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SLUDGE STRATEGY IN CARAS SEVERIN COUNTY AND REHABILITATION OF CONTAMINATED SITES

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Abstract

The sludge generation main source of Caraş-Severin County are the sewage treatment plants; the amount of sludge generated by the water treatment plants being insignificant. Because the annual amounts of sludge generated is high the processing, storage, recovery of sludge creates specific and complex engineering problems. The elaboration of the sludge strategy considered the quantities and quality, of current sludge, as well as those resulted after the completion of the construction works for the new water treatment and purification plants included in the Water - Water Waste Master Plan.

Also, the sludge resulting from the implementation of the Integrated Waste Management System at the county level must be taken into account. The sludge strategy aims to provide on a medium term sustainable solutions for the final recovery / disposal of the sludge generated in accordance with the legal provisions and the national strategy.

The paper presents one of the sustainable and viable options for sludge recovery in Caraş-Severin County, using them as an artificial soil for re-ecological contaminated sites (33), amounting to 629 hectares: mining waste dumps, tailings ponds and non-compliant deposits.

Key words: sludge strategy, contaminated sites, sewage treatment plants, degraded lands, sustainable recovery

INTRODUCTION

The main source of sludge generation in Caraş-Severin County is the sewage treatment plants, because the sludge from the water treatment plants are low quantity and their constituents are predominantly of mineral nature.

Contaminants contained in the wastewater, as well as the transformation products removed from the liquid phase during the process of treatment of influences in treatment plants, are found in the majority of cases in sludge process (Burtica et al., 2000; Negulscu, 2016).

Some of the sludges are chemically inert, others ferment (sludge generated by biological treatment processes). Organic sludge requires specific treatment processes that allow their inclusion in the natural environment as organic fertilizers and artificial soil (Iorgulescu, 2015).

Because the generated sludge of the sewage sludge plants are very high sewage sludge processing, storage, recovery and/or disposal create complex engineering problems in the global field of treatment of influences in sewage treatment plants (Mirel, 1998; Kainz et al., 2002).

The sludges are polyphase mixtures consisting of a basic fluid, water and various mineral or organic constituents dispersed in the aqueous medium. Sludge processing methods aim for removing as much water as possible from the polyphase mixture (Ianuli et al., 2001).

The sludge management strategy for Caraş-Severin County aims to provide sustainable solutions for final recovery of sludge generated by the "ACVABANAT" Inter-community Development Association, adapted to the specificity of the county, which is in line with the legal provisions and the national strategy in the field (Dima et al., 2014; Man, Mateoc-Sîrb, 2008).

The objectives for short and medium term strategy are to capitalize on the sludge by:

- sludge use as organic fertilizer on agricultural land (Fekete, Pepó, 2017);
- sludge use as organic fertilizer on forest lands;
- sludge use as artificial soil on degraded land, including the re-ecology of mining waste dumps and tailing ponds (Pantea et al., 2015);
- sludge use as the daily coverage layer of the active area of domestic waste storage cells at the Lupac Integrated Waste Management Center;
- use of artificial soil for ecological reconstruction of non-compliant landfills in Caraş-Severin county.

MATERIAL AND METHOD

From the agglomerations of Caraş - Severin County result two types of sludge:

1. sludges generated by the process of water treatment plants, a predominantly mineral sludge;
2. sludge generated by the sewage treatment process - a predominantly organic sludge.

The sludge generated by the water treatment plants being predominantly inorganic requires a simple treatment process consisting in thickening and dehydration of the sludge (Cozma et al., 2014).

In order to reduce humidity, it is stored on the drying platforms in the treatment stations, and the moisture loss from 24 % to 35 % it is realizing in 2-3 weeks, in warmer months if the thickness of the sludge layer is <50 cm.

Sludge from sewage treatment plants contain a large amount of organic substance, there are fermentable and require a specific treatment process that allows them to be re-introduced into the natural environment (Robescu et al., 2001).

