ADVANTAGES OF SEWAGE SLUDGE DEHYDRATION BY GEOTUBE METHOD

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Abstract

This paper describes the benchmarking of municipal sewing sludge dewatering technology with traditional geotube technology and air drying beds. The use of geotube dehydration technology process occurs faster due to reagents that provide clogging sludge. Applying the technology of dehydrating the sludge in geotube leads to reducing: the time required for dehydration from 18 months up to one month; the surface of land required for the dehydration from 6.0 to 1.25 ha, and respectively, for storage, from 27.7 to 3.65 ha. Removal of toxic gases into the atmosphere is reduced from 1.4 to 6.2 times. Compared with the traditional technology of air drying beds, the dehydrated sludge in geotubes contains 2 times more carbon and total nitrogen. Total phosphorus content had a slight tendency to decrease, total potassium concentration increases with 1.76 times. One tonne of dried sewage sludge stored in geotube and stocked for one year has the humidity of 65% and contains 151 kg of organic matter, 9.0 kg N, 10 kg P_2O_5 and 2.9 kg K_2O. Heavy metal content is below the maximum that is allowed by national legislation from 2008. The application of sewage sludge as a fertilizer provided a specific increase of the total yield over the two years of 100.5 kg per ton of grain units at the dose of 18 t/ha and 45.5 kg per ton of grain units at the dose of 36 t/ha .

Keywords: Sewage sludge, technology of dehydration, geotube, soil.

INTRODUCTION

The joint-stock company „Apă-Canal Chişinău" along with the specialists from Holland and Poland in 2008 started testing the processing the sewage sludge by the geotube method - with sacks used to dehydrate the sludge, being considered a solution of getting rid of the unpleasant smell. The process of dehydrating the sewage sludge by the geotube method happens rapidly in 7-20 days. The process is cathalysed by reagents, that make sure to bound the sludge and eliminate the water surplus. [6,7]

There was launched a pilot project from September to the end of 2009 year to dehydrate the sewage sludge in geotube, then it has continued with the works planned in the Project of Execution „Geotube". There had been dehydrated about 90 thsnd m^3 of gross sewage sludge in the framework of the pilot project. In this regard, were used 40 sacks of different dimensions, being used only 1.25 ha of the platform, which in comparison with the old traditional

method, it was used 6 ha [2,8]. Therefore, the sewage sludge pomped in this period was dehydrated in one month. Previously, this process would have taken more time, which was about 18 months.

After dehydration, the sewage sludge from the geotube sacks is evacuated once to the storage place in the cold period of the year, which is December-February, when the processes of releasing the unpleasant smell and decreasing the risk of infections are minimum. Approximately in the same way are working the epuration stations in Europe [2]. The only thing is that in Europe the „geotube" method is not used for such big enterprises as the epuration station from Chişinău. In this regard, with the production of such a form of sewage sludge has appeared the necessity to have a closer look by doing some research.

The aim of this work is about the technological and agri-chemical characteristic of the sewage sludge that was dehydrated by the geotube method and being tested as a fertilizer.

THE EXPERIMENTAL PART

The research was conducted during the period of 2010 – 2013 years. As a material of study has served the dehydrated sewage sludge in geotube with a term of storage greater than one year which was from the wastewater treatment plant in municipality Chisinau. Sludge samples were collected and analyzed from October 2011 to October 2012, in total being analyzed 6 samples.

There were made some field experiments in order to test the effect that the sewage sludge has on plant growth and the change of the soil content. There were experimented two doses of incorporating the sledge of 18 t/ha and 36t/ha, that was applied with these doses - 170 kg and 340 kg N/ha. The sewage sludge in the trial had the following chemical composition: pH – 7.05; humidity – 46.4%; organic mater – 22.2%; total nitrogen – 0.93%; total P_2O_5 – 1.00%; total K_2O – 0.29%; N-NH_4 – 606 ppm; P_2O_5 – 1450 ppm. The ratio C:N = 12:1. The sewage sludge was applied in autumn before ploughing the soil. The peas for grain (*Pisum sativum*) has benefited directly of the sludge. It was cultivated wheat in the second year of experiment. There were made specific works of herbiciding the area and applying different pests in the period of vegetation. The trials were made at the Experimental Station of the IPAPS „Nicolae Dimo", situated in the commune Ivancea, rayon Orhei, on levigated black content soil with a loamy-clayey texture, humus content 3.8-4.0%, mobile phosphorus 18-20 ppm (Macighin method), changable potassium – 270 ppm, PH of 6.7 and hydrolitic acidity – 26.5 me/kg.

