THE INFLUENCE OF TEXTURISERS ON HYGIENIZATION EFFECTIVENESS OF SEWAGE SLUDGE COMPOSTING PROCESS

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Key words: sewage sludge, composting, texturisers

Introduction

Sewage sludge composting is a common way of its effective stabilization and hygienization. The effectiveness of this method depends on many factors, of which high temperature, humidity, pH and the amount of oxygen in biomass are believed to be the most significant (Stentiford 1996). The proper state of a pile, determined by carbon to nitrogen ratio, also plays an important role in composting process.

Owing to the low value of C/N ratio in raw sludge it is normally composted after mixing with the material, which contains large amount of carbon, such as bark, sawdust, straw etc. Apart from increasing the C/N value, the addition of these substances also contributes to the improvement of pile structure and facilitates its aeration (Sharma et al. 1997, Kluczek 1999).

The aim of the present study was to estimate the effect of pile composition on the effectiveness of two different composting systems. The basic criterion determining the effectiveness of the process hygienization was the inactivation rate of indicator microorganisms introduced into piles – fecal streptococci D-group.

Material and methods

The research was conducted in the summer 2002 in two sewage sludge composting plants using different technologies of biomass aeration:

- facility A – mechanically, by biomass turning in time intervals depending on temperature in a pile
- facility B – using forced air circulation, sucked into a pile through the system of perforated pipes

Two experimental piles were observed in each facility. Proportions in the composition of the first pile were similar in both composting plants and amounted to 1: 0.7 : 0.3 (sewage sludge dehydrated and fermented in anaerobic conditions: sawdust : straw, respectively). The composition of the other pile was typical of the piles commonly made in a given facility –

there was one part sewage sludge to 0.5 part sawdust and 0.5 part straw in composting plant A, while in composting plant B 1/3 sawdust was added to sewage sludge.

Enterococci were placed in various places in the piles using special carriers made of compost, previously inoculated with the suspension of these microorganisms. The initial number of fecal streptococci in the suspension amounted to about $10^8 - 10^9$ cfu · ml^{-1}. The number and construction of the carriers used enabled us to control biomass hygienization fully, and at the same time ensured the safety of the experiment.

The number of tested microorganisms population in the carriers removed from the piles was determined using the MPN method.

In order to determine the number of enterococci we used fluid medium with glucose and azide (Merck, No 1590). After 24-hour incubation in 37^0C the material was transferred to agar medium with esculin and azide (Merck, No 5222) (48 hours in 37^0C).

The results obtained were calculated statistically and regression lines were drawn. In this way the decrease rate in enterococci number in composted biomass could be determined.

Results and discussion

The results of the research were presented in Tables 1 and 2.

In facility A streptococci in the upper layers of the mechanically aerated pile with sawdust were totally inactivated after 3 days. In the bottom part of biomass, where the daily decrease in number of enterococci was 1.12 $\log_{10}$, they were isolated last time after 6 days (Tab. 1).

The surprisingly fast elimination of streptococci in all parts of composted material was observed in the other pile. In the bottom parts tested microorganisms died after 5 days, while in the upper and central parts – after 6 and 7 days, respectively (Tab. 2).

In facility B, using forced air circulation in the composted biomass, daily reduction in number of streptococci D-group in the top layer of the pile with the addition of sawdust amounted to 0.23 $\log_{10}$ and was higher than in the central part – 0.14 $\log_{10}$ and bottom part – 0.15 $\log_{10}$. Theoretical bacteria survival in these conditions ranged from 33 days in the upper layer to 54 days in the central part (Tab. 1).

The results of analyses proved that the time needed to obtain the total elimination of enterococci in the pile II was exceptionally long. In the top and central parts the reduction of microorganisms count during 25-day composting was only about 1.3 $\log_{10}$. In the lower part of the pile streptococci died almost twice faster than in upper parts (Tab. 1). The count of the microorganisms there in the last time of the research amounted to 8.57×10^6 NPL·g^{-1}, while it did not change significantly in the central part (Tab. 2).

