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Treatment of sewage sludge for agricultural purposes with the use of solarization and sanitizing products

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INTRODUCTION

- Sanitary sewage collected by Effluent Treatment Stations (ETS) go through chemical, physical-chemical and biological treatments to meet legal standards determined by Brazilian environmental legislation about disposal of such residues.
- The high pathogen contents of sewage sludge is the major limiting factor for its use in agriculture, due to the risk of causing diseases in the population. From the environment perspective, the presence of heavy metals and organic elements in the sludge cannot be over the limits determined by environmental standards for agricultural use, such as the Resolution CONAMA n. 375 (29 August 2006), by Conselho Nacional de Meio Ambiente (CONAMA - National Council of Environment), that establishes criteria and procedures for agricultural use of sewage sludge generated in ETS.
- Among the several agents capable of disinfecting the sludge, three factors are the most important: temperature, pH, and solar radiation. These factors present ranges in which the microorganisms are alive and thrive in the sludge, but, beyond such ranges, the living organisms are eliminated. Intensity and time of exposure to these factors determine the efficacy of disinfestation of the sludge (ANDREOLI et al., 2001).
- This study evaluated the effect of combining chemical treatments with solarization in sanitization and chemical and physical composition of sewage sludge from an anaerobic reactor with upflow and sludge blanket UASB (Upflow Anaerobic Sludge Blanket Reactor) at the Treatment Station – ETE Uberabinha, located in Uberlândia-MG.

MATERIAL AND METHODS

- The experiment was done from 07 to 27 August 2013, at the na Fazenda Experimental do Glória, at Universidade Federal de Uberlândia, located at 18º 57' 30" S, 48º 12' 0" W. The sludge was treated at an artisanal UASB anaerobic reactor (Upflow Anaerobic Sludge Blanket), after passing through a drying process, by the addition of cationic polymers ($FeCl_3$) and centrifugation to reach 71.21% moisture content and dry matter of 28.79%, and collected at the exit of the screw conveyor.
- The experimental design was randomized blocks, as a 5x3 +1 factorial in split plots, with four replications. The plots were the sanitizing products (peracetic acid 260 mg L^{-1}, compounds with quaternary ammonium 2400 mg L^{-1}, hydrated lime at 30% of sludge dry matter, sodium hypochlorite 2500 mg L^{-1} and untreated sludge) and split plots were different incubation periods (T_1= 7 days, T_2= 14 days and T_3= 21 days), plus an additional treatment consisted of freshly collected untreated sludge, in a total of 64 split plots.

- **Table 1.** Treatments used in the sanitation process of sludge and their concentrations after 7, 14 or 21 days.

Treatment	Chemical product concentration
Sludge+ peracetic acid	260 mg L^{-1}
Sludge+ Compounds of Quaternary ammonium	2400 mg L^{-1}
Sludge+ Hydrated lime	30% of sludge dry matter
Sludge+ Sodium hypochlorite	2500 mg L^{-1}
Fresh sludge with no chemical products	-

RESULTS

Table 2. Thermotolerant coliforms (MPN) g^{-1} Total Solids, as a function of sanitizing products and incubation periods.

Source of Variation	Incubation period (days)			
	0	7	14	21
Control	2.87×10^7 *			
Peracetic acid		*1.02×10^5 Bb	*1.86×10^4 Bb	*8.50×10^3 Ab
Quaternary ammonium		*4.26×10^5 Bc	*1.41×10^4 Ab	*2.04×10^4 Ab
Hydrated lime		*0.71 Aa	*0.23 Aa	*0.23 Aa
Sodium Hypochlorite		*2.1×10^5 Bb	*2.00×10^5 ABb	*1.5×10^4 Ab
Untreated sludge		*7.07×10^5 Bc	*1.38×10^5 Bc	*6.15×10^4 Ab

Averages followed by small cap letters in the columns (Scott-Knott) and capital letters in the rows (Tukey) do not differ at 5% probability.* Significant at 5% by the Dunnett test.

