with the progress of the new technologies, the introduction of different innovative solutions and striving towards creation of „New economic cycles", the consideration of the sediments is not considered as a burden and expense, and as an achievements (Golub & Stukova, 2001).

LEGAL FRAMEWORK AND TRENDS WITH THE USAGE OF SEDIMENTS IN AGRICULTURE

Grounds for the usage of sediments from the city purification plants in the agricultural soils on the territory of the European Union is enacted in Directive 86/278/EU, dated 12 June 1986 for protection of the environment. The requirements of this directive in the Bulgarian legislation are regulated by „Regulation for the order and way for utilization of sediments from waste waters purification by their usage in the agriculture" dated 14 December 2004 (Marinova et al., 2016). It requires of the operators from the purification plants for waste waters the sediments to be stabilized before they are entered into the soil. The purpose is to be reduced the release of the unpleasant odours, as well as prevention of spreading pathogenic organisms. In accordance with this Directive the applying in the soil of sediments of waste waters, which exceed the critical concentrations of pollutants, is forbidden. The present Directive is applied in the national legislation of the member countries, most of which have determined lower boundaries than the prescribed in the directive (Mininni et al., 2015), with purpose preservation of the soils and decrease of the possible emissions (Pacyna et al., 2006; Thevenon et al., 2011).

The solution of the problem with the effective wastes elimination is connected with increase of their recycling degree. Throughout the years in the EU are observed important changes regarding the quantity of the used sediments and the ways for their utilization. According to the last researchnapproximately 39% of the formed sediments in the EU are used in the agriculture. Except for agricultural needs, the sediments are utilized also in the forestry, as well as with the recultivation of disrupted terrains, as for example unusable mines or closed repositories. Regardless of the fact that on the territory of the EU the total quantity of the sediments, utilized in agriculture is continuing to grow after 1995, significant changes are already observed in some member countries. Switzerland and the Netherlands, for example have terminated the usage of sediments in agriculture. Other regions of Europe like Flandria in Belgium, Bavaria in Germany and parts of Austria are beginning stage-by-stage to forbid this possibility because of the growing public concern regarding the safety. As of the present moment the main alternative of spreading sediments on agricultural areas in the countries from EU-15 is their burning, while in the new 13 members, this is still the landfilling. However, in both groups there are big differences between the separate countries. Many member countries are already burning a part of their sediments and are landfilling the residual ash. The quantity of the burnt sediments significantly increases, when their utilization in agriculture is not accepted or is forbidden. For example, in Flandria (Belgium) more than 70 % of the formed sediments are already burning, in the Netherlands - around 60 %, and in Austria, Denmark and Germany – approximately 40 %. In Slovenia the sediments are dried and 50 % are burnt in other countries. As a trend more and more are encouraged the activities as per treatment of sediments with utilization of the energy (NSPMRB, 2014). In province of Valencia (Kingdom of Spain) the procedure for usage of sediments is simplified and is completely in favour of the agricultural producer. It is an obligation of the operator of the purification plant for waste waters to do soil and sediment analyses, to prepare a report for application and to transport the sediment free of charge to the place of application.

The above indicated European trends set increased requirements regarding the qualities of the used sediments (transposed and in the Bulgarian legislation), which on its behalf is leading to increased requirements regarding the technologies for their treatment. Simultaneously it is of great importance the chosen technology for sediments treatment to allow more than one opportunity for utilization, i.e. at eventual change in the sediments parameters and impossibility for usage in the agriculture, these sediments to be able to be effectively used and in other directions.

In Table 1 is presented data about the quantities of sediments utilized in agriculture from purification plants in 2019 in several European countries.

The data in table 1 indicates that the biggest sediments quantity annually is generating France – 1174 thousand tons dry matter, and the least Slovenia. The sediments quantity generated by Slovenia is 32 times less than the one in France. The percent of sediments utilized in agriculture in comparison with the total generated quantity is different at the 11 studied countries. Ireland is utilizing in agriculture 79.31% of the total sediments quantity, followed by Latvia and the Czech Republic respectively with 47.62% and 46.19%. Slovenia and Slovakia do not use sediments in agriculture. Bulgaria is using in agriculture 32.35% of the obtained sediments as with this percent it is in the fifth place out of the considered countries.

EFFECTS ON THE SOIL BY THE USAGE OF SEDIMENTS FROM CITY PURIFICATION PLANTS

The usage of the sediments from the city purification plants is possible only in the cases when they conform with the requirements of the legislation and their usage is included in the respective design solutions. The bringing in of valuable elements as nitrogen, phosphorus and potassium and in less

Table 1. Sludge recovered in agriculture in 2019 (https://ec.europa.eu/eurostat)