The complexity of sludge treatment problems due to the following issues:

- the sludge contains most of the contaminants contained by the influent in the station (industrial and domestic sewage);

- the active sludge excess resulting from the biological treatment process that need to be temporarily stored contains besides organic compounds resulting from process and pollutants whose concentration may be higher than that of the influent.

RESULTS AND DISCUSSION

Sludge quantity

After the implementation of the project "Modernization of the Water and Wastewater Infrastructure in Caraş - Severin County" financed by POS Mediu Phase 1, the quantities and types of sludge produced in the water treatment plants are presented in Table 1.

Table 1

Sludge quantity produced in treatment plants

Treatment Plant	Sludge quantity 35 % SU (to/year)	Sludge quantity 35 % SU (m3/year)	Sludge elimination
Resita	581.89	505.99	Sludge deposit
Caransebes	179.61	156.18	
Anina	8.88	7.72	
Baile Herculane	49.40	42.96	
Total	819.78	712.85	

The quantities and types of sludge that will be produced in the treatment plants in the county are presented in table 2.

The quantities of sludge obtained after the implementation of the project and projected up to 2031 are shown in table 3.

Sludge quality

The sludge from the treatment plants in the Caras-Severin County currently does not respect the quality imposed by the normative norms. So that the financing exercises funded by the project "Modernization of the water and wastewater infrastructure in Caraş-Severin County". Initially through POS Mediu 1, subsequently, by POIM, the implementation of the specific technological solutions and fluxes necessary for the operation of the wastewater treatment plants at parameters according to the laws.

Thus, the Resita Wastewater Treatment Plant, for which CS-CL -03 works contract is currently in progress - Extension with the Tertiary Stage of the Wastewater Treatment Plant, as well as for the agglomerations Anina, Oravița, Bocșa, Moldova Nouă, Băile Herculane, Oțelu Roșu. Rehabilitation/retechnology in progress at different stages of physical progress for each agglomeration: Anina (21 %), Moldova Nouă (82 %), Oravița (95 %), Oțelu Rosu (83.4%), Băile Herculane (7 %), Bocșa (79.60 %).

For the Caransebeș agglomeration, the new treatment plant is completed, but due to delays in the CS-CL-07 contract, which provides the influential necessary for the operation of the treatment plant, the treatment plant is currently unable to be put in function. (Giurconiu et al., 2002)

Table 2

Quantity of sludge produced in treatment plants

Name of the agglomeration	**Sludge treatment process**	**Sludge quantity 35 % SU (to/year)**	**Sludge quantity 35 % SU (m3/year)**	**Sludge quantity 22 % SU (to/year)**	**Sludge quantity 22 % SU (m3/year)**
Resita	Stabilized anaerobic, thickened, dehydrated + lime treatment	7.514.01	6.533.92	-	-
Caransebes	Stabilized anaerobic, thickened, dehydrated	-	-	3.464,43	3.149,48
Bocsa	Stabilized anaerobic, thickened, dehydrated	-	-	1,725.16	1,568.33
Otelu Rosu	Stabilized anaerobic, thickened, dehydrated	-	-	1.202,09	1.092,81
Moldova Noua	Stabilized anaerobic, thickened, dehydrated	-	-	913,68	830,60
Oravita	Stabilized anaerobic, thickened, dehydrated	-	-	1.139,75	1.036,14
Anina	Stabilized anaerobic, thickened, dehydrated	-	-	685,98	623,62
Baile Herculane	Stabilized anaerobic, thickened, dehydrated	-	-	702,33	638,48
TOTAL		7.514,01	6.533,92	9.833,42	8.939,48

Table 3

Quantity of sludge projected in treatment plants and treatment plants

Sludge quantity from water treatment plants 35 % SU	U.M	2015	2016	2020	2025	2030	2035
	to/year	808.13	819.78	866.37	783.25	700.12	683.50
Sludge quantity from sewage treatment plant Resita 35 % SU	to/year	7,579.62	7,514.01	7,257.20	6,948.48	6.652.91	6,595.32
Sludge quantity from sewage treatment plants 22 % SU	to/year	9,925.47	9,833.42	9,487.34	9,093.34	8,706.52	8,631.16

Resita sewage and treatment system

Waste water collection in Resita municipality is realized through a unitary collection system, the sewerage network has a beach of 200 ÷ 1000 mm in diameter, with a total length of 106 km of which the main collector is 8.5 km.

