AEROBIC CO-COMPOSTING OF WWTP RESIDUAL SLUDGE WITH VEGETAL WASTES

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Din bube, mucegaiuri si noroi
Iscat-am frumuseti si preturi noi.
Tudor Arghezi (Testamet)

Abstract

The most preferred method of stabilization of sewage sludge is composting. It is apparently a simple process aimed at stabilization of organic matter – ripening, destruction of pathogenic organisms, production of an environmental friendly material which can be sold or used as fertilizer. To reach the above aims the sludge has to be mixed with structural materials in suitable proportion to obtain a C:N ratio of about 25:1. In practice, the most often used structural materials contain cellulose (i.e. wooden chips, sawdust, bark, straw, leaf litter, other vegetal wastes).
The present study presents several composting experiments performed using as raw materials dewatered anaerobic digested sludge from a municipal WWTP, two different vegetal wastes (wood chips, straws, vine shoots) in different proportions and water in order to ensure a 50 to 70% humidity. The experiments were performed using aerated heap method; the heap is arranged on a porous layer, which is periodically aerated by a blower. Composting process evolution was verified during the whole period of 3 months of experimentation by online measurement of temperature, periodic pH and humidity monitoring and by weekly microscopic observations. The quality of the obtained compost was good, similar to commercial products used for pot-flowers, with heavy metal concentrations below the limits imposed by 344/2004 Order.

Keywords: municipal WWTP, residual sludge, compost, vegetable wastes

Introduction

During the last years, WWTP operators in Romania, which mostly have biogas installations for sludge stabilization through anaerobic digestion, upgraded the mechanical equipments for fermented sludge dewatering. Even if they reduced this way the sludge volume and succeeded more or less, the problem of storing/using it still remains unsolved.
The initiatives regarding sludge utilization as agricultural fertilizer dates for more than 25 years at the level of EU legislation (Directive 86/278/EEC *Sludge Directive)* which encourages the valorization of sludge and imposes restrictive rules in order to protect the environment when these are used as soil amendments. This Directive has been revised by EC Regulation 807/2003 and still applies today. This document was transposed into Romanian legislation as Ministerial Order 344/2004 (708/2004) which is still enforced. These regulations have as a primary goal the valorization of the agrochemical potential of municipal WWTP sludge, prevention of all negative effect (especially due to heavy metals) upon soils.
The valorization of wastewater treatment sludges in agriculture can be made as it is or after a post-treatment by composting it in a mixture with vegetal wastes, respecting the quality norms imposed by Order 344/2004 and after a previous pedological study on the specific area of application.
Composting represents the totality of aerobic microbial transformations, biochemical, chemical and physical that undergoes in the organic wastes mass (municipal sludge, different vegetal biomass) from their initial state and till they reach different transformation states, of improved quality of the final product: compost.
Besides the interest that this process has in waste treatment (volume, mass, odours and humidity reduction) a product with low environmental risk is obtained, the compost rich in macronutrients that can be used as a valuable soil amendment.

Experimental part

Composting process steps:

- Phase I, mesophilic aerobic fermentation, characterized by the increase of microorganisms number and temperatures between 25 and 40^{0}C;
- IInd Phase, thermophilic, characterized by the presence of bacteria, fungi and actinomicetes in large number, at temperatures between 45-60^{0}C. Cellulose, hemicelluloses, lignin and other components are being degraded. Temperature can reach 70^{0}C and is necessary to be mentained at this value for at least one day in order to ensure pathogens and organic contaminants destruction.
- Maturation phase, when temperature is stabilizing and the oxidative biological processes are ongoing, thus transforming the organic substrate into humus.

