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SOCIO-ECONOMIC AND BEHAVIORAL ASPECTS OF SLUDGE UTILIZATION IN BULGARIAN FARMS

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ABSTRACT

The issue of sludge governance received from the wastewater treatment plants (WWTP) is extremely relevant and indisputably one of those discussed not only in Bulgaria, but also around the world. The positive role of sludge on the balance of humus as a result of activating the activity of soil microorganisms has also been proven. The aim of this article is to analyze the socio-economic and behavioral aspects of sludge utilization on farms. Extensive in-depth interviews have been conducted and summarized with farmers using and not using sludge in the Sofia region, aiming to gather complete information of production, economic, behavioral, organizational and other nature from farmers using and not using sludge. The main (economic, technological, behavioral, etc.) factors that influence the decisions on the use and non-use of sludge in agricultural production are identified. The results show that the effect of sludge utilization on crop yield is not instantaneous. It is established that there is a lag in revealing the benefits of this activity. Interviews conducted with farmers using sludge in their agricultural activities show twice the yields compared to conventional production. However, the application of sludge is accompanied by a number of challenges: public opinion, properties of sludge, as well as many issues related to the technological introduction of sludge in arable agricultural land.

Keywords: *agriculture, governance, sewage sludge, socio-economic aspects, Bulgaria.*

INTRODUCTION

The issue of sludge governance received from the WWTP is extremely relevant and indisputably one of the issues discussed not only in Bulgaria but also worldwide. The positive role of sludge on the balance of humus as a result of activating the activity of soil microorganisms has been proven. The socio-economic and behavioral aspects of the utilization of sludge obtained as a result of wastewater treatment have been studied in the scientific literature around the world.

A report published by RPA, Milieu Ltd and WRc for the European Commission, DG Environment (2008) states that at present not all impacts from sludge recovery

can be assessed. Palme et al. (2005) and Stenstrom et al. (2011) focus on socio-economic factors as determinants for farmers in the recovery of sewage sludge in wastewater treatment plants.

Currently in Bulgaria on the topic of WWTP sludge includes many studies related to the technological process, technology management and assessments of environmentally friendly and efficient use of WWTP sludge (Marinova and Tzolova, 2005; Baykov et al., 2013; Popova et al., 2017), without considering the influence of socio-economic factors.

The objective of the present paper is to identify the main economic, social and behavioral factors that encourage farmers to use sludge as a soil improver.

MATERIAL AND METHODS

The team developed a survey in the form of a structured questionnaire in three parts. The first covers questions with a general description of the interviewees. The second and third are aimed at farmers who use and do not use sludge, respectively. An analysis of the socio-economic and behavioral aspects in the utilization of sludge in agricultural holdings is made. During the period 2019-2020, in-depth interviews were conducted and summarized with farmers who use and do not use sludge in the Sofia region. The aim was to gather complete information on the production, economic, behavioral, organizational and other nature of farmers who use and do not use sludge. The analysis is based on a qualitative "picture" and summarized on quantitative data, given the restriction that is set - Sofia region. In some of the data differences and contradictions were found, but these are the real impressions of the interviewees in agricultural activity. They only reinforce some of the identified trends in practice.

RESULTS AND DISCUSSION

Characteristics of the surveyed farmers using sludge

According to the available information, there are seven farmers in the Sofia region, who use sludge. Their arable fields are located in the villages of Chepintsi, Svetovrachane, Lokorsko, Negovan, Buhovo, Seslavtsi, Stolnik and Grigorevo (Figure 1). The soils on which the sludge is used are diverse and include: chernozems – vertisols, chromic cambisols, gray luvisols, mollic cambisols, eutric fluvisols.

The largest producer cultivates 12 thousand decare of agricultural land. The other farmers cultivate an average of between 700 and 5,000 decare. The average age of farmers varies from 40-55 years. The farms are well provided with equipment, labor, good knowledge of the legislation and a positive attitude towards innovation in agriculture. All farmers have many years of experience in the industry for at least 10 years. The identified trends in sludge users will be divided, as follows:



Figure 1. Map of the conducted in-depth interviews with agricultural producers from Sofia region

Economic benefits

Interviews conducted with farmers using sludge in their agricultural activities show twice and in some cases up to three times higher yields compared to conventional production. This is additionally comparable to some challenges: public opinion, sludge properties, issues with technological input into agricultural land.

