FOREST SEEDLINGS PRODUCTION USING STABILIZED SEWAGE SLUDGE

PRODUÇÃO DE MUDAS FLORESTAIS UTILIZANDO LODO DE ESGOTO ESTABILIZADO

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ABSTRACT

Aiming tThis study aims at evaluating the physical, chemical and biological characteristics of sewage sludge and its feasibility for use as a component of substrata to produce seedlings of native and exotic trees. The sewage sludge was previously stabilized through the process of composting with grass remnants. Before and after the composting, chemical analyses were carried out in order to quantify levels of heavy metals, macro nutrients and micro nutrients in addition to microbiological analyses of sewage sludge. The mixtures (Treatments) in the proportions vary from 0 to 100% of organic compost of sewage sludge (OCSS) in composition with carbonized rice husks (CRH) and were compared to control treatments, which consisted of commercial substrates (PLANTMAX-EUCATEX) and cattle manure. Porosity, density, capacity of water retention and particles size of treatments were evaluated. Results of the physical characterization of substrates revealed that proportions ranging from 100 to 40% of the compost showed better results for tree seedlings cultivation. The use of organic compost of sewage sludge (OCSS) to produce seedlings of forest essences is a viable alternative for waste reuse, aggregating not only economy and quality of inputs in the yields, but also environmental benefits.

Keywords: Sewage sludge, Composting, Forest seedlings.

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RESUMO

Este trabalho tem como objetivo estudar as características físicas, químicas e biológicas de lodo de esgoto e avaliar a viabilidade da sua utilização como componente de substrato para a produção de mudas de árvores nativas e exóticas. O lodo de esgoto foi previamente estabilizado através do processo de compostagem adicionando restos vegetais. Antes e depois da compostagem, análises químicas foram realizadas para quantificar níveis de metais pesados, macro e micronutrientes complementando-se com análises microbiológicas do lodo de esgoto. Os tratamentos com proporções variando de 0 a 100% de composto orgânico de lodo de esgoto (COLE) em composição com casca de arroz carbonizado (CAC) foram comparados com tratamentos de controle, os quais consistiram em substratos comerciais (PLANTMAX-EUCATEX) e esterco de gado. Porosidade, densidade, capacidade de retenção de água e tamanho de partículas, dos tratamentos, foram avaliados. Os resultados da caracterização física dos substratos revelaram que as proporções na faixa de 100 a 40% do composto mostraram melhores resultados para o cultivo de mudas de árvores. O uso de composto orgânico de lodo de esgoto (COLE) para a produção de essências florestais é uma alternativa viável para o reuso do resíduo, agregando economia e qualidade na produção de mudas, bem como benefício ambiental.

Palavras–Chaves: Lodo de esgoto,Compostagem, Mudas florestais.

INTRODUCTION

Sewage sludge is generated in wastewater treatment plant and it has high contamination potential by pathogens that can be transmitted to humans and animals besides heavy metals contained in it. It has high levels of organic matter, macro nutrients and micro nutrients, essential to the proper development of plants. Pathogens and heavy metals are limitations that must be observed when evaluating the possibility of using this waste in agricultural areas.

According to KIEHL (1998) composting is a biological process to convert organic matter into stabilized substances, becoming a natural and viable alternative for sewage sludge treatment, which promotes disinfection of waste by the raising temperature effect, with an input of high agronomic value as a final product. An alternative for sewage sludge use may be the supply of organic matter in the composition of substrates for fruit and forest seedlings formation.

Sludge promotes organism growth, improves the fertility level and increases the cation exchange capacity (CEC) of soil and, when adequately managed, it is a good organic fertilizer (MELO et al., 1994; VANZO et al. 2001). In Brazil, sludge agricultural use is regulated by CONAMA resolution No. 375- 2006, based on the American USEPA 40 CFR 503 (1997) standard.