Experimental setup

The main components of the composting pilot installation are:

- Aeration system that ensures the air flow and pressure necessary in the mass of the composting mixture.
- Monitoring system for direct on-line measurements and data logging for the following parameters :
  - temperature in the compost heap: range 0 – 90 ^{0}C
  - oxygen concentration in residual air (heap outflow air) : range 0 – 21%
- Composting membrane, gases permeable, used to cover the heaps with the aim to:
  - Maintain ptimum humidity conditions (protects the compost heap from rainfalls and limits the humidity loss due to wind or sun exposal);
  - Ensure gases exchange with atmosphere.
  - Ensure thermal insulation and helps maintaining higher temperatures in the upper layer of the composting heap;
  - Maintain the structure of the compost heap.

Composting experimental model

The composting heaps were formed following the operational flow presented in fig.1. The humidity in the heap was corrected to ~60% by adding water during the components mixing. After th heaps were formed, they were covered with the gases permeable membrane.

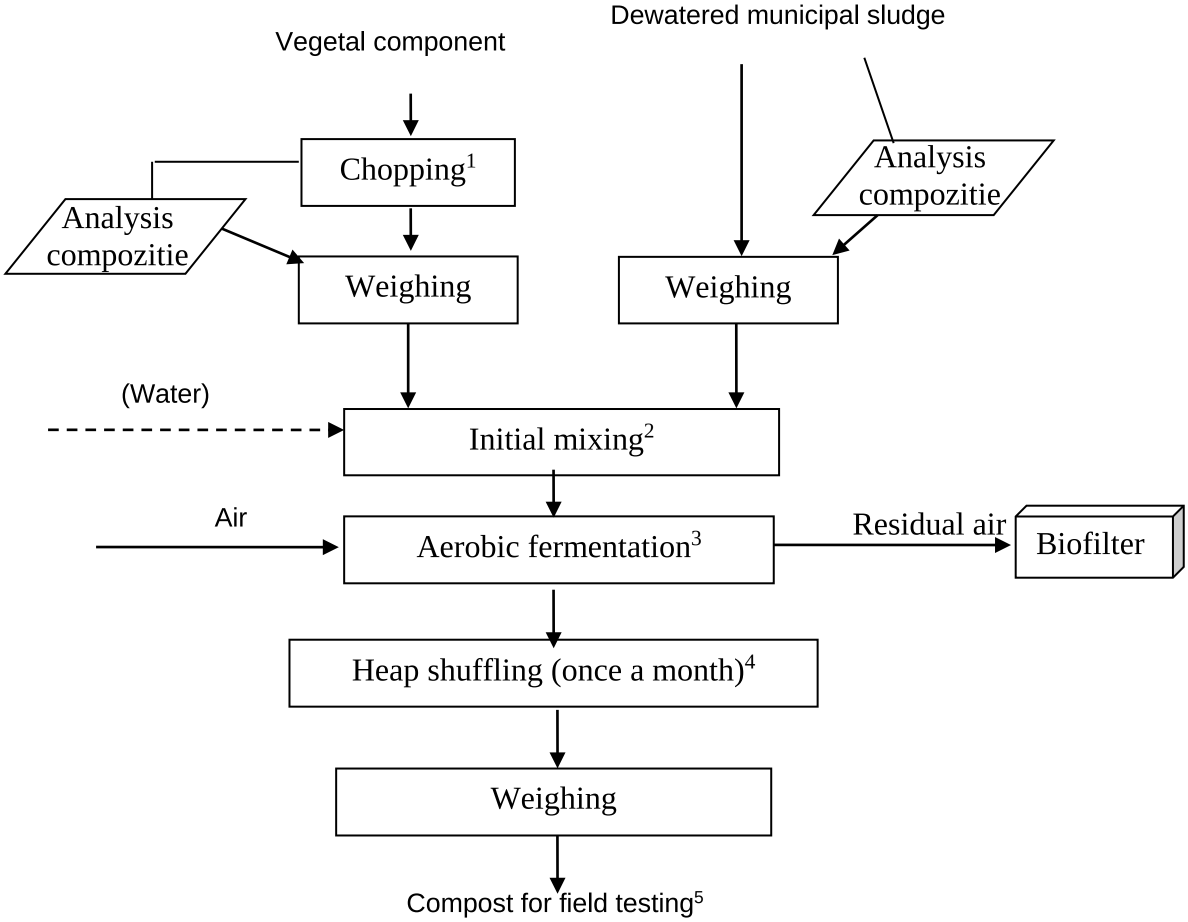
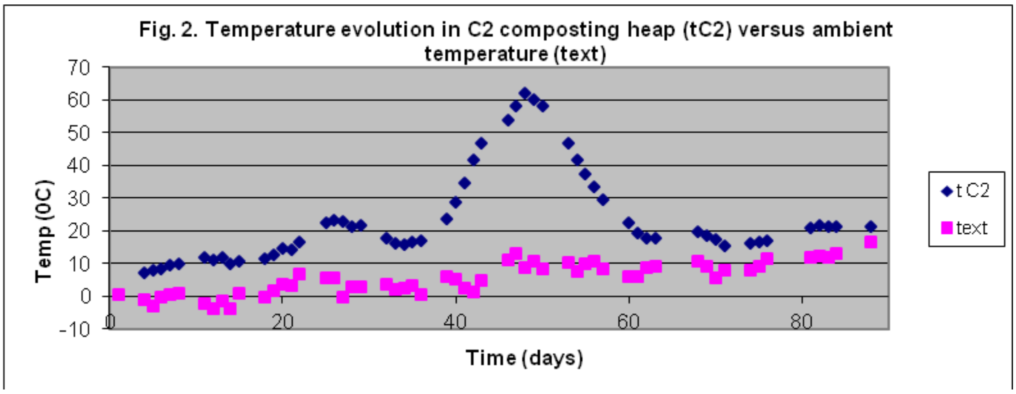
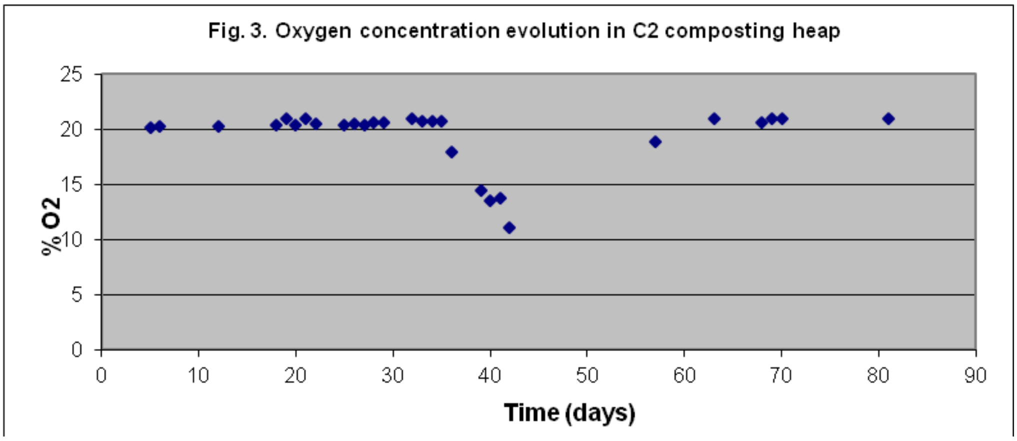


Fig.1 The operational flow for forming the composting heaps of municipal sludge with vegetal component (see also photos below)

In figures 2 and 3 can be observed the intensity of the aerobic biological processes that occur in the composting heap C2 (formed of dewatered sludge from Pitesti WWTP and chopped wood) emphasized by the temperature increase up to 63^{0}C (while the temperature outside the heap varied between -5 and 15^{0}C) and correlated with the oxygen concentration decrease to ~10%.