The technological flow of the Resita wastewater treatment plant has a 300 l/s mechanical water line (313 l/s designed) consisting of a two - compartment mechanical grate, two - compartment scrubbed scrubber, grease separator, grease separator 2 ponds with air-insulating installation, and on the sludge line 1 primary decantor 25 m in diameter with railing and 4 sludge platforms. The quality of the sludge from the Resita treatment plant is shown in table 4, table 5 and table 6.

Table 4

Chemical analysis of the sludge sample - results of PAH analyzes in the sludge sample (relative to dry matter)

Sludge components	**Slugge (mg/kg)**
Beginning of sample preparation / completion of measurements	20.10.2014/28.10.2014
Naphthalene	0,176
2 methyl- naphthalene	0,082
1 methyl- naphthalene	0,048
Acenaphthylene	0,018
Acenaphthene	0,046
Fluorene	0,044
phenanthrene	0,253
anthracene	0,039
fluoranthene	0,323
pyrene	0,288
benzo (a) anthracene	0,087
chrysene	0,154
benzo(b) fluoranthene + benzo(k) fluoranthene	0,200
benzo(e) pyrene	0,119
benzo(a) pyrene	0,092
indeno (1,2,3-cd) pyrene	0,082
dibenzo(a,h) anthracene	0,019
benzo(g,h,i) perylene	0,098
Total naftaline	***0,306***
Total PAH fără naftaline	***1,86***
Total PAH	***2,17***

Source: SC AQUACARAŞ SA, Resita Wastewater Treatment Plant - Analytical Bulletin date 18.10.2014

Political, legal and institutional framework

Sludge is classified as waste, but according to the waste management hierarchy, the policy is to use sludge beneficially whenever feasible, as an organic fertilizer on land, or as a source of energy recovered by combustion.

There are a large number of CE directives and regulations with direct or indirect implications on the management of sludge that have been transposed into Romanian legislation (Brown Lester et al., 2002).

Table 5

Chemical analysis of the sludge sample - results of PCB analyzes in the sludge sample (relative to dry matter)

Sludge components	***Sludge (mg/kg)***
Beginning of sample preparation / completion of measurements	*20.10.2014/27.10.2014*
PCB 28 (2,4,4'-trichlorobiphenyl)	*nedetectat*
PCB 52 (2,2',5,5'-tetrachlorobiphenyl)	*0,0075*
PCB 101 (2,2',4,5,5'-penta CB)	*0,0049*
PCB 118 (2,3',4,4',5-penta CB)	*0,0029*
PCB 153 (2,3',4,4',5,5'-hexa CB)	*0,0109*
PCB 138 (2,2',3,4,4',5,5'-hexa CB)	*0,044*
PCB 180 (2,2',3,4,4',5,5'-hepta CB)	*0,0090*
Total PBC 28-180	***0,0467***
Total PCB 1-209	***0,2190***
Total PAH	***2,17***

Source: SC AQUACARAŞ SA, Resita Wastewater Treatment Plant - Analytical Bulletin date 18.10.2014

Table 6

Chemical analysis of the sludge sample

Sludge components	**U.M.**	**Sludge**
Beginning of sample preparation / completion of measurements		21.10.2014/28.10.2014
PH		7,41
Umiditate	m/m%	76,6
Pierdere la calcinare	m/m%	36,5
Fosfor total, P_{tot} (P_2O_5)	m/m% s.u.	2,77
Potasiu total, K_{tot} (K_2O)	m/m% s.u.	0,52
Azot total, N_{tot}	m/m% s.u.	3,3
TOC	mg/kg s.u.	4267
AOX	mg/kg s.u.	1,08
Cd	mg/kg s.u.	1,45
Cu	mg/kg s.u.	248
Ni	mg/kg s.u.	31,7
Pb	mg/kg s.u.	06,2
Zn	mg/kg s.u.	786
Hg	mg/kg s.u.	3,25
Cr	mg/kg s.u.	73,5
Co	mg/kg s.u.	6,58