There were used the following methods of determination for the analysis of the soil: humus –Tiurin method, mobile phosphorus – by colormetric dose after Macighin, changable potassium in the extract after Macighin by photometry in the light flame. There were used the following methods at the analysis of the sewage sludge: humidity – GOST 26713-85; organic matter – GOST 27980-88; total nitrogen – GOST 26715-75; total phosphorus– GOST 26717-85; total potassium– GOST 26718-85; N-NO_3 after Grandval – Leaju; N-NH_4 - GOST 26716-85. The processing of sludge from the statistic point of view of the obtained results was made according to B. Dospehov (1990).

RESULTS AND DISCUSSIONS

By analysing the presented information by the water provider from the municipality Chişinău, the dehydration of the sewage sludge by the „geotube" method, it was shown the method to be efficient (tab.1). By using this method, it was allowed to decrease the surface used for storage the dehydrated sludge of 7.6 times, necessary time to dehydrate of 18 times and the necessary site for dehydration of 4.8 times. Concomitantly with this decreased the elimination of toxic gases in the atmosphere from the surface unit in one year: to hydrogen bicarbide - 1.4 times; to sulphuretted hydrogen - of 6.2 times.

Table 1

Comparative analysis of dehydrating technology of the sewage sludge in an annual cycle at the epuration station of the municipality Chişinău (data of joint-stock company „Apă Canal Chişinău")

Nr.	Indicator, measure unit	geotube technology	air drying beds technology
1	Necessary time for dehydration, months	1.0	18
2	Necessary site surface for dehydration, ha	1.25	6.00
3	Necessary site for storaging the dehydrated sludge, ha	3.65	27.7
4	Elimination of toxic gases in the atmosphere on an area of 1 ha during 1 year, kg: a) Sulphuretted hydrogen b) Hydrogen becarbide	 85 3600	 530 5000

According to the presented date by the joint-stock company „Apă Canal Chișinău" , in the last two years at the epuration station annually is accumulated 110-115 thsnd m^3 of dehydrated sludge through „geotubes" with the humidity of 78-82%. The sewage waters at the entrance into the „geotubes" contain about 96% of humidity, after 40-45 days the percentage of humidity decreases to 78-82%. The transportation of dehydrated sludge from geotubes at the fermenting storage is done in the period December-February.

The results of the chemical analyses made in the dehydrated sludge and kept more than one year are presented in Table 2. The studied sludge is characterised by alkaline weak reaction. The pH value varies from 7.1 to 7.8, the aerage being 7.4. The standard abnormalty of the pH is 0.5%, and the coeficient of variation – 6.7%. The humidity constitution is on average 65.1% with a standard abnormalty of 16.4% and a coeficient of variation – 25.2%. The content of organic substances at the natural humidity is 15.1%. The standard abnormalty of the content of organic substances is 4.2%, and the coeficient of variation – 27,8%. The coeficient of variation of the organic substance in comparison with the dry substance ascertained by us, comprise, on average,

41%. The similar results were obtained by the researchers from Romania and other countries [4].

The chemical composition demonstrates that the sewage sludge is an important source of organic matter for the soil and nutritive elements for farm crops. The sewage sludge is very rich in content of total nitrogen – 0.90%, but also in phosphorus which is very deficient for 76 per cent of the tillable soils of the Republic of Moldova [1]. The content of the calculated total phosphorus at the mass with natural humidity is 0.99% with a posible spread from 0.94 to 1.05%. The standard abnormalty of the average value in absolute size is 0.05%, and the coeficient of variation – 4,5%. The sewage sludge has a very low content of potassium and natrium, and these elements are simultaneously eliminated, mostly, with the effluent, that is the reason they cannot be represented as a source of potassium to enrich the soil in this element [4]. The sludge under the trial contains on average 0.29% K_2O reported on mass to the natural humidity. The mobile forms of nitrogen and phosphorus comprise aprox. 14-17% of the total content (Table 2).