Using agribusiness waste, regionally available as components for substrates, can reduce costs, besides decreasing the pollution level originated from accumulation of these materials in the environment (FERMINO, 1996). Forest seedlings yield, in both quantity and quality, is one of the most important steps to establish a good oak forest with native species. In this context, this study aims to test the use of sewage sludge, stabilized through a composting such as substrata, which is a source of organic matter and nutrients for seedlings yield of native essences.

MATERIALS AND METHODS

The experiment was conducted and developed in the seedlings tree nursery, located in the Franco Montoro Municipal College (FMPFM), in the city of Mogi Guaçu, state of São Paulo, Brazil.

The experiment was carried out in three stages. In the first phase, the physical and chemical characteristics of the sewage sludge, its structural waste (grass clippings) and carbonized rice husks, which composed substrates and also control treatments that consisted on commercial substrata (PLANTMAX-EUCATEX), as well as cattle manure, were studied. In the second stage, the composting of sewage sludge took place, following KIEHL's methodology (1998).

To prepare the mixture, the carbon / nitrogen relationship in both sewage sludge and structural waste was observed, taking into account their physical and chemical analyses.

To obtain a C:N ratio of 25:1 of the mixture, part of sludge for 3.75 shares of waste (humid base) was mixed. After composting, the product was named organic compost of sewage sludge (OCSS). The chemical characterization of OCSS was conducted in the laboratory of Soils Analysis at the Agriculture Institute of Campinas-IAC (Campinas, São Paulo, Brazil), before mixtures of organic compost of sewage sludge (OCSS) with carbonized rice husks (CRH) were made. Tests were carried out with heavy metals, macro nutrients and micro nutrients concentration, pH, volatile solids and electrical conductivity. Tubes used in the experiment are made of polypropylene, based on round tapered format and size of 145 x 47 mm with a capacity of 110 cm3. After that, the composting mixtures were set in proportions 0 to 100% of OCSS in composition with CRH, resulting in eleven treatments with different OCSS/CRH (100/0; 90/10; 80/20; 70/30; 60/40; 50/50; 40/60; 30/70; 20/80; 10/90; 0/100). Each mixture composed a treatment. The treatments were compared to control treatments, which consisted of commercial substrate PLANTMAX-EUCATEX **(**from pine bark, peat, vermiculite and charcoal) and cattle manure. In the experiment, a randomized experimental design was used, with 13 treatments and 4 repetitions.

For data statistical analysis the Tukey Test was used, which is based on the average significance level (A.S.L.) < 5%, in addition to the F test for analysis of variance.

RESULTS AND DISCUSSIONS

COMPOSTING

Throughout the operation it was possible to observe that the composting process had a good development according to the temporal evolution of temperature.It is illustrated in Figure 1.

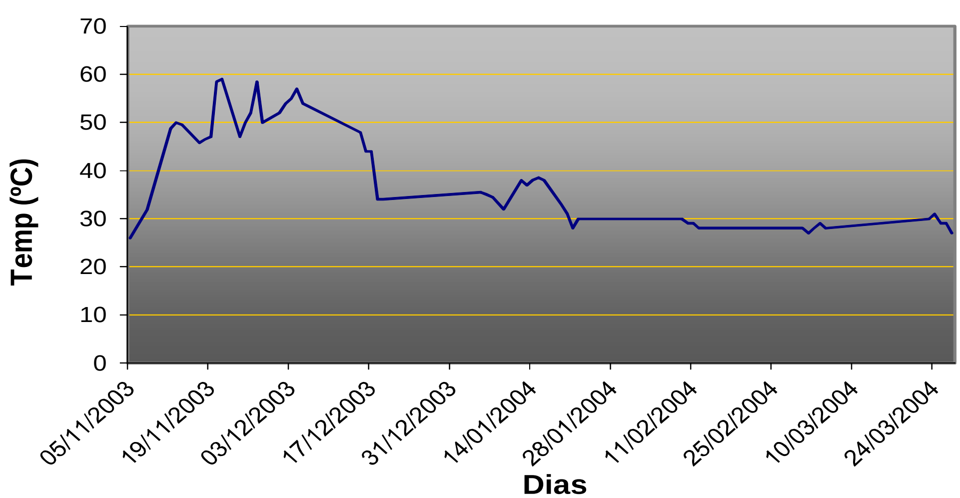

FIGURE 1 - Evolution of composting according to the temperature

The temperature reached 50 ° C in the first ten days, rising to 60 ° C and remaining in the average 55 °C for a month and a half. After this initial period, the average temperature remained around 45 ºC for a further fifteen days, decreasing and then keeping up to 35 º C for another month and a half. From there, the temperature has stabilized at 30º C (ambient temperature). More complete details about the control parameters monitored during composting were reported by PADOVANI (2006).

