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# INFLUENCE OF SLUDGE ON SOME TECUCI PLAIN SANDY SOILS FROM GALATI COUNTY

**Simionică Răzvan [1,*], Simionică Alina [1], Manea Mirela [1], Popescu Adina [2], Contoman Maria [2]**

[1] The „Lower Danube" University of Galati, Domneasca Street No. 47, Galati, Romania
[2] County Office for Pedological and Agrochemical Studies Galati, Romania

***Abstract***
*This paper presents some aspects regarding the use of sludge obtained from Tecuci wastewater treatment pilot plant, sludge that was used for the fertilization of some sandy soils of Tecuci Plain, Galati County. To reduce the polluting effect of the sludge that will be used for agriculture and to exploit the nutrients it contains, it is necessary to subject the sludge to a proper treatment, to apply it only on suitable soils in the right doses and at the appropriate periods, at certain recommended crops, and to also ensure the proper control of the environmental quality. This study was in accordance with Order no. 344/2004 for approving the technical norms when active sludge is used in agriculture concerning the environmental protection and, in particular, of soil, of the Romanian Soil Taxonomy System (2012) and Development of Soil Survey Methodology (1987). Fertilization with sludge from the treatment plant was applied on eutric and district psamosoils from Protisoils Class that are characterized by a sandy texture in the upper portion of the profile and a poor supply with chemical elements. Always to be noted that before using the sludge as a fertilizer two processes will be performed such as the limestone amendment of soil and also the fertilization with chemical fertilizers that have an alkalizing action.*

*Keywords: degradation, pasture, ecological reconstruction*

## 1. INTRODUCTION

This paper presents some aspects related to the use of sludge from the Tecuci Wastewater Treatment Plant for the fertilization of sandy soils from the Tecuci Plain, Galati County. The study was drawn up on the basis of a contract requested by S.C. Water Canal S.A. Galati and aimed to monitor the effects of the sludge from the Tecuci Waste Water Treatment Plant on the fertilization of the soils owned by BUON AFFAIRES SRL in the out-of-town of Barcea commune.
Sludge fertilization was applied to district and eutric psamosols, belonging to the protisoils class, that are characterized by a sandy texture at the top of the profile and a poor supply of chemical elements

## 2. MATERIALS AND METHODS

This study was done in accordance with the stipulations of Order 344/2004 for the approval of technical norms concerning the environmental protection, especially of soils, when active sludge is used for agriculture in regards to the Romanian Soil Taxonomy System (2012), the Methodology for the Development of Pedological Studies (1987) and the Public Agricultural Business Bulletin.


*Corresponding author, E-mail address: simionica.razvanlaurentiu@yahoo.com

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For the present study, soil analysis were performed according to the specific methods used by ICPA.

## 3. RESULTS AND DISCUSSIONS

### The natural conditions of the studied area

*Relief.* The territory taken under study belongs to the Tecuci Plain area, which has the appearance of a plain bay that enters deep within the southern part of the Moldavian Plateau between the Tutovean Hills in NNW and the Covurlui High Plain in the east.

Hydrogeography and Hydrogeology. The studied territory belongs to the Siret Hydrographic basin, but also to the Barlad River. Barlad water is poorly mineralized and contains chlorine and sulphur salts, causing by successive flooding the salting of the soils in the area.

*Climate.* Thus, the studied territory is characterized by the temperate continental climate with excessive conditions, with hot and dry summers and cold winters. Thermal regime: The average annual temperature is 10.1 ° C, the hottest months being July (22.6 ° C) and August (22.0 ° C). Water regime: annual average rainfall is 483.0 mm, with a maximum value in June and a minimum in February. Wind regime: The average wind speed is 3.0 m/s.

*Soils.* The soils in the studied area are part of the Protisoils class, the eutric psamosol and district psamosol types.

From a morphological point of view, the soil presents the following horizons: Aop - Ao – Cn

*Physical properties.* The soil has a rough texture in the upper part of the profile and a medium texture in the middle and lower part of the soil profile, low compacted, and it also has a high-medium permeability, well drained, moderate surface erosion due to both water and wind.

*Chemical properties.* A slightly acidic reaction was observed in the first horizon and moderately acidic in the other horizons, a very low and extremely low humus content, very low total nitrogen content, low mobile phosphorus content, very low and low mobile potassium content.

### Soil suitability assessment regarding the active sludge treatment

In order to reduce the polluting effect of the active sludge so that it can be used in agriculture and to recover the nutrients it contains, it is necessary to treat the sludge properly, to apply it only on suitable soils, at the right doses and in the established periods, to a certain range of recommended crops, so that the proper quality control of environmental factors can be ensured (Davis et al., 1996).

