Study Regarding Agricultural Use of Mud Waste from a City Sewage Purification Station

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The use of city muds in agriculture, an important method in many of the EU member states, has become lately a controversial subject in Romania. This paper presents determinations of the constituent components of mud and soil destined for the agricultural use coming from the Sewage Purification Station from Targu Jiu. The experimental data showed that the mud coming from Targu Jiu Sewage Purification Station is in agreement with the requests of its use as a fertilizer on agricultural fields, and the soils of the Gorj County allow the use of muds.

Keywords: mud waste, agricultural use of mud waste

The waters that circulate through the water network of the cities contain various organic substances coming from domestic waters, such as soluble and insoluble salts, clay particles driven by the street waters into the network, various species of cations and anions retained by the colloidal fraction, of organic or mineral nature, detergents and industrial-originated substances [1-6].

Before the discharge into the receiver, the wastewaters are purified in special purification stations by a series of successive actions having as purpose, on one hand retaining of solid particles, the biodegradation of soluble or insoluble organic compounds and the precipitation of the phosphate ions which may lead to the waters eutrophication from the receiver, and on the other hand to act in the sense of their cleaning by destroying the pathogen germs.

Initially, „crude" or „basic" sludges are obtained, which are passed through large concrete basins for the anaerobe fermentation, then they reach the so-called „drain tables", where their moisture is up to 70 – 80%. Such materials may be used as organic fertilizers in certain conditions: heavy metals content under certain limits and the lack of pathogen germs [7-9].

There was observed lately that there is a permanent risk on human health and to the environment (underground water, surface water, soil) resulting from the use of the mud in the agriculture, without previous analysis, because it may contain dangerous components [10-12].

This paper presents determinations of the mud and soil components destined for the agricultural use of mud coming from Targu Jiu Sewage Purification Station .

Experimental part

Primary and secondary mud from the city purification station was treated as follows:

- gravitational pre-thickening;
- anaerobe fermentation;
- dehydration of the fermented mud with centrifugal devices.

The fermented mud is dehydrated by centrifuges in the presence of a cationic poli-electrolyte.

The sampling was made according to the recommendations from the standard „The General Guide for the Sampling of Mud Resulted in the Processes of Pre-Treatment and Treatment" ISO 4832/92 (Coliform bacteria) and SR ISO 7251/96 (Escherichia coli); these are standards for products intended for the human consumption or animal food [13,14].

The bacteriological content of the mud sampled from Targu Jiu purification station was analyzed according to bio-solids norms.

The heavy metal content of the mud, the humidity, *p*H and nutrients concentration were determined.

The samples for the determination of the utilization possibility in agriculture of the mud were taken from the soil surface, from 2 agro-chemically homogeneous plots, of 1 hectare each, the sampling depth being 0 – 20 cm, in 1 kg plastic bags, separately labeled. The soil sampling was done with the help of the Mole type agro-chemical probes.

The soil samples were passed through solution with the help of the mineralizer by oxidation with concentrated H_2SO_4 and 50% perhydrol, then the samples are analyzed by flame atomic absorption spectrometry by using a flame system AA Spectrometer novAA®300.

Results and discussion

The analyzed data provide information regarding the composition and the quality of the anaerobic mud, fermented and dehydrated, obtained from the purification station of Tg. Jiu, as follows:

- all mud samples have a weak alkaline reaction; the *p*H value is 7.3 – 8.1;
- the dry substance content (≤ 30%) is specific for the anaerobic fermentation and for the mud dehydration by centrifuging;
- in normal working conditions, the dehydrated mud has a remanent humidity of minimum 74% (Tg. Jiu mud – 73%).

In Romania, the legislation doesn't settle the bacteriologic content from the residual mud which is going to be used in agriculture.

The residual dumped mud by anaerobic fermentation is in B class of the muds, which must be analyzed in order to identify the presence of residual coliforms and of Escherichia coli and is presented in table 1.