Table 3. Heavy metals in the sludge as a function of treatment and incubation period[1]

Incubation period (days)	Zn	Cu	Cd	Cr	Ni	Pb
	mg kg^{-1}					
Control (0)	1500.00^{NS}	211.00^{NS}	0.94^{NS}	166.72^{NS}	31.93^{NS}	Nd
7	1620.00 A	195.45^{NS}	0.98 A	157.83^{NS}	28.68^{NS}	Nd
14	1750.00 A	199.00^{NS}	0.72 A	149.23^{NS}	29.45^{NS}	Nd
21	2670.00 B	192.00^{NS}	0.90 A	153.48^{NS}	28.65^{NS}	Nd
Source of Variation						
Peracetic acid	1840.00 b	210.16 b	1.05 c	176.25 b	32.60 b	Nd
Quaternary ammonium	2700.00 b	209.00 b	1.08 c	171.52 b	31.15 b	Nd
Hydrated lime	1180.00 a	157.91 a	0.45 a	85.34 a	19.86 a	Nd
Sodium Hypochlorite	2340.00 b	201.00 b	0.83 b	162.41 b	30.12 b	Nd
Untreated sludge	1990.00 b	199.33 b	0.93 b	172.07 b	30.90 b	Nd
MAC	2800	1500	39	1000	420	300

[1] NS= Non significant, Nd- Not detected. Averages followed by small cap letters in the columns (Scott-Knott) and capital letters in the rows (Tukey) , within the same characteristic, do not differ at 5% probability. MAC= Maximum Allowed Concentration.

Table 4. Sewer sludge properties

Incubation period (days)	pH	M.O	C	N	Na	Al	Ca	Mg	P	K
		g kg^{-1}								
Control (0)	8.62*	573.91*	332.89*	30.01*	0.75*	39,33*	17,3 *	2,6*	9,6 *	1,0^{NS}
7	9.37 A	523.83^{NS}	310.05^{NS}	29.64^{NS}	1,38^{NS}	30,33^{NS}	79,3^{NS}	3,3^{NS}	7,7^{NS}	0,9^{NS}
14	8.79 B	531.97^{NS}	303.84^{NS}	32.30^{NS}	1,52^{NS}	29,90^{NS}	79,4^{NS}	3,2^{NS}	8,3^{NS}	0,9^{NS}
21	8.80 B	534.54^{NS}	308.56^{NS}	31.92^{NS}	1,52^{NS}	29,56^{NS}	87,2^{NS}	3,3^{NS}	7,0^{NS}	0,8^{NS}
Source of variation										
Peracetic acid	8.17 b	570.36 b	330.83 b	33.48 a	0,94 b	33,59 b	21,5 b	3,1 b	10,2 a	0,9^{NS}
Quaternary ammonium	7.88 b	559.65 b	324.62 b	34.21 a	0,83 b	32,31 b	22,7 b	3,1 b	9,4 a	0,9^{NS}
Hydrated lime	12.65*a	368.60* a	213.80* a	20.88* b	0,61 a	20,10*a	302,0*a	4,2*a	1,6*b	0,6^{NS}
Sodium Hypochlorite	8.05 b	568.91 b	329.99 b	30.86 a	4,10*c	32,80 b	22,2 b	3,1 b	9,0 a	1,0^{NS}
Untreated sludge	8.15 b	583.05 b	338.19 b	36.84 a	0,88 b	30,85 b	41,4 b	3,0 b	8,1 a	0,8^{NS}

Averages followed by small cap letters in the columns (Scott-Knott) and capital letters in the rows (Tukey), within the same characteristic, do not differ at 5% probability.* Significant at 5% by the Dunnett test.

CONCLUSIONS

- Sewer sludge homogenized with compounds of quaternary ammonium, sodium hypochlorite and peracetic acid, subjected to solarization, did not reduce the concentration of thermo-tolerant coliforms below 1,000 MPN g^{-1} of Total Solids (TS).
- Heavy metals contents (Zn, Cu, Cd, Cr, Ni and Pb) were below the limits established by the Resolution CONAMA 375/2006.
- Liming at 30% of sludge dry matter caused high alkalinity and decreased the concentration of thermo-tolerant coliforms to levels below those established by the Resolution CONAMA 375/2006.
- Increasing pH of limed sludge resulted in lower availability of N, P, Na, M.O, C, Al, Zn and Cu and increased the concentration of Ca and Mg.

Financial support: FAPEMIG Fundação de Amparo à Pesquisa do Estado de Minas Gerais; CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico; Pró-Reitoria de Pesquisa e Pós-Graduação Universidade Federal de Uberlândia