Table 1. Regression lines equation and survival time of bacteria investigated in different layers of examined windrows.

composting plant	pile	pile layer	regression equation	r^2(%)	survival of microorganisms tested (days)
A	I	top			1,0 [a]
		centre			1,0 [a]
		bottom	y = - 1,122x + 7,481	77,7	6,7
	II	top			5,0 [a]
		centre	y = - 1,207x + 7,603	89,4	6,3
		bottom			2,0 [a]
control carrier			y = - 0,155x + 8,282	37,1	53,5
B	I	top	y = - 0,233x + 7,791	61,1	33,4
		centre	y = - 0,141x + 7,591	61,2	53,8
		bottom	y = - 0,150x + 7,697	54,3	51,3
	II	top	y = - 0,053x + 7,777	22,1	145,4
		centre	y = - 0,056x + 7,851	17,0	140,7
		bottom	y = - 0,110x + 8,165	51,2	74,2
control carrier			y = - 0,140x + 7,661	69,2	54,6

[a] the day of the process when bacteria tested were isolated from the carrier for the last time

Mixing sewage sludge with additives improving the pile structure, such as bark, wood snips, green waste, straw, sawdust, is an important factor that influences the effectiveness of composting process. They ensure the proper C/N ratio in composted biomass, creating suitable conditions for the development of microorganisms that carry out the mineralization of organic substances it contains (Bresters et al. 1997). The improvement of pile structure also facilitates appropriate air distribution inside it (Feachem et al. 1983).

The results of our studies indicate that in facility A differences in composted material composition did not influence significantly the process effectiveness. The inactivation rate of indicator microorganisms introduced into piles, connected with its effectiveness, was very fast and balanced at all levels (Tab. 1). It may result from the fact that despite of the different proportions of straw and sawdust added to the sludge while making the piles, the general ratio of those substances to raw sludge was the same in both piles and amounted to 1 : 1.

In facility B, where the contribution of texturisers in the composition of the pile I was remarkably higher in comparison with the pile II, the survival of the bacteria was significantly lower in biomass with more sawdust added (Tab. 1).

During the experiment the significant differences were observed in the survival of fecal streptococci in piles I, which had similar composition, but were made in different composting plants (A and B). The differences may suggest that apart from appropriate proportions in biomass composition also the way of its aeration was an important factor contributing to improper course of composting process.

Table 2. The number of streptococci D-group in experimental piles tested [MPN·g^{-1}]

Layer in pile	time of sampling	Composting plant A			time of sampling			
		pile I	pile II	control carrier		pile I	pile II	control carrier
	0	8,25x10^{8}			0	9,42x10^{8}		
top	1 1 day (2)*	4,00x10^{7}	8,65x10^{5}	1,53x10^{8}	1 5 days	8,42x10^{6}	7,65x10^{6}	5.73x10^{6}
centre		5,40x10^{5}	8,70x10^{4}			8,70x10^{6}	6,35x10^{7}	
bottom		4,80x10^{6}	8,70x10^{2}			1,82x10^{7}	3,32x10^{8}	
top	2 3 days (5)	ns	1,50x10^{5}	2,67x10^{7}	2 12 days	6,72x10^{5}	8,66x10^{7}	4.50x10^{5}
centre		ns	1,40x10^{1}			5,98x10^{5}	9,27x10^{6}	
bottom		8,30x10^{3}	ns			1,09x10^{6}	1,65x10^{7}	
top	3 6 days	ns	ns	5,47x10^{7}	3 17 days	2,53x10^{4}	2,43x10^{7}	3.40x10^{5}
centre		ns	1,40x10^{1}			2,08x10^{4}	2,45x10^{7}	
bottom		3,17x10^{3}	ns			3,17x10^{4}	1,61x10^{6}	
top	4 7 days	ns	ns	9,03x10^{7}	4 21 days	1,50x10^{5}	5,58x10^{6}	7.22x10^{4}
centre		ns	ns			2,37x10^{5}	4,75x10^{6}	
bottom		ns	ns			8,63x10^{4}	6,72x10^{5}	
top	5 8 days (9)	ns	ns	1,88x10^{7}	5 25 days	9,00x10^{3}	5,17x10^{6}	1.47x10^{5}
centre		ns	ns			3,25x10^{5}	2,23x10^{8}	
bottom		ns	ns			2,08x10^{5}	8,57x10^{6}	

values in brackets refer to the pile II in facility A

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