Table 2

Chemical composition of dehydrated sewage sludge by the geotube method at the epuration station of wastewater of the municipality Chişinău, reported to the mass with natural humidity

Analysed ingredient and measure unit	$\bar{x}$	Min	Max	S	V %	Sx	Sx %	Δx (+,-)
pH	7.4	7.1	7.8	0.5	6.7	0.35	4.8	1.1
Humidity, %	65.1	45.4	81.5	16.4	25.2	8.2	12.6	26.2
Organic substance,%	15.1	3.6	21.1	4.2	27.8	2.1	13.9	6.7
ash, %	19.7	10.1	33.5	13.2	66.8	6.6	33.4	17.9
Carbon, %	7.6	6.8	10.6	2.1	27.8	1.0	13.9	3.4
Total nitrogen,%	0.90	0.69	0.96	0.1	11.1	0.05	5.5	0.2
N-NO_3, ppm	39.0	24.1	64.1	2.12	54.4	1.06	27.2	34.0
N-NH_4, ppm	632	302	711	15.1	23.8	6.8	10.7	218
Total P_2O_5,%	0.99	0.94	1.05	0.05	4.5	0.02	0.002	0.06
P_2O_5 ppm	1450	1250	1680	0.12	0.02	0.06	33.3	20
Total K_2O, %	0.29	0.13	0.38	0.14	38.0	0.04	7.3	0.1
Total calcium, %	2.07	1.86	2.27	0.19	9.0	0.05	2.4	0.1
Total magnezium,%	0.42	0.14	0.85	0.31	73.0	0.08	19.0	0.2
Total sulphur, %	0.30	0.15	0.52	0.14	45.0	0.04	13.3	0.1

Remarque: $\bar{x}$- arithmetic average value; min – minimum value met; max - maximum value met; S – standard abnormalty of average; V – coeficient of variation; Sx – precision of average in absolute size; Sx % - relative precison of average; Δx – interval of assurance of average to the probability of 95%.

The sewage sludge, in comparison with other organogenic wastes, contains different heavy metals. Many of these metals (Mn, Zn, Cu, B, Mo) are necessary for the plants as nutritive microelements. Frequently, as a rule, on the soils with an intensive agriculture the lack of these microelements leads to the decrease in quantity and quality of the crops [3]. From this point of view, the sewage sludge is characterised as a complex fertilizer that includes all the biofile elements.

The content of heavy metals from the sewage sluge of the municipality Chişinău is under the maximum level permited by the current law (tab.3). The harmful metal for the vertebrate's organism (Cd and Pb) are on minimal level. The maximum limits under the law in 2008 were less severe than those established by CE by Directive 86/278/1988, as it is resulted in Table 3.

The main source of heavy metals are the wasted waters from the industial enterprises. Due tot the modifications that took place in the last 12 years in the structure and volume of production of the industrial enterprises of the municipality Chişinău, it was a decrease in volume of the wasted water and the concentration of heavy metals. By making a comparative analysis of technologies of dehydrating the sewage sludge at the epuration station of municipality Chişinău and the influence of on the composition of sewage sluge (tab.4), we can mention that, when applying the geotube method, the period of dehydration is more reduced in comparison with the classical technology. The content of carbon and total nitrogen reported to the dried mass was about two times higher (21.8 –11.4% and 2.58 –1.41%). The content of total phosphorus has a tendency of decreasing nonsignificantly with about 10% from 3.13 to 2.84%. The concentration of the total potassium increases with 1.77 times, from 0.47 to 0.83%. The ratio carbon:nitrogen is on the same level (8:1) for both the technologies and are characterized with a very small value that will bring benefits to an abundant assurance for the fertilized plants with nitrogen.

Table 3

Content of heavy metals from the sewage sludge obtained at the epuration station Chişinău, ppm

Sewage sludge origin	Cd	Cu	Ni	Pb	Zn	Cr	Mn
Air drying beds	-	415	92	53	1120	511	401
Geotube	22	209	115	24	460	43	441
LMA (CE)	10	1000	300	750	2500	1000	-
LMA (Republic of Moldova)	40	1750	400	1200	4000	-	-

LMA (CE) - Maximum limits admited by Directive 86/278/1988
LMA (Republic of Moldova) - Maximum limits admited in RM, HG nr 1157,MO nr.193-194 from 28.11.2008.