According to the interviewed farmers, about 40% of the total production costs are for fertilization – N, P and K. The farmers prove that sludge successfully replaces mineral fertilizers for a relatively long period of time - 5 years, during which they do not fertilize with mineral fertilizers, but continue to accumulate the benefits of the stock of sludge with minerals. Respondents say that the economic benefit is the elimination of costs of about € 60/ha per year for fertilization.

All farms communicate an additional benefit - the delivery of sludge is free from the treatment plant. The costs for plowing, depreciation of equipment, salary, consumables, etc. upon delivery of the sludge in the cultivated fields are paid by the WWTP.

Of cereals, it has been shown that maize is most strongly affected by sludge and the effect on yield is significant. Different effects on yield are reported for different soil types (Table 1;2;3), as follows:

Table 1. Maize yield with used sludge in different soil types

Maize	Chernozems – vertisols	Gray luvisols	Chromic cambisols	On average without the use of sludge
Yield (kg/dca)	1800	1600	1200	650

*Source: Author’s elaboration based on the questionnaire survey results, 2019-2020.

Table 2. Effect of sludge on grain yield on Chromic cambisols

Chromic cambisols:	Wheat	Barley	Maize	Sunflower
Yield with used sludge (kg/dca)	700	750	1200	300
Yield without used sludge (kg/dca)	350	300	500	180

*Source: Author’s elaboration based on the questionnaire survey results, 2019-2020.

Table3. Effect of sludge on yield in different crops in eutric fluvisols

Eutric fluvisols	Wheat	Sunflower
Yield with used sludge (kg/dca)	800	300
Yield without used sludge (kg/dca)	500	150

*Source: Author’s elaboration based on the questionnaire survey results, 2019-2020.

According to Farmers, sludge helps twice as much to retain soil moisture. In addition, provided there is no sediment, the soil itself retains no more than 20-30% of the water, depending on the type of soil. In comparison, about 80% of moisture retention is lost in the soil when there is no sediment. One of the key advantages of the influence of sludge on soil fertility is its ability to retain water and improve moisture retention. According to their calculations and observations, the sludge retains water 6 times more. This is an extremely important condition for harvesting and development of plants, given that for the period 2008-2018 there is a reduction of precipitation in 2.5 times in the region of Sofia. The effect of the sludge on the soil is visualized as a "sponge", and in addition the soil becomes looser. At the same time, given that the year is rainy, this is a sign that there will be better yields. In addition, the soil is easier to cultivate, which also affects the load on the tractors during plowing. The effect on wheat and barley is established after 3 years from the introduction of the sludge.

In addition, the following should be noted: maize grown with imported sludge has larger cobs, and wheat has a larger grain. Maize grown with the use of sludge has a significantly better developed stem, higher, with better developed leaf mass, larger cobs compared with that grown without sludge.

Social aspects

The biggest problem is the socio-psychological factor and the perception of the general public - the specific unpleasant smell emitted by the sludge during its introduction into the cultivated fields and resentment among the population. The passage of trucks through the settlements; the long plowing period; local government intervention; police; Complaints, anxiety, are part of the problems of farmers. The farmers say that the dry sludge does not emit such a specific smell.

It has been identified that the more liquid the state of the sludge, the more pungent the smell. Their concern comes from the fact that as a result of agro-technical requirements, they have a window of two months in the summer - these are the months from July to August, after harvest (after harvest), during which period a perfect plan must be made for days the introduction of the sludge, i.e. after harvesting, applying the sludge, spreading it on the field and plowing immediately. This is the next critical moment. If it is not plowed immediately and does not mix with the soil, especially when the wind increases and at high humidity, an unpleasant smell is released.

The farmers say that when the climate is dry - it does not smell, and when it is humid, the specific smell increases. However, everyone is aware that most often about 90% of the sludge content is the result of waste caused by human activity. Farmers are worried that if sludge is widely used in agriculture in the Sofia region, the amount of sludge during the plowing period "will not be enough for everyone". Perhaps this is the reason why many of them do not share with other farmers the positive effect of sludge.