The microbiological and parasitological parameters of sewage sludge before and after composting are presented in Table 1 and Table 2.Helminthes eggs, due to their greater capacity for survival, are the most important indicator to assess the sludge health conditions. Analyzing results concerning the initial phase, it appears that raw sewage sludge showed 28.6% of viable eggs, out of the total number of eggs before composting. The process of cleaning by composting presented significant decrease in helminthes eggs present in the sewage sludge, with percentage of viability of 0%, reaching an 80% reduction in the number of viable eggs and total eggs. After the sewage sludge composting fecal coliforms and enterococci was reduced by approximately 99.9% in the most probable number (MPN) per gram of total solids (TS), in addition to absence of the bacterium Salmonella, present in sewage sludge before the beginning of this process. Composting promoted the sewage sludge disinfection, making it feasible for the production of forest essences, as observed results in Table 1 and Table 2.

TABLE 1 - Microbiological parameters of sewage sludge before and after composting

PARAMETERS TESTS	Before composting	After composting
Counting of enterococci MPN/g TS	1.1×10^6	<3
Counting of fecal coliforms MPN/g TS	4.6×10^5	3.6
Research of salmonella sp/25g	Presence	Absence

MPN= Most probable number; ST - Total solids

TABLE 2 - Parasitological parameters of sewage sludge before and after composting

HELMINTHES	Before composting AVERAGE		TOTAL	After composting AVERAGE		TOTAL
(number of eggs)	viable	unviable		viable	unviable	
Ascaris sp	0	0	0	0	0.08	0.08
Toxocara sp	0	0.10	0.10	0	0.02	0.02
Trichuris trichiura	0	0	0	0	0	0
Trichuris vulpis	0	0	0	0	0	0
Trichuroidea	0	0.10	0.10	0	0	0
Hymenolepis diminuta	0.10	0.30	0.40	0	0	0
Total	0.10	0.50	0.60	0	0.10	0.10

The physical characterization was performed on samples of 11 treatments established for the preliminary test to produce seedlings, using mixtures of sewage sludge organic compost **(SSOC)** and carbonized rice husks (CRH), in addition to control treatments PLANTMAX-EUCATEX (commercial substrate) and cattle manure. The results are presented in Table 3 and show that treatment with higher doses of sewage sludge organic compost (100% to 50% SSOC/50 C%CRH) had greater size and therefore were more appropriate when compared with treatments such as high content of carbonized rice husks.

The PLANTMAX-EUCATEX control treatment shows the results achieved through greater particles uniformity.

TABLE 3 - Results in percentage of substrates size by dry weight

TREATMENT	Retention screen(mm) 4.75	2.00	1.18	0.59	0.29	bottom	Total
	Distribution of particles (%)						
T1- [1]100/00	32.1	21.2	16.8	13.2	10.1	6.5	100
T2 - 90/10	19.0	26.8	19.2	14.1	12.5	8.3	100
T3- 80/20	19.1	21.7	18.4	18.5	13.6	8.7	100
T4- 70/30	15.1	19.9	24.9	16.5	16.0	7.6	100
T5- 60/40	13.5	18.6	29.1	17.0	14.7	7.2	100
T6- 50/50	13.8	13.3	27.6	20.4	14.1	10.7	100
T7- 40/60	11.3	15.9	34.0	14.6	15.9	8.4	100
T8- 30/70	9.4	10.3	48.9	9.8	13.2	8.4	100
T9- 20/80	6.3	8.1	42.5	17.5	15.6	9.9	100
T10- 10/90	4.7	5.9	54.9	14.1	13.3	7.1	100
T11- 0/100	0.0	15.9	48.7	12.1	13.8	9.4	100
T12- PLANT	0.4	12.1	17.6	20.9	23.5	25.6	100
T13- manure	27.7	17.2	18.9	138	14.7	7.7	100