Source: SC AQUACARAŞ SA, Resita Wastewater Treatment Plant - Analytical Bulletin date 18.10.2014

The use of sludge in agriculture is the sustainable management of sludge, but the preference for agriculture is reiterated in CE legislation (Directive 91/271/CEE and Directive 86/286/CEE) as the sludge quality standard satisfies certain requirements and its use is co-ordinated and monitored to minimize potential impact on the environment and human health (Mateoc-Sîrb, 2004).

The main legislation in Romania in this respect is MO 344/2004 transposing CE Directive 86/278/CEE on the protection of the environment and especially of the soil when sludge is used in agriculture. The use of sludge in agriculture implies its treatment and the most preferred method is anaerobic fermentation. Control of pollutants (heavy metals and organic micro-pollutants) in sludge is important to ensure the conformity of sludge quality with OM 344/2004.

Consequently, the entry into of the quality standards for industrial wastewater discharged into the sewage system is crucial, although the pollutant elements in the sludge will not be completely eliminated due to the different existing sources (human faeces, materials used for pipeline repairs, domestic order etc.). Prior to sludge application, agricultural land should be assessed for its suitability and compliance with OM 344/2004 (and other legislation on the protection of water resources). Issuing a permit to apply sludge to agricultural land involves the involvement of OSPA, the County Department for Agriculture and Local Environmental Protection Agencies.

Of all the existing options for sludge recovery, its use in agriculture is the most plausible both technically, logistically and institutionally, and therefore it has been given the utmost attention in the elaboration of the national strategy for sewage sludge management in Romania.

By comparison, the other sludge disposal or disposal options are relatively simple from an institutional and operational point of view as well as from the perspective of the operator of the treatment plant because it is only necessary to transport the sludge to a third party that will assume the subsequent responsibility for the sludge management. Such facilities involve the co-processing of sludge in cement plants, the composting of sludge with solid waste, or the discharge of sludge into solid waste landfills (Man, 2014).

Removal of sludge in landfills is regarded as the ultimate option, EC legislation progressively restricts the disposal of organic waste. The new waste legislation in Romania sets an objective for 50 % reduction of waste disposal in landfills by 2020, which will have an impact on the cost of landfilling sludge in landfills.

Surfaces and total capacities for temporary sludge deposition

Total areas and capacities for the temporary disposal of sludge available in the treatment plants are shown in Table 7.

Table 7

Surfaces and capacities for temporary storage in treatment plants

Wastewater treatment plant	Sludge quantity 2016	Storage period	Surface of the temporary storage facilities	Total storage capacity
	mc/year	months	square feet	mc
Reșița	6,533.92	2	750	1,100
Caransebeș	3,149.48	6	641	1602.5
Bocșa	1,568.33	6	320	800
Oțelu Roșu	1,092.81	6	222	555
Moldova Nouă	830.62	6	170	425
Oravița	1,036.14	6	211	527.5
Anina	623.62	6	60 (cohesion funds) 40 (government funds)	150
Baile Herculane	638.48	6	130	325

The sludge generated by the 8 agglomerations in the county, a part are mineral sludge (from the 4 water supply stations) and a part are organic sludge (generated by the 8 treatment plants).

The sludge generated from water treatment processes with inorganic character requires a simple treatment process consisting of thickening and dehydration up to 35 % SU.

The sludge generated from the treatment plants, following investments, financed from the Cohesion Funds through POS Mediu, for the treatment plants, the effluent will be in the NTPA 001-2005 provisions.

The sludge characteristics are estimated to be almost similar to sludge from WWTPs in Europe.

The sludge from the Resita treatment plant will be thickened and dehydrated to 3 5% US, and in the other 7 treatment plants up to 22 % US.