Behavioral aspects

All interviewees are unanimous, that after plowing the sediment in the soil, its structure is compacted, as a result of which the soil is significantly compacted and fails to recover in the first year, especially if it was wet. This greatly hinders germination and slows down the physiological development of plants if sown. Everyone shares, that in the first year the sludge does not have the expected effect on the yield. It is generally recommended that in practice, after the application of the sludge, in the first year, the field should be set aside to restore aeration and improve the soil structure. This can happen in the second year. Farmers who use sludge strongly express their support and trust the officials of the treatment plant for technical assistance. In the area, producers have studied the presence of heavy metals and the content of minerals in the soils intended for cultivation. For the most part, soils are acidified with the presence of iron, heavy metals, lead. Farmers say they are doing analysis and soil samples and seeking the help of licensed laboratories. It is important for them to monitor the amount of N, P and K in the soil. They are interested in what substances the cultivated plant has "absorbed" from the soil. But so far they have not studied the mineral composition of crops and the presence of heavy metals in the grain, because they are not required by the legal framework in Bulgaria. Studies have been performed on maize for silage and the nitrate content is within the permitted norms. They found that the presence of zinc

in the sludge was a critical element. One of the producers shared that he found that after sunflower and corn - not to apply the sludge, which was not confirmed by the other interviewees. Most agreed that the best crop for sludge absorption is corn. Others mentioned that it was not good to use wheat as the first crop in the crop rotation. Quite different opinions have emerged here, on the basis of which no definite opinion can be taken. Apparently, each farmer has other influencing factors that have been spared or have not yet been identified by them. Agricultural experience has taught them that it takes 60 days to absorb mineral fertilizers into the soil, and the nutrients from the sludge are immediately absorbed by the plants.

Attitudes and summarized opinions of the group of farmers who do not use sludge. These are agricultural producers who grow land massifs (from 600 dca to 6000 dca) and are leading tenants for their regions. The main crops grown are: corn, wheat, sunflower and barley. There are farmers who specialize in growing mainly bread varieties of wheat.

The average age of farmers is about 40-55 years, actively working on farms, with extensive practical experience theoretical knowledge in agricultural science. They have a good technical provision of the farms with production equipment. They work with long-term partners for the realization of the production on the market.

Definitely everyone mentions that they are familiar with the use of WWTP sludge. It is noteworthy that everyone knows each other well and has observed changes in the harvest and yield of their colleagues using sludge. For most farmers, what they have heard, felt and observed and what worries them most is the separation of the specific smell and negative public opinion from it. Some of them even say that public opinion is leading for them, for fear that a large part of the people would withdraw to rent their land to them.

Many of them know that this also changes the structure of the soil, enriching and improving it. They share that for them this is not sludge, but it is a product that improves soil fertility.

It is noteworthy that some farmers have read scientific articles about sludge and for them the dried and treated sludge should not have a problem with the smell when plowing it into the soil.

Farmers have been informed by farmers using sludge that in the first year the sludge must be placed on land where corn is grown and not wheat. They have seen that corn in the first year does not give the desired yield (it sprouts and reaches a maximum height of 40-50 cm from the ground). To the assessment of the socio-economic impact of sludge in agricultural activity. Farmers believe that attending specialized information seminars will provide more clarity on the issue of WWTP sludge; informal conversation between farmers; television; internet and social networks and more publicity. At this stage in Bulgaria there is no specialized literature on the technology and the effect of sludge fertilization in agriculture, which is a guide for farmers. At the present stage they learn from practice, mutually and often with contradictory findings. We decided to test the readiness of farmers and their ability to calculate the risk, using something new (sludge to

improve soil fertility) on their farm - most of them are ready to sign a contract with WWTP to test half of their land and gradually to close the whole production cycle. In the interviews we identified respondents (mainly agricultural cooperatives with a large number of members) for whom, the sludge becomes a controversial point, in terms of the members' concerns that it could affect human and animal health. Agricultural cooperatives are extremely clear that will not use sludge. This categoricalness comes from the attitudes of the older population, which are the predominant members of the cooperative. The opinion imposed in the society is that the sludge is a waste product from a wastewater treatment plant, which is contrary to the principle of cooperatives before the society - their social role.

CONCLUSIONS

Preliminary observations show (also confirmed by interviews) that the effect of sludge recovery is not instantaneous. It is established that there is a lag in revealing the benefits of this activity. The recovery of sludge in agriculture should be considered as one of the possibilities for recovery of this waste product by WWTP in the long run, among other alternatives. Interviews conducted with farmers using sludge in their agricultural activity show twice the yields compared to conventional production. This also reveals the potential of the results. However, the application of sludge is accompanied by a number of challenges: public opinion, properties of sludge, issues related to the technological introduction of sludge in arable fields. The main (economic, technological, behavioral, etc.) factors that influence the decisions on the use and non-use of sludge in agricultural production are identified. The effect of sludge recovery in agriculture undoubtedly has a positive role to play. What will be their future as an element of the bio-economy is a question that depends on future European policies.

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