The temperature evolution in the composting heaps G1 and G2 (Focsani municipal WWTP dewatered sludge mixed with chopped wood in massic ratios of sludge : vegetal wastes of 3:1 and 1:1 respectively) can be observed In figures 4 and 5. The experiments were performed in a closed area (sludge storing facility of Focsani WWTP), during summer time. The sudden temperature decrease in the composting heaps during days 33, 46, 58 and 83 are due to different activities performed on the heap, such as humidity correction and/or heap shuffling.

Table 3 presents the analytical results for quality parameters of the obtained composts compared to a commercial product and the limits imposed by the enforced legislation (at national and European level) for the main macronutrients and physical chemical parameters.

Fig.4. Temperature evolution in G1 compost heap

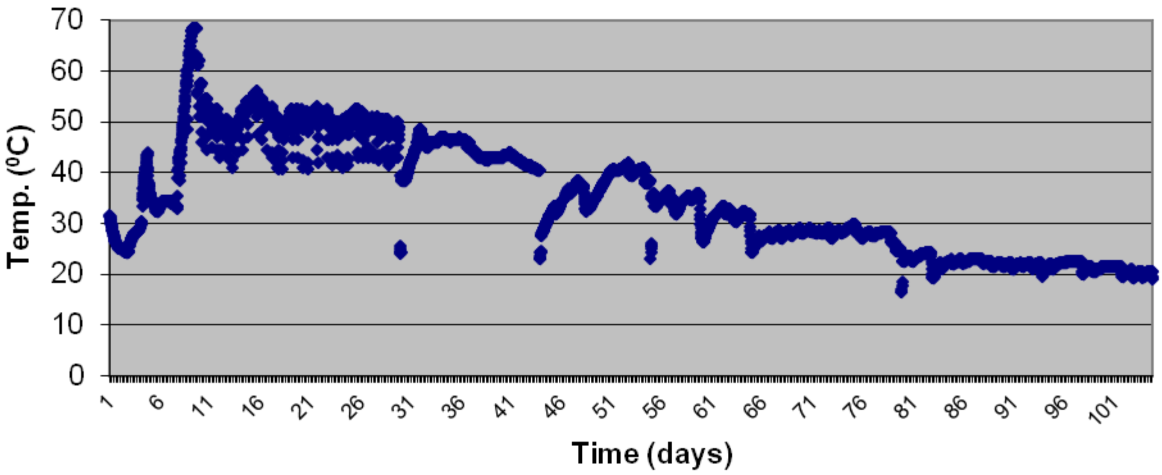
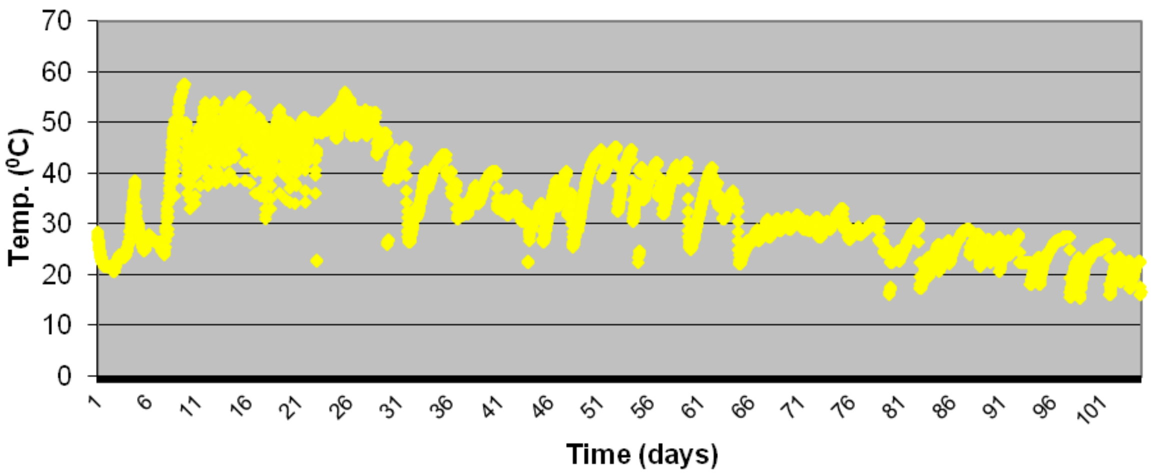