The internationally and nationally conducted research reported that soils behave differently when active sludge is applied. The potential soil treatment mechanisms include filtration, biological oxidation, ion exchange, chemical precipitation, adsorption and the assimilation by plants and animals (Mihalache et al., 2012).

The soil suitability determination for the treatment with active sludge was done according to the instructions of Order 344/2004.

To determine the suitability of the land for active sludge treatment, a number of factors have been taken into account (Budoi, 2005):

*Land topography* - influences the movement of surface and groundwater; influences the amount of eroded soil and the potential of entrainment of surface and ground water of the sludge or its decomposition compounds. For the application of sludge on agricultural soils, only the lands with a more homogeneous topography will be chosen.

*Land slope* - affects the velocity and the amount of surface leakage. For the sludge applications, slopes of less than 5% are accepted while slopes lower than 2% are considered appropriate.

Soil texture - influences the infiltration rate and soil adsorption capacity.



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*Soil permeability* - influences the distribution of water on the soil profile; In its circuit, the water also deploys the sludge particles as well as the compounds resulting from its decomposition. Very high or very low permeability is not appropriate for soils destined for the recycling of the sludge.
*Soil drainage* - directly influences all physical, chemical and biological processes that take place in the soil. By influencing the redox potential, it affects the degree of mobility of various elements. In poorly drained soils there is an anaerobic digestion of residues, resulting in primary compounds and non-oxidized intermediates, many of which being toxic to plants. In soils with low water and air permeability, and therefore poorly drained, the rate of decomposition of organic matter is lower. Very poorly drained and excessively drained lands will be excluded from the application of active sludge.
*Erosion and surface leakage* – favours the washing of sludge and soil particles.
*The useful water capacity* - the depth between 0-100 cm or up to the limiting layer, must be greater than 1400 m3 / ha. The land with a low water capacity will be removed from the sludge application.
*The depth of groundwater* - the protection of groundwater (especially the drinking water source) against pollution by pathogens, mineral elements (especially N-NO3) resulted from sludge decomposition and heavy metals is one of the most restrictive factors in the application of active sludge. The land where the depth of the groundwater is low is excluded from the sludge application.
*Edafic volume* – the soils with a small edafic volume are also removed from the application of sludge.
*Soil response* - greatly influences the degree of mobility of heavy metals, increasing or decreasing their absorption by plants. Soils with a reaction below 5.5 will be excluded from the uncontaminated or untreated sludge treatment, and those with a reaction between 5.5-6.5 will be compulsorily fined to raise the pH above 6.5.
*Cationic exchange capacity* - has an influence upon the mobility of heavy metals. The soils with a very low or a very high cation exchange capacity will be eliminated from the sludge application.

**The heavy metal content of the used sludge**

In Romania, provisionally, the proposed values by I.C.P.A. Bucharest, in collaboration with ICPEGA Bucharest, transposed at the legislative level by Order 344/2004, are accepted.
In order to avoid the excessive accumulation of heavy metals in the soil and plant following the agricultural valorisation of the sludge in Romania, norms have been developed regarding their maximum permissible limits in the soil and in the sludge from the urban waste waters.
The active sludge was classified into three categories, depending on their heavy metal content:
- *with low content* – they do not exceed the maximum admissible limits set out in the table above;
- *with high content* - sludges with metals content between the following limits: 25-40 ppm Cd, 2500-4000 ppm Zn, 900-1500 ppm Pb, 900-1500 ppm Cr, 80-150 ppm Co and 15-30 ppm Mo;
- *with very high content* - higher heavy metal content than previously stated

***Table 1. Heavy metals maximum allowable limits in the soil (ppm)***

| **Parameters** | **Limit values** |
|---|---|
| Cadmium | 3 |
| Copper | 100 |
| Nickel | 50 |
| Lead | 50 |
| Zinc | 300 |
| Mercury | 1 |
| Chromium | 100 |


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***Table 2. Annual quantities of heavy metals limit values that can be introduced into the agricultural land (according to Order 344/2004)***

| Parameters | Limit values |
|---|---|
| Cadmium | 0,15 |
| Copper | 12 |
| Nickel | 3 |
| Lead | 15 |
| Zinc | 30 |
| Mercury | 0,1 |
| Chromium | 12 |

Analytical results on the heavy metals content of the sludge (Cd, Cu, Pb, Zn, Mn, Ni, Cr, Co, Hg) in regards to the collected soil samples after the field monitoring were obtained by atomic absorption spectrometry (AAS) with a mineralization with a mineral acids mixture - ICPA Methodology (1981), vol. 1, SR ISO 1104 as presented in Table 3.