Country	Total sludge generated (thousand tonnes dry matter)	Utilised in agriculture (thousand tonnes dry matter)	Rate of utilization in agriculture (thousand tonnes dry matter)
France	1174	299	25,47
Poland	584	108	18,49
Romania	283	35	12,37
Hungary	264	28	10,61
Czech Republic	223	103	46,19
Albania	98	10	10,23
Bulgaria	68	22	32,35
Ireland	58	46	79,31
Slovakia	54	0	0,00
Latvia	42	20	47,62
Slovenia	36	0	0,00

quantities calcium, sulphur and magnesium improves the structure and the nutrient regime of the soils. When using the sediments as a fertilizer occur positive changes in the soil properties, in the yields and quality of the plant produce (Levin & Habarova, 2012). Its water-retaining capacity and erosion resistance increase. By increasing the porosity and aggregation, the water-air regime of soils improves, the permeability of water and air increases, which leads to increase in the capacity for water retaining (Kanunnikova, 2000; Kasatikov et al., 1987). By increasing the doses dry matter in the sediments the level of the soil acidity decreases, and the quality of movable phosphorus increases (Yapparov et al., 2017). The permeability and porosity of the soil improve, which are indicators for its good functional condition (Pacyna et al., 2006). The organic substances, magnesium and calcium, which are entering the soil together with the sediments, contribute for the soil structuring, the adhesion of the soil particles to one another and the formation of microaggregates, which leads to increasing the content of fractions with size 0,25-0,50 mm (Baranovsky & Gladkikh, 2007).

A positive role of sediments is also proven on the humus balance as a result of the active activity of the soil microorganisms (Georgieva et al., 2017). The sediments can be used for restoration of forest terrains destroyed by fire. Their entering on such terrains improves the physical, chemical and biological characteristics of soils and accelerates the restoration of the soil functions and the forest ecosystem as a whole.

However, it should be taken into account that the uncontrolled usage of sediments may be accompanied by serious negative processes, affecting all components of the agro-ecosystems - soil, crops, atmosphere, underground and surface waters, since they cannot be a source of excessive quantities heavy metals and pathogenic microflora (Alekseeva, 2002). Besides the degree of pollution depends on the chemical composition of the wastes, as well as on the ways of their usage (doses, methods, frequency of application, combination with other agrochemicals and etc.) (Merzlaya et al., 2016). The chemical and biological composition of sediments from the city purification plants may be characterized with significant fluctuations over the different years, in different cities, as well as within the framework of one and the same purification equipment, which complicates the development of standards for their effective usage (Baibekov et al., 2013).

The usage of sediments in agriculture may cause transfer of heavy metals and pollutants in the arable land. The heavy metals, getting into by the sediments, are adsorbed by the soil in the upper humus horizon, forming slightly soluble compounds, absorbed by microorganisms and plants, a certain part of them is transferred in the lower horizons of the soil profile and in the underground waters (Levine, 1989). Their regular usage may increase the concentrations of the metal toxicants in the soil to levels, toxic for the soil microorganisms, which renders negative impact on their activity (Giller et al., 1998). The metal toxicants cause decrease of the general biogenity of the soil (Brookes & McGrath, 1984; Witter et al., 1993), lead to decrease of the activity of the nitrogen-fixing bacteria, freely living forms, as well as acting in symbiosis with roots (Martensson & Witter, 1990; McGrath et al., 1988; Owczarzak et al., 1993).

The regulation for the order and way of sediments utilization from waste waters purification by their usage in agriculture (published in State Gazette, issue 63/12 August 2016) (OPMR, 2016) specifies the maximum admissible concentrations (MAC) of heavy metals and arsenic (Table 2), as well as the microbiological and parasitological requirements (Table 3), which have to be fulfilled after treatment of sediments, intended for utilization in agriculture.

Disturbance of the soil microbial processes because of the heavy metals getting in by the sediments from the purification plants, has forced the legislators to impose strict decrees regarding their usage in agriculture on national level. Decrease of the pollutants emissions in the waste waters and decrease of heavy metals admissible concentrations in the sediments are the leading principles of work and control for decrease of arable soils pollution with heavy metals and pathogenic organisms. Different methods for disinfection of sediments are applied for destroying the pathogenic organisms (for example treatment by lime materials), with purpose their harmless and beneficial usage as a fertilizer in agriculture.

Table 2. Maximum permissible concentrations of heavy metals and arsenic in sludge, intended for use in agriculture (mg/kg to absolute dry matter)

№	Indicator	Maximum permissible concentrations
1	Cadmium	30
2	Cuprum	1600
3	Niccolum	350
4	Plumbum	800
5	Zincum	3000
6	Hydrargyrum	16
7	Chromium	500
8	Arsenicum	25

CONCLUSION

In order to be provided the soil reproduction and the increase of the agricultural crops productivity at the present conditions of mineral and organic fertilizers deficiency, it is appropriate to be developed ecological and promising methods for usage of non-conventional fertilizers, including sediments from the purification plants. Even the usage of a part of the sediments as means for fertilizing shall decrease the humus deficiency in the agriculture.

The sediments utilization in agriculture is necessary to be carried out in compliance with the legal framework, with special care about the human health and preservation of the environment.

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Table 3. Microbiological and parasitological requirements of treated sludge

№	Indicator	Tolerance on the indicator	Unit of measurement
1	*Salmonella* spp.	Absence (not allowed)	20 g wet weight (in 20 g sample from the sludge in the wet state, no presence of *Salmonella* spp. when applying a qualitative detection method)
2	*Escherichia coli*	100 MLN (most likely a number)	g wet weight
3	*Clostridium perfringens*	300 MLN (most likely a number)	g wet weight
4	Viable helminth eggs	1	1 kg dry weight

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