The fermented and centrifuged mud samples from the purification station of Targu-Jiu have an Escherichia coli

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Table 1
PATHOGEN AGENTS

Indicators		Escherichia coli Nr/g	Coliform bacteria Nr/g
Targu-Jiu Purification Station	Date		
	24.01.2006	$4236 \cdot 10^6$	$7985 \cdot 10^6$
	25.02.2007	$3128 \cdot 10^6$	$600 \cdot 10^6$

Table 2
NUTRIENTS CONCENTRATION (mg/kg US)

Indicators	Date	N_+	NH_4^+	NO_3^-	P_2O_5	MgO	CaO	K_2O
Targu-Jiu Purification Station	26.06.2006	41850	3385	360	1395	17895	121799	2847
	27.02.2007	43920	3416	237	1166	8397	54389	2189

Table 3
HEAVY METALS

Heavy metals (mg/kg SU)		Cd	Ni	Pb	Zn	Hg	Cr	Mn	Cu
Târgu-Jiu Purification Station	27.06.2006	<0.4	51	33	1049	<0.1	<0.3	302	92
	28.02.2007	<0.4	25	85	51	<0.1	<0.3	135	11
Maximum allowed values Directive 86/278 EEC		20 - 40	300-400	750-1200	2500-4000	16-25			1000-1750

Table 4
THE CHARACTERIZATION OF THE SOIL SAMPLES - FIRST SAMPLING POINT

Parameters	Unit	Source values										Normal Values	Limit Alert Values Sensitive use
		01	02	03	04	05	06	07	08	09	10		
pH at 20°C	pH unit	8.32	7.93	8.11	8.00	8.20	8.08	7.30	8.15	8.3	7.46	-	-
Humidity	%	3.37	3.19	3.89	3.11	3.69	3.65	3.65	3.65	3.75	3.72	-	-
N-total	mg/kg SU	1.776	1.829	1.716	1.650	1.648	1.678	1.647	1.814	1.930	1.525	-	-
NO_3 - N	mg/kg SU	41.68	42.59	44.42	46.35	44.34	44.51	47.65	47.46	43.7	44.19	-	-
NH_4 - N	mg/kg SU	16.88	18.0	19.20	18.6	15.8	13.9	17.7	15.49	20.00	16.2	-	-
P_2O_5	mg/kg SU	3.814	4.181	4.473	2.615	3.087	1.42	1377	3.323	3.90	1.140	-	-
MgO	mg/kg SU	10.779	11.400	11.523	11.77	13.03	10.96	11.117	13.68	14.61	11.64	-	-
CaO	mg/kg SU	17.411	14.921	15.068	16.49	14.75	12.77	12 615	12.31	22.82	21.66	-	-
K_2O	mg/kg SU	4.973	3.841	4.513	4.123	4.899	3.764	4640	4.733	3.49	4.42	-	-
Cd	mg/kg SU	<0.5	<0..5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	3
Cu	mg/kg SU	17.2	20.02	16.76	16.23	14.19	16.68	1892	17.21	15.30	18.76	20	100
Ni	mg/kg SU	27.21	25.66	24.59	23.7	22 51	23 54	25.38	2319	2 88	2795	20	75
Pb	mg/kg SU	15.06	14.12	14.95	13.41	12.33	14.54	13.38	1415	14.17	14.77	20	50
Zn	mg/kg SU	36.32	36.47	32.08	29.5	25.8	25.82	29 33	26.50	25.19	30.29	100	300
Cr	mg/kg SU	32.04	33.2	37.55	37.22	31.3	37.42	31.85	31.66	30.3	34.11	30	100
Mn	mg/kg SU	374.48	378.35	403.5	416	363.9	376.8	413.17	426.8	467.7	439.1	900	1.500
Hg	mg/kg SU	<0.1	<0.1	< 01	<0.1	<0.1	<0.1	1	<0.1	<0.1	<0.1	0.1	1