***Table 3. Heavy metals soil content after the use of sludge***

| Identification | Cd mg/kg | Cu mg/kg | Ni mg/kg | Pb mg/kg | Zn mg/kg | Cr mg/kg | Hg mg/kg |
|---|---|---|---|---|---|---|---|
| Agrochemical Sample | 0,21 | 12,9 | 6,83 | 9,08 | 25,3 | 10,13 | bdl* |
| 0-25 cm Depth | 0,21 | 11,3 | 2,6 | 8,90 | 20,7 | 11,2 | bdl* |
| 25-45 cm Depth | 0,20 | 13,6 | 5,2 | 7,80 | 29,2 | 14,8 | bdl* |

bdl * - below the detection limit of the used analysis method
The content of heavy metals is below the limit imposed by Order 344/2004

**The results of the application of active sludge concerning the physical properties of the soil**

From the data shown in Table 4, it can be seen that the texture, permeability and the reaction factors have changed positively by decreasing the degree of damage. Cationic exchange capacity has remained the only factor that is affected after the application of active sludge (Blaga, 2000,2001). Nonetheless, given the fact that calcareous amendments will be applied and only fertilizers with alkalinizing action will be used, the soil reaction can be maintained in the slightly acidic interpretation field.

***Table 4. Assessment of soil suitability regarding the the application of sludge (Comparative table according to Order 344/2004)***

| Factor | Meaning | | Affecting degree | |
|---|---|---|---|---|
| | Initial study | Monitoring study | Initial study | Monitoring survey |
| Topography of the land | Slightly uneven | Slightly uneven | Small | Small |
| The slope of the land | 2.1-5% | 2.1-5% | Small | Small |
| Soil texture | Sandy –clay coarse | Clay-sandy coarse | High | Small |
| Soil permeability | High | Medium | Small | Without |
| Soil drainage | Well drained | Well drained | Without | Without |
| Risk of surface erosion | Moderate | Moderate | Medium | Medium |
| Flooding | Unflooded | Unflooded | Without | Without |
| Useful water capacity | Medium | Medium | Small | Small |
| Depth of groundwater | Very high | Very high | Without | Without |
| Edafic volume | High | High | Medium | Medium |
| Soil reaction | 5.27 – Moderately acidic | 5.72 – Moderately acidic | Absent | High |
| Cationic exchange capacity | Small | Small | Absent | Absent |


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**The results of the application of active sludge on the physical properties of the soil**

Following the application of the amount of the recommended fertilizer as stipulated by the fertilization plan, the physical characteristics of the soil have improved, in the sense that the clay content has increased over the entire length of the profile, while the apparent density has decreased, although these parameters show an increase in the process of soil formation (Lixandru, Filipov, 2012).

*Table 5. Physical and hydrophysical soils indicators (comparative table)*

| Physical and hydrophysical indicators | Initial profile | | Monitoring profile | | |
|---|---|---|---|---|---|
| | Ao (0-30) cm | Cn (>30 cm) | Aop (0-25 cm) | Ao (25-45 cm) | Cn (>45 cm) |
| Content of clay (%) | 5.40 | 10.30 | 9.78 | 13.50 | 14.10 |
| Apparent density ($g/cm^3$) | 1.12 | 1.56 | 1.38 | 1.38 | |
| Total porosity (% v/v) | 59 | 43 | 49 | 49 | |
| Degree of compression (% v/v) | -29 | 8 | -5 | -4 | |
| Aeration porosity (% v/v) | 49.83 | 22.47 | 31.61 | 26.35 | |
| Hygroscopicity coefficient (% g/g) | 1.29 | 2.44 | 2.31 | 3.19 | |
| Wilting coefficient (% g/g) | 1.94 | 3.66 | 3.47 | 4.78 | |
| Water capacity in the land (% g/g) | 8.19 | 13.16 | 12.60 | 16.41 | |
| Useful water capacity (% g/g) | 6.25 | 9.50 | 9.13 | 11.63 | |
| Total water capacity (% g/g) | 52.68 | 27.56 | 35.51 | 35.51 | |
| Capillary field capacity (% g/g) | 8.19 | 13.16 | 12.60 | 16.41 | |

**Application of active sludge on the soil's chemical properties results**

The application of active sludge as a fertilizer on the studied land as a result of the monitoring activity showed that no changes in the heavy metal content of the soil occurred according to the ranges mentioned in Table 3 in comparison to the values admitted in Order 344/2004 (Table 1 and Table 2). The heavy metal content in the soil is below the required maximum.