Table 4

Comparative analysis of chemical composition of the sewage sludge from the epuration station of mun. Chişinău

Nr	Analysed incredient and measure unit	Dehydration technology of sewage sludge			
		Geotube		Air drying beds	
		Natural humidity	Dried mass	Natural humidity	Dried mass
1	Humidity, %	65.1	-	36.9	-
2	Organic substance,%	15.1	43.3	14.4	22.8
3	Ash, %	19.7	56.4	48.7	77.1
4	Carbon, %	7.6	21.8	7.2	11.4
5	Total nitrogen, %	0,90	2,58	0,89	1,41
6	N-NO_3, ppm	39,0	112	65	103
7	N-NH_4, ppm	632	1810	62	98
8	Total phosphorus, %	0,99	2,84	1,98	3,13
9	P_2O_5, ppm	1450	4154	2980	4720
10	Total potassium, %	0,29	0,83	0,30	0,47

The sludge from the epuration of urban waste water station is essentially different of the traditional organic fertilizers not only by total content of nutritional elements, but also regarding the mobile forms that are easily accessible for plants. From this point of view they are more appropriate to the industrial fertilizers and can offer a guaratee of increased effect on plants from the first year of action [3].

The trial tests made in the field of the sewage sludge dehydrated by the geotube method has demonstrated to us that under its influence the peas used for grains have obviously increases in size (Table 5), the increase being of 400 kg to a dose of 18 t/ha and of 650 kg when the dose is being doubled. In the next year in autumn the wheat production increased significantly. At a dose of 18 t/ha the production of grains was with 34% higher that the non-fertilized control variant. But on the sites that received about 36t/ha the increase of yield after the sludge constituted 22% - of 1.5 times less than the variant treated with 18t/ha. These results, besides the results obtained, are saying to be attentive or crops sown densely in a row. We hope that in the next years to come the questions will be answered and thoroughly analyzed. Only the organic fetilizers, especially the sewage sludge requires observations and multi-annual eperiences.

Table 5

Influence of sewage sludge on peas yield and autumn wheat cultivated on levigated black soil, kg/ha

Variant	2012 First year of action Pea grains			2013 Second year of action autumn wheat			Total yield per 2 yrs in cerial units	Efficency of yield per 2 yrs in cerial units	
	yield	Efficiency of yield		yield	Efficiency of yield			kg/ha	%
		kg/ha	%		kg/ha	%			
Contol variant	2900	-	-	3970	-	-	7450	-	-

Sewage sludge (18 t/ha)	3300	400	14	5300	1330	34	9260	1810	24
Sewage sludge (36 t/ha)	3550	650	22	4830	860	22	9090	1640	22
DL 5%, kg/ha	-	320	-	-	640	-	-	-	-

Coming back to the discussion of the results obtained, we come to the conclusion that the total yield for two years at the variants fertilized with sewage sludge constituted 9090 – 9260 kg/ha in comparison with 7450 t/ha at the non-fertilized control variant. The specific efficiency of yield was 100.5 kg units of cerials per one tonne of sewage sludge in case of the dose 18 t/ha and 45.5 kg units of cereals per tonne at the dose of 36 t/ha. This is a fact that makes us believe that in small doses of 18-20 t/ha of sewage sludge it will be more efficient as well as from the agricultural point of view, fact that demonstrates us concludently the results of the experience as well as in economic aspect, only it will be operated with smaller quantities of sewage sludge per one unit of site.