Table 5

THE CHARACTERIZATION OF THE SOIL SAMPLES FROM THE SECOND SAMPLING POINT

Parameters	Unit	L1 01	L2 02	L3 03	L4 04	L5 05	L6 06	L7 07	L8 08	L9 09	L10 10	Normal Values	Limit Alert Values
pH at 20°C	pH unit	8.39	8 29	8.01	8.30	8.27	7.57	7.68	8.36	7.66	8.09	-	-
Humidity	%	3.75	3.74	3.11	3.60	3.66	3.58	3.35	3.41	3.63	3.50	-	-
N total	mg/kg SU	2.034	1.911	1.931	1.841	1.582	1.689	1.838	2.09	1.748	1.731	-	-
$N\text{-}NO_3$	mg/kg SU	41.74	36.86	39.60	42.12	37.25	37.78	39.07	38.12	38.59	37.17	-	-
$N\text{-}NH_4$	mg/kg SU	10.69	8.61	9.35	10.80	7.93	10.36	5.45	11.77	11.17	11 .5	-	-
P2O5	mg/kg SU	3.446	2.673	3.504	3.085	2.205	1.661	1.420	1.836	1.664	1.304	-	-
MgO	mg/kg SU	19 838	13. 519	1Z82	11.41	15.308	205	14.925	19.050	12.062	10. 7fth	-	-
CaO	mg/kg SU	30.225	21.272	19. 517	19.464	18.70	21.385	25.121	28. 818	17.445	23..	-	-
K_2O	mg/kg SU	3.927	4.05	3.667	3.678	3.689	3.777	4.033	3.578	4.241	4.329	-	-
Cd	mg/kg SU	<0.5	<0.5	<0.5	< 0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	3
Cu	mg/kg SU	38.91	37.50	38.78	33.69	33.68	40.03	37.03	34.92	34.68	36.81	20	100
Ni	mg/kg SU	26.41	21.70	19.37	29.0 7	26.87	32.13	29.92	30.94	H2.41	27.02	20	75
Pb	mg/kg SU	21.88	20.97	15. 16	25.64	17.96	24,21	22.92	24.03	22.40	18.33	20	50
Zn	mg/kg SU	49.58	45.34	43 39	46.89	43.71	46.61	43.40	39.27	31.34	48.12	100	300
Cr	mg/kg SU	36.69	28.51	51.92	32.3-4	32.62	29.64	30.18	32.05	31.05	30.11	30	100
Mn	mg/kg SU	412.72	402.69	362.53	418.96	451.12	405.82	373.54	433.16	387.53	405.78	900	1500
Hg	mg/kg SU	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	1

content in the range of 3 – 4.5 millions/g total solids, and a Coliform bacteria content in the range of 6.06 – 7.9 millions/ g total solids.

The mud is, consequently, a possible bearer of pathogen agents such as bacteria (e.g. Salmonella), viruses (e.g. Hepatitis B), protozoa (e.g. Entamoeba) and helminthes (e.g. Ascarius). If the mud was hygienically cleaned before the use by advanced treatment, the risk regarding the human and animal health is low.

For this reason, the mud must be introduced by ploughing, immediately after applying.

Analyzing the concentration values of nutrients from table 2, it may be appreciated that the mud contains not only organic matter, but valuable nutritive elements as well, which are recycled and contribute to plants feeding.

The heavy metal content presented in Table 3 indicates lower concentration values as compared to the limits stipulated by the Directive 86/278 EEC for the biological mud used in agriculture as fertilizer.

The combination of low concentrations for heavy metals and the medium concentrations of nutrients make the mud coming from the Purification Station of Targu-Jiu a valuable organic fertilizer.

As compared to the muds from other European countries, the generated mud is adequate for applying in agriculture.

The dehydrated mud and the humid one have a caloric power between 229 – 463 cal/kg.

For the first sampling point (table 4), the results of the samples indicate the fact that the soil has a neutral to weak alkaline pH (7.3 – 8.5), a relatively constant humidity (3.47 – 3.90%), and the heavy metals content is under the alert limit.

The analytic results of the heavy metals in the medium soil samples lead to the following conclusions:

- cadmium and mercury are not detectable
- nickel with concentrations of 20-30 ppm exceeds the normal values for the soil (20 ppm), but is still under the alert limit (75 ppm)
- total chrome with concentrations from 30 to 37 ppm exceeds the normal value of 30 ppm, but is still under the alert limit (100 ppm).

The lead, zinc, copper, manganese concentrations are under the normal limits.

In Table 5 there are presented the analytic results for the second sampling point. The results of the samples indicate the fact that the soil has a weak alkaline *p*H (8.4 – 8.4), a relatively constant humidity (3.2 -3.5%), and the heavy metals content is under the alert limit. The heavy metals concentration is not significantly different as compared to other areas:

- cadmium and mercury are not detectable;
- copper is present in a concentration between 11.48 and 23.03 ppm. Three of the medium samples have concentrations that exceed the normal value of 20 ppm, but are much below the alert limits (100 ppm).
- nickel, with concentrations from 16.2 to 34.5 ppm, often exceeds the normal value (20 ppm), but remains under the alert limit (75 ppm);
- total chrome, with concentrations between 27.1 and 37.34 ppm, for all samples, is much under the alert limit (100 ppm);
- the zinc and manganese concentrations are below normal limits.

Conclusion

The residual mud is a rich source of nutritive elements for plants and improves the physical-chemical features of the soils, and the one coming from Targu Jiu Purification Station is in agreement with the requests of usage as fertilizer on agricultural fields. The qualitative indicators emphasize the fact that the heavy metals and pathogen agents content does not exceed the allowed limits for mud.

Due to its weak alkaline pH and to its physical characteristics, the soils of the Gorj County allow the use of muds coming from the Purification Station, but they must respect the dosage applied and calculated per surface unit.

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