[1] OCSS / CRH = Organic compost of sewage sludge / Carbonized rice husks

The efficiency level of substrata for seed germination, root initiation, and rooting of cuttings, formation of roots and shoots are linked closely to its ability for aeration, drainage, water retention, and availability of balanced nutrients.

These characteristics are highly correlated with each other. The first two are directly related to macro porosity and water retention, the nutrients are related to micro porosity (GONÇALVES et al., 2000). The studied physical parameters of various treatments are presented in Table 4 and show the increase in the dose of sewage sludge organic compost (SSOC) in mixtures that promoted the increase in porosity. The substrate micro porosity was raised, which provides greater substrate capacity in water retention, a fact noted in treatments T1 (100% SSOC) , T2 (90% SSOC/10% CRH), T3 (80% SSOC/20% CRH), T4 (70% SSOC/300% CRH), T5 (60% SSOC/40% CRH), T6 (50% SSOC/50% CRH) and T7 (40% SSOC/60% CRH).

TABLE 4 - Physical parameters of substrates in different treatments studied

Treatment	Macro porosity (%)	Micro porosity (%)	Total porosity (%)	Water retention ml 50cm^{-3}	Apparent density g cm^{-3}
T1- 100/0	26.19 ab	40.99 bc	67.18 abc	45.09 bc	0.36 a
T2- 90/10	28.19 a	39.86 c	68.05 abc	43.85 c	0.29 ab
T3- 80/20	28.81 a	36.83 cde	65.64 abc	40.51 cde	0.25 bcd
T4- 70/30	24.09 abc	38.89 cd	62.99 bc	42.79 cd	0.25 bcd
T5- 60/40	30.74 a	37.81 cde	68.55 ab	41.59 cde	0.23 cde
T6- 50/50	28.53 a	40.62 bc	69.15 ab	44.68 bc	0.23 cde
T7- 40/60	20.19abc	37.25 cde	57.44 cd	40.97 cde	0.22 de
T8- 30/70	13.77 bc	34.93 cdef	48.69 de	38.42 cdef	0.21 ef
T9- 20/80	14.14 bc	29.91 ef	44.05 e	32.90 ef	0.18 fg
T10- 10/90	12.26 c	30.09 def	42.35 e	33.09 def	0.17 fg
T11- 0/100	18.21 abc	26.95 f	45.16 e	29.65 f	0.16 g
PLANTMAX	14.64 bc	52.25 a	66.89 abc	57.48 a	0.26 bc
Manure	25.12 abc	48.87 ab	73.99 a	53.76 ab	0.24 cde
F	NS	NS	NS	NS	NS
A.S.L.	13.39	8.89	10.97	9.77	0.399
V.C. (%)	24.51	9.36	7.33	9.36	6.92

Average values under same letter did not have differences about 0.05 level of probability
A.S.L. - Average significance level; V.C. - Variation coefficient; NS - Not significant

Treatments T8 (30% SSOC/70% CRH), T9 (20% SSOC/80% CRH), T10 (10% SSOC/90% CRH) and T11 (100% CRH) revealed the increases in the dose of carbonized rice husks, promoted reduction in the proportion of substrate micro pores, reducing its capacity for water retention. The density value of treatments increased as they raised the SSOC dose in mixtures. According to the physical characteristics set presented by GONÇALVES et al. (2000), substrates containing SSOC had physical characteristics suitable to produce tree seedlings as observed in Tab. 4. Table 5 shows the limits of heavy metals found in the initial sample of sewage sludge and sewage sludge organic compost (SSOC) compared with the limits of metals adopted by CONAMA Resolution No. 375, August 29, 2006, which regulates the disposal of sewage sludge and its derivatives. It appears that heavy metals such as cadmium, copper, nickel and zinc had their values reduced after sewage sludge composting, while the other elements had their values maintained as observed before composting.