Having a relative incresed content of organic matter and nutritive elements, the sewage sludge has contributed to the improvement of some physical, chemical and biological conditions of the soil. Data from Table 6 demonstrate the average of determinations in the samples of soil taken in spring in the first and second year of sewage sludge action activity. In the limits of expectance and the rules extablished by the law, it was created the process of transformation of the organic matter that was incorporated with the sewage sludge. It is observed a significant increase with 0.22-0.35% of the soil mass of the organic matter content in the arable soil at the fertilized variants. The content of mobile phosphorus grows in comparison with the non-fertilized variant with 11-19 ppm, and of changable potassium – with 70-80 ppm. These increases of phosphorus and potassium, that are accessible for plants, are due to not only the quantity applied with sewage sludge but also the solubilizer influence of the sewage sludge on the rocks and minerals from the soil that contain phosphorus and potassium. For instance, at a level of 0.29% of total K_2O with 18t of sewage sludge incorporated in the arable soil layer of 52.2 kg K_2O is corresponding to the size of 22 mg/kg soil (22 ppm). Therefore, it was incorporated with sewage sludge per total 22 ppm total K_2O, but in the soil of this variant it was found 70ppm accessibile K_2O.

Table 6

Modification of the organic matter content and accessible forms of phosphorus and potassium from the soil under the influence of applied sewage sludge (average on two years, tillable soil layer)

Experience variant	Organic matter, %		P_2O_5, ppm		K_2O, ppm	
	content	difference	content	difference	content	difference
Control variant	3.90	-	24.5	-	280	-
Sewage sludge,18 t/ha	4.12	0.22	35.8	11.3	350	70
Sewage sludge,36 t/ha	4.25	0.35	43.8	19.3	360	80

Table 7

Content of heavy metals (total forms) from fertilized soil with sewage sludge, ppm (arable soil layer)

Variant	Cd	Cu	Ni	Pb	Zn	Cr	Mn	Mo
Control variant	0	14	20	89	32	70	894	0.66
Sewage sludge,18t/ha	1.5	18	18	107	38	80	755	0.71
Sewage sludge,36t/ha	1,.6	18	20	89	37	75	857	0.64
LMA*	3	140	75	300	300	100	1500	3

LMA* = maximum admitted limits in the soil (HG. MO nr.193-194 from 28.11.2008)

That means, the accessible form of the potassium excceded the limit three times more (70:22) the quantity of the total potassium incorporated in the sewage sludge.

The heavy metals in the soil suffered little changes. In comparison with the non-fertilized variant it is observed an ascendancy in the content of Cd with 1.5-1.6 ppm, Cu – with 4 ppm and Cr – with 7 ppm (Tab.7), but their concentration does not exceed the maximum limits admitted in the soil.

CONCLUSIONS

At the epuration station from the waste water from the municipality Chişinău are annually resulted 110-115 thsnd m^3 of dehydrated sewage sludge in geotubes with the humidity of 78-82%. After one year, the humidity descreases to approx. 65%, that make the sewage sludge to be favorable from the technological point of view to be transportable and then applied as a fertilizer. In one tonne of dehydrated sewage sludge in geotubes and kept properly for one year it is contained 151 kg of organic matter, 9.0 kg of total nitrogen, 9.9 kg of total phosphorus, 2.9 kg of potassium and 20.7 kg of calcium. The content of heavy metals is under the maximum limits allowed by the national legislation starting from 2008. Comparatively with the classical technology, the dehydration technology of the sewage sludge in geotubes reduces: time required to be dehydrated with 18 times, the site surface for dehydration of 4.8 times, the site surface for storage of 7.6 times and elimination of toxic gases into the atmosphere of 1.4-6.2 times. The dihydration into the geotubes lead to a twice level increase of carbon, nitrogen and total potassium and reduced the level of total phosphorus in the sewage sludge with approx. 10 per cent.

Applying the dehydrated sewage sluge by geotubes as a fertilizer with a dose of 18 t/ha has assured to be a total efficiency of production of 1810 kg/ha of conventional cereals. At a dose of 36 t/ha of sludge the efficiency of yield was with 2 per cents less in comparison with the 18 t/ha dose. The specific efficiency of yiel per one tonne of sewage sludge constituted 100.5 kg in the first case and 45.5 kg of conventional cereals in the second experimented case.

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www.chisinau.md/print.php?l=ro&idc=403&id=3666

7. Până la vară, *nămolul* de la Staţia de epurare din Chişinău va fi **...** (Until summer the sewage sludge from the epuration station of Chisinau will be …)
www.chisinau.md › Prima › Serviciul de presă › Comunicate de presă

8. Au demarat lucrarile la Staţia de epurare a apelor din Chişinău (There have been stared the works at the epuration station of waste waters from Chisinau)

social.moldova.org › Social