Fig.5. Temperature evolution in G2 composting heap

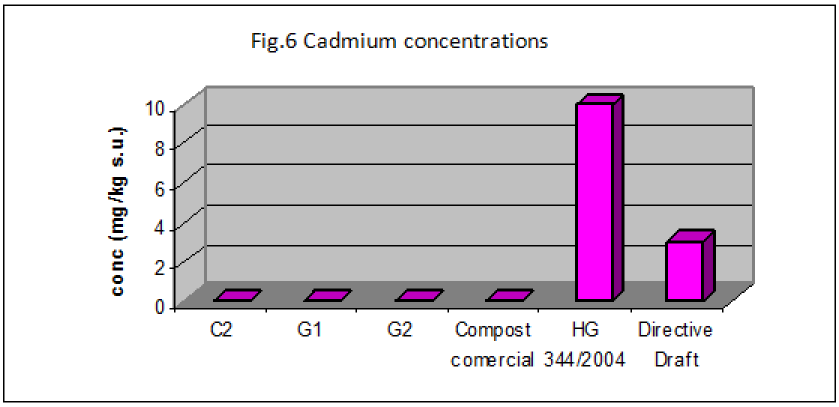


The concentrations of main heavy metals in the composts obtained and one compost – commercial product used as flower substrate are presented graphically in figures 6-11 compared to limits imposed by the GD 344/2004 and the European Directive for sludges and biowastes (Working Document Sludge and Biowaste, septembrie 2010). As it can be observed, all limits imposed by the GD 344/2004 arespected by all produced composts. However, the compost that had as raw material sludge from the municipal WWTP Pitesti has a high concentration of Zn hat exceeds the proposed limit by the Working Document Sludge and Biowaste, septembrie

Table 3. Analytical results of the obtained composts comparatively with the commercial product and limits imposed. *

Parameter	C2 Pitesti	G1 Focsani	G2 Focsani	commercial compost	HG 344/2004	86/2000/CE
D.w. (%)	33,26	35,62	38,09	55.53	-	-
V.S. (%)	49,57	54,64	63,81	-	-	-
pH	6,73	6,45	8,11	7.63	-	-
Nt (mg/kg d.w.)	25681	26523	25833	-	-	-
P_2O_5 (mg/kg d.w.)	7964	12780	11216	-	-	-
K_2O (mg/kg d.w.)	756	7327	8913	12237	-	-
CaO (mg/kg d.w.)	11251	43641	51108	20676	-	-
Cd (mg/kg d.w.)	<0,02	<0,02	<0,02	<0.02	10	20 - 40
Cr (mg/kg d.w.)	122,5	<0,1	<0,1	88.9	500	-
Cu (mg/kg d.w.)	129,15	42,63	51,13	45.3	500	1000 - 1750
Ni (mg/kg d.w.)	61,2	82,98	34,64	85.8	100	300 - 400
Pb (mg/kg d.w.)	74,68	<0,2	<0,2	45.7	300	750 - 1200
Zn (mg/kg d.w.)	1951	482	345	150	2000	2500 - 4000
Co (mg/kg d.w.)	<0,2	<0,2	<0,2	27.3	50	-
As (mg/kg d.w.)	<1,3	<1,3	<1,3	<1.3	10	-
Hg (mg/kg d.w.)	$<88x10^{-3}$	$<88x10^{-3}$	$<88x10^{-3}$	-	5	16 - 25
TOC (% of d.w.)	18,43	66,59	52,48	-	-	-
PCB (mg/kg d.w.)	0,043	<0,002	<0,002	-	0.8	-
HAP (mg/kg d.w.)	3,88	1,64	1,03	-	5	-