TABLE 5 - Heavy metals concentration

Heavy metals	Sewage sludge (initial sample)	Organic compost (OCSS)	Heavy Metals Limits(CON.2006)
	Concentration in mg / kg dry weight		
Arsênio	< 0.01	ND	41
Cadmium	1.50	ND	39
Copper	219.00	94.0	1500
Lead	45.60	42.4	300
Mercury	< 0.01	ND	17
Molybdenum	< 0.01	ND	50
Nickel	13.40	6.2	420
Zinc	550.00	261.00	2800
Selenium	< 001	< 001	100

ND= Not detected, concentrations less than 0.1 mg / kg

Chemical indicators of agronomic value of sewage sludge organic compost (SSOC) and control treatments are presented in Tab. 6 and show that SSOC contains nutrient levels can be used in the composition for seedlings yield, reforestation and urban afforestation (CARNEIRO, 1995).

The concentration of macronutrients, pH, moisture and volatile solids are shown in Tab. 6. The compost pH is within the range considered adequate to develop seedlings, from 5.5 to 6.5, according to GONÇALVES et al.

(2000) and VALERI & CORRADINI (2000).

TABLE 6 - OCSS and control treatments characterization in pH, moisture, organic matter (O.M.), organic carbon, C/N ratio and nutrients for total solids

Substrates	Ph (H_2O)	moisture (%)	O.M.(%) (m/m)	C g/Kg	C/N	Pmg/dm	N g/Kg	K	Ca	Mg	S	Al mg/Kg
								mmol$_c$ dm^{-3}				
OCSS	5.5	50.2	60.5	335	16	2050.3	21.3	268	1334	86.3	427	12100
PLANT	5.6	4.1	48.2	325	44	598.5	6.0	293	1132	5765	3.5	18166
manure	6.9	14.6	31.6	281	14.6	360.5	12.1	271	1334	33.6	127	31008

The carbon/nitrogen ratio was around 16/1. It is considered an adequate value according to literature (KIEHL, 1998) and shows that the compound was stable. Effects in growth and development of tree seedlings(*Ingá uruguensis*, *Lafoencia glipogarpa*, *Poecilanthe parviflora* and *Tecoma Stans*) were evaluated in experiments using the best treatments, which were selected in preliminary tests with tomato seeds (*Lycopersicum esculentum*). Treatments with proportions varying from 100 to 40% SSOC were tested in the experiment for seedlings yield. Better results of grown seedlings were obtained with treatments ranging from 90 to 80% SSOC for *Ingá uruguensis*,100 to

80% for *Lafoencia glipogarpa*,80 to 70% for *Poecilanthe parviflora* and 90 to 70 for *Tecoma Stans* .Preliminary tests and others experiments using tree seedlings are illustrated in Fig. 2 and 3. More complete details of this study were registered and reported by PADOVANI (2006).

FIGURE 2 - View of preliminary tests using seeds of tomatoes (*Licopersicum esculentum*)

Lafoensia glyptocarpa | *Poencilanthe parviflora* | *Tecoma stans* | *Ingá uruguensis*

FIGURE 3 - View of the treatments (T1, T2, T3, T4, T5, T6, andT7) which were evaluated for the growth of forest seedlings

CONCLUSIONS

The microbiological and parasitological characterization of sewage sludge organic compost (SSOC) showed the composting promoted sewage sludge disinfection, making it feasible for forest essences yield.

The sewage sludge (SSOC) had suitable chemical characteristics to be used as a substrate in tree´s seedlings yield.

A physical characterization of substrata revealed that proportions ranging from 100 to 40% of the compound showed better results for tree´s seedlings cultivation.

Using sewage sludge organic compost (SSOC) to produce forest essences seedlings is a viable alternative for waste reuse, in addition to economy and quality of inputs in seedlings yield, as well as its environmental benefit.

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