The application of active sludge did not lead to significant changes of the chemical properties of the soil. Our results confirm the literature data concerning the effect of urban active sludge of the soil chemical properties. Thus, the pH value does not change significantly compared to the initial profile.

The soil presents a slightly acidic reaction in the first 25 cm and moderately acidic after this depth, a low humus content in the first 25 cm and a very low content after this depth, a very low nitrogen content, low supply of nitrogen after IN, medium content of mobile phosphorus in the first 25 cm and low after this depth, being a submerged soil (VAh 89.33-90.24%), with a small amount of exchange bases (SB), a very low hydrolytic acidity (Ah), and also a low total salt content.

*Table 6. Soil chemical indicators (comparative values)*

| Chemical indicators | Initial profile 2014 | | Monitoring profile 2015 | | |
|---|---|---|---|---|---|
| | Ao(0-45) cm | Cn (>45 cm) | Aop(0-25 cm) | Ao(25-45 cm) | Cn(>45 cm) |
| Humus (C x 1.72) (%) | 0.87 | 0.22 | 0.71 | 0.34 | - |
| IN (%) | 0.38 | 0.15 | 0.63 | 0.31 | /- |
| total N (%) | 0.044 | 0.012 | 0.038 | 0.018 | - |



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| | | | | | |
|---|---|---|---|---|---|
| Total P (ppm) | 24.5 | 15.6 | 22.0 | 14.3 | - |
| K –Al (ppm) | 50 | 60 | 60 | 72 | - |
| C:N | 13.4 | 12.4 | 13 | 12.8 | - |
| $CaCO_3$ (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water pH | 5.27 | 5.59 | 5.93 | 5.47 | 5.75 |
| Ah (me/100 g sol) | 4.43 | 3.54 | 1.41 | 1.53 | - |
| SB (me/100 g sol) | 3.38 | 7.34 | 11.80 | 14.15 | - |
| VAh (%) | 43.28 | 67.46 | 89.33 | 90.24 | - |
| Electrical conductivity (micromho / cm) | - | - | 56 | 139 | - |
| Total salt content (mg / 100 g soil) | - | - | 19 | 47.2 | - |

**Recommendations for Soil Fertilization**

One requirement of good agricultural practice is that each agricultural producer applies the recommendations on how to use different types of chemical or organic fertilizers and also knows very well the conditions for their application. This information, together with the correct assessment of the amount of nitrate in the soil, allows the agricultural producer to optimize the ratio between the cost of the fertilizer and the value of the production obtained under environmental protection.

The recycling of active sludge on agricultural fields is generally considered to be the best practical option for the environmental protection.

The concentration of heavy metals in the active sludge is limited due to the transfer possibility from soil to plants, along trophic chains, until the final consumer - man.

Some heavy metals are recognized as microelements or trace elements required for plant nutrition. They show toxicity only when they are in excessive quantities. Others (cadmium, lead, mercury) in all cases show toxic action (Epstein, 1997).

The maximum permissible levels in the soil improvement process will take into account the nitrogen requirements of the crop so that there is no risk of surface water and groundwater pollution with nitrates.

The experiments have shown that the production is higher when chemical fertilizers are used alongside treated sludge.

On the studied field, sunflower was cultivated, for it being recommended the following amounts: 7.27 t / ha active sludge; 56 kg / ha for phosphorus fertilizers; 76 kg / ha s.c. fertilizers with potassium; 4.05 t / ha calcareous amendments (Simionica et al., 2004).

## 4. CONCLUSIONS

The use of active sludge in agriculture is an effective way of replacing the mineral fertilization, while ensuring the reintegration of sludge into the circuit of matter in nature.

The use of sludge from a treatment plant is conditioned by its content in heavy metals and pathogenic microorganisms, and, moreover, for the agricultural crops the assessment of chemical and biological properties is mandatory.

The soils in the studied area belong to the Protisoils Class, namely eutric and distric psamosoils, and have a sandy-clay textures at the top of the profile and sludge-like in the median and lower part of the profile, with a poor supply of chemical elements.

Regarding the suitability of the analyzed field for the application of active sludge, the following actions are required: calcareous soil fining and the use of alkaline-containing chemical fertilizers.



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*Corresponding author, E-mail address: simionica.razvanlaurentiu@yahoo.com