* Single samples



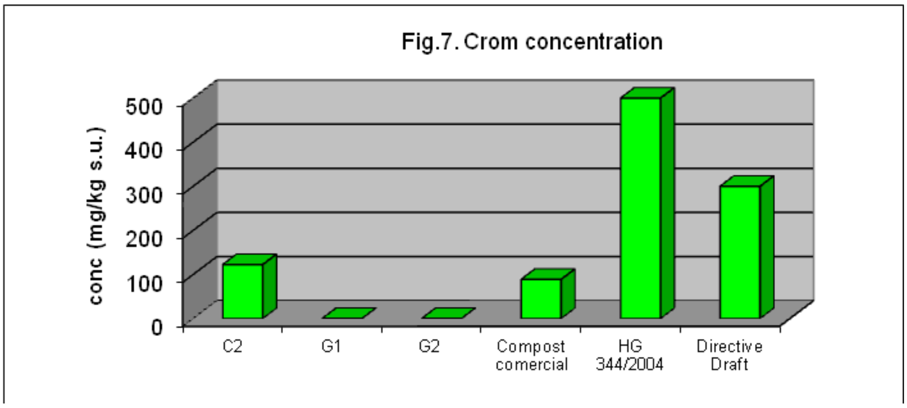


Fig.8. Copper concentration

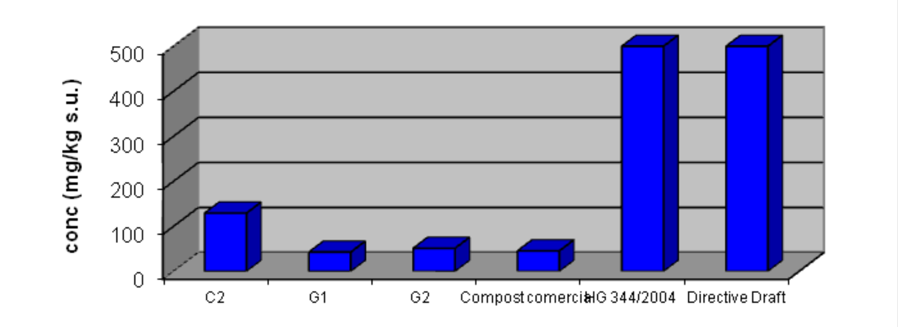


Fig.9. Nickel concentration

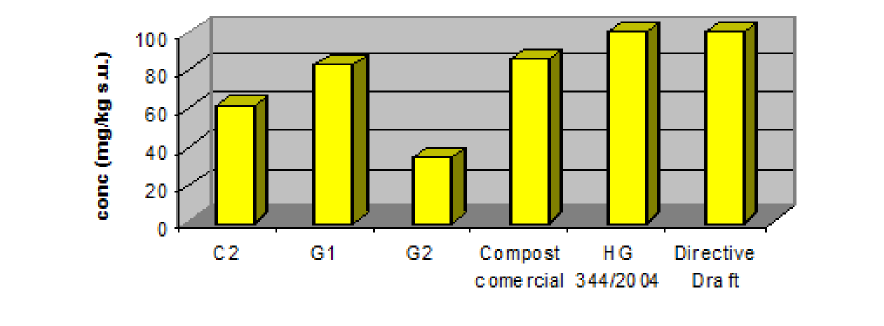


Fig.10. Lead concentration

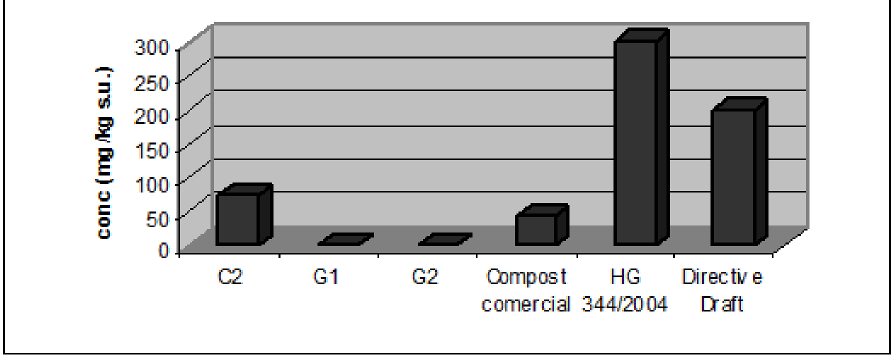


Fig.11. Zinc concentration

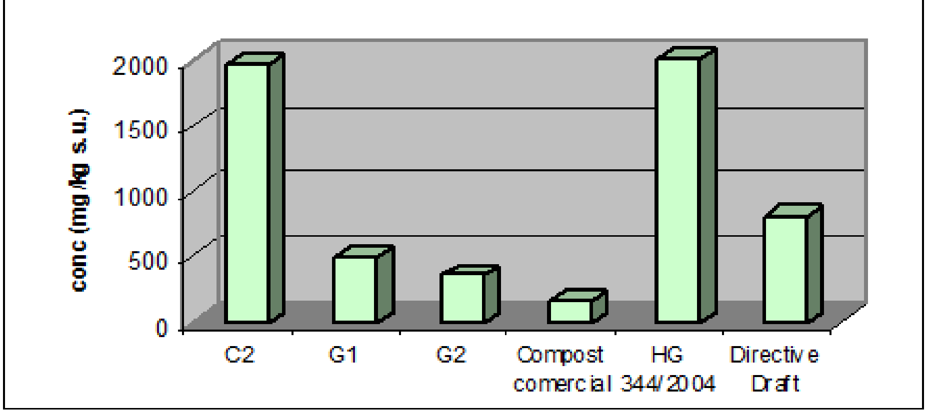


Table 4 presents the microbiological quality of the residual sludge used as raw material in the composting process as well as in the obtained composts emphasizing the significant decrease of colony forming units decrease as a result of the composting process (due to thermophiic stage) especially for total coliforms, fecal coliforms and fecal streptococcus. The values obtained for the quality parameters *E.coli* and *Salmonella sp*. are within the limits proposed by the sludge and biowaste Directive Proposal.

Table 4. Microbiological characterization of the residual sludges used as raw materials and the composts obtained

Parameter	Pitesti Dewatered sludge	C2 Pitesti	Focsani Dewatered sludge	G2 Focsani
Colonies at 22^{0}C	6 x 10^9	4 x 10^9	4 x 10^9	3 x 10^8
Colonies at 37^{0}C	2 x 10^9	6 x 10^9	2 x 10^9	6 x 10^8
Total coliforms	9 x 10^4	4777	4 x 10^4	6288
Fecal coliforms	9 x 10^4	56	4 x 10^4	52
Fecal streptococcus	9 x 10^4	<56	1 x 10^6	865
E.coli	-	-	-	6168
Salmonella	-	-	-	lipsa

Applying the aerobic composting technology for mixtures of dewatered sludge and vegetal wastes (cellulosic materials), composts of good quality comparable with existing commercial products were obtained.

Conclusions

Aerobic co-composting of dewatered, anaerobic digested sludge mixed with vegetal components leads to the following:

- Municipal residual sludges transformation in a new product, the compost, which has similar characteristics as existing commercial flower substrate, without repelling odours and with good fertilizing capacity.
- The compost contains a more stable organic form of nitrogen that releases gradually in soil, thus ensuring for a longer period the nitrogen need in soil.
- During the thermophilic stage, significant decrease of pathogen/ potential pathogen bacteria occurs.
- Compost is a good soil amendment, improves soil structure and has an important contribution of organic matter and reduces the soil erosion potential.

References

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