Possibilities for final disposal/disposal of the sludge. Use of sludge in the form of artificial soil to cover tailings dumps/soil degradation

The hazardous industrial deposits in Caraş - Severin County, specified in annex no. 5 of HG 349/2005, stopped their activity according to the closure/shutdown program, being involved in the rehabilitation programs through closure and ecological or exploitation.

The area occupied by industrial and domestic waste inventories so far is 459.32 ha, of which:

- 5.15 hectares of slag and ash waste from CET Crivina Anina;
- 70 ha of landfills, of which 31 ha in the urban area;
- 327.97 ha occupied with tailings from the extractive industry;
- 56.2 hectares of slag resulting from processing processes in the ferrous metallurgical industry.

These deposits, even if the storage on them has been stopped, are in most cases a source of soil pollution (including adjacent land), the atmosphere, surface water, groundwater that affect the landscape. There is also a potential risk of loss of local stability, a potential permanent risk for human settlements, communications routes and adjacent land.

Critical areas in terms of soil degradation, affected by different industrial and agricultural activities are shown in table no.8.

Table 8

Soils affected by pollution in Caraş-Severin County

ID	Name	Surface (ha) and degree of damage					
		weak	moderate	strong	very strong	excessive	**Total**
01	Pollution by day-to-day excavation (up-to-date mines, ballasts, quarries, etc.)					711	**711**
TOTAL 01						711	**711**
02	Deposits, waste dumps, tailing ponds, flood tailings, landfill sites, etc.					629	**629**
TOTAL 02						629	**629**
06	Organic waste and residues from the food and light industry and others					150	**150**
TOTAL 03						150	**150**
07	Wastes, agricultural and forestry residues					10	**10**
TOTAL 04						10	**10**
08	Animal manure					93	**93**
	TOTAL GENERAL					**1593**	**1593**

Sludge from sewage treatment plants may be used as artificial soil for the ecological rebuilding of land on which waste is stored or is excessively degraded. Artificial soil technology is simple and can be transported in big bags.

Taking into account the experience of other countries as well as the large areas (629 ha) of contaminated sites (33), the artificial soil is a viable and sustainable solution for the final valorization of the sludge from the Caraş - Severin wastewater treatment plants. Within a short time, there will also be a market for this product.

Thus, in the short term (2018-2020) the quantities of sludge obtained in agglomerations used as artificial soil for degraded lands are:

• Use of sludge from the Caransebeș, Bocşa, Oţelu Roşu, Moldova Nouă, Oraviţa, Anina and Baile Herculane slopes as artificial soil on degraded lands – 10 % of the generated quantity;

• Use of sludge from Reşiţa treatment plant as artificial soil on degraded lands – 15 % of the generated quantity.

In the medium term (2018-2031) the quantities of sludge to be utilized as artificial soil for degraded land are:

- The use of sludge from the Caransebes, Bocşa, Otelu Roşu, Moldova Nouă, Oraviţa, Anina and Baile Herculane sludge sites as artificial soil on degraded lands – 20 % of the generated quantity.

Use of sludge from Reşiţa Wastewater Treatment Plant as an artificial soil on degraded land - 35% of the generated quantity.

CONCLUSIONS

Sludge from sewage treatment plants can be used as artificial soil for the ecological reconstruction of excessively degraded land or on which waste is deposited. Artificial soil production technology is simple, and easy transport (in big-bags).

Given the mining mono-industrial character of several agglomerations in Caras-Severin County (Anina, Moldova Noua etc), the contaminated land area is significant: 629 ha: mining waste dumps, tailing ponds and non-compliant landfills.

Under these conditions, the artificial soil is a viable and sustainable alternative for the final recovery of the sludge from the treatment plants of the agglomerations: Resita, Moldova Nouă, Oraviţa, Oţelu Roşu, Anina, Bocşa, Caransebeş, taking into account the large area of the contaminated sites (33), which requires reecology works in Caraş-Severin County.

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