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VERMICOMPOSTING OF WASTEWATER SLUDGE FROM PAPER-PULP INDUSTRY WITH NITROGEN RICH MATERIALS

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Summary—The vermicomposting of pulp mill sludge mixed with sewage sludge, pig slurry and poultry slurry at different ratios was studied. *Eisenia andrei* (Bouché, 1972) showed high growth rates and high mortalities in all the mixtures considered. © 1997 Elsevier Science Ltd

INTRODUCTION

The solid paper mill sludges derived from the pulp and paper industry are interesting sources of organic matter. On an industrial scale, the pulp mill sludges are usually managed through destructive methods: incineration and landfilling practices (Springer, 1986; Tirsch, 1990), but vermicomposting could be an adequate technology for its transformation. However, two factors may limit the biooxidation processes: the difficult degradation of the structural polysaccharides and the low nitrogen content of the sludge. Both problems could be solved by mixing this waste with some nitrogen-rich materials acting as a natural inoculants of microbial communities. However, the mixture will affect both the earthworm process and the quality of the final product, thus it is very important to know the chemical composition and the best mixture.

The aim of this study was to determine the potential of earthworms in managing solid paper-pulp mill sludge (SPPMS) mixed with several organic nitrogen sources in different proportions.

MATERIALS AND METHODS

Fresh SPPMS was obtained from the wastewater treatment of Kraft paper-pulp (ENCE, Pontevedra, Spain). This waste was amended by adding sewage sludge, pig and poultry slurry, characterized by low total solids content and high organic matter and nitrogen (Table 1). Nine mixtures were established by mixing SPPMS (dry wt) with one part of each nitrogen rich material mentioned above, according to three different proportions (dry wt; see Table 2) and moistened to 80%. Immature specimens of *Eisenia andrei* were placed individually in every plastic flask (600 ml) containing 100 g of each mixture (wet wt). Fifteen replicates of each treatment were set up at room temperature and earthworm growth and survival were recorded periodically. When mortality occurred in a higher proportion than 75% in any of the treatments, these were interrupted.

RESULTS

The increasing proportion of sewage sludge in the mixture promoted a decrease in the survival and growth of *E. andrei* [Fig. 1(a)]. The 3:2 mixture produced the highest growth rates and the lowest mortalities (Table 2). With regards to the mixture of SPPMS with pig slurry; earthworms exhibited a fast growth [Fig. 1(b)] and high mortality (Table 2) and their survival after 45 days was always less than 25% in all proportions tested. When poultry slurry

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Table 1. Chemical characteristics of SPPMS and nitrogen rich materials (all values given as percentage except C-to-N and pH)

	Total solids	Ash	TOC	TKN	C-to-N	pH	Crude fibre
SPPMS	18.9	87.5	47.6	0.24	188.3	9.2	67.9
Sewage sludge (SS)	8.2	58.9	32.7	2.75	11.9	5.5	6.6
Pig slurry (PS)	9.6	62.6	34.1	4.22	8.0	8.0	10.2
Poultry slurry (PtS)	11.5	53.2	30.1	5.07	5.9	6.6	8.5

TKN, total Kjeldahl nitrogen; TOC, total organic carbon.

was added, rapid growth is observed in the 3:2 and 2:1 mixtures although the mortality was high [see Fig. 1(c) and Table 2]. The maximum weight was achieved when the SPPMS was presented in the highest proportion but showed a low growth rate during the entire experiment.

Figure 2 shows the earthworm growth in the three 2:1 mixtures and in the control (100% SPPMS). It can be seen that there was no weight increase when they were fed with SPPMS only and significant differences ($P < 0.01$) between the mixtures and the pure material were detected. The three mixtures showed high mortalities, although the sewage sludge mixture showed the slowest growth rate and the longest survival time.

DISCUSSION

There are few comparable studies dealing with the management of SPPMS. Hartenstein (1978) and Hand and Hayes (1983) carried out a study using paper refuse from MSW but its different origin and composition make comparisons unreliable.

The first idea of the suitability of this waste for earthworm feeding was pointed out by Edwards (1988).

Butt (1993), in a study using *Lumbricus terrestris* and *Octolasion cyaneum* populations growing in a 66:1 mixture (wet wt of SPPMS and dry wt spent brewery yeast), found out that *L. terrestris* showed the highest growth rate (30 mg worm^{-1} d^{-1}) after 120 days, and mortalities ranging between 40 and 80% were recorded for both species. According to Bouché (1972) these two species are considered to belong to different ecological categories so their food requirements are quite different from *E. andrei*, a typical surface-living worm strongly associated with high organic matter contents.

SPPMS is not able to support earthworm growth by itself, however the mixture could be a suitable technique for its utilization as food source in vermicomposting (see Fig. 2). The growth rates we obtained were high in all the cases considered and comparable to the results for other diets with organic wastes recorded in previous studies. The high mortality in the majority of the mixtures suggests that proportions play an important role in SPPMS breakdown and in environmental changes. The rapid initial growth rate in all the mixtures and the sudden mortality in all SPPMS–pig slurry mixtures and those with the lowest content of SPPMS for the other two suggest that mortality was not due to the lack of food but the degradation process probably results in changes of the environmental characteristics, the polysaccharides breakdown could modify the structure of the substrate so the water retention capacity decreases and this fact would increase worm mortality.

Table 2. Growth and mortality of *E. andrei* fed on three different food sources mixed in different proportions

Food source	Mixture (dry wt)	Slope (mg worm^{-1} d^{-1})	Max. wt achieved (mg ± SE)	Mortality (%)
SPPMS (control)		−0.1	101 ± 30	0
SPPMS + sewage sludge	3:2	6.9	570 ± 20	> 75 (55)
	2:1	8.3	780 ± 70	> 75 (80)
	3:1	7.7	930 ± 50	< 50 (108)
SPPMS + pig slurry	2:1	24.8	900 ± 40	> 75 (31)
	5:2	23.4	840 ± 80	> 75 (31)
	5:1	18.8	900 ± 70	> 75 (42)
SPPMS + poultry slurry	3:2	16.6	440 ± 30	> 75 (18)
	2:1	10.5	610 ± 40	> 75 (40)
	4:1	6.7	920 ± 130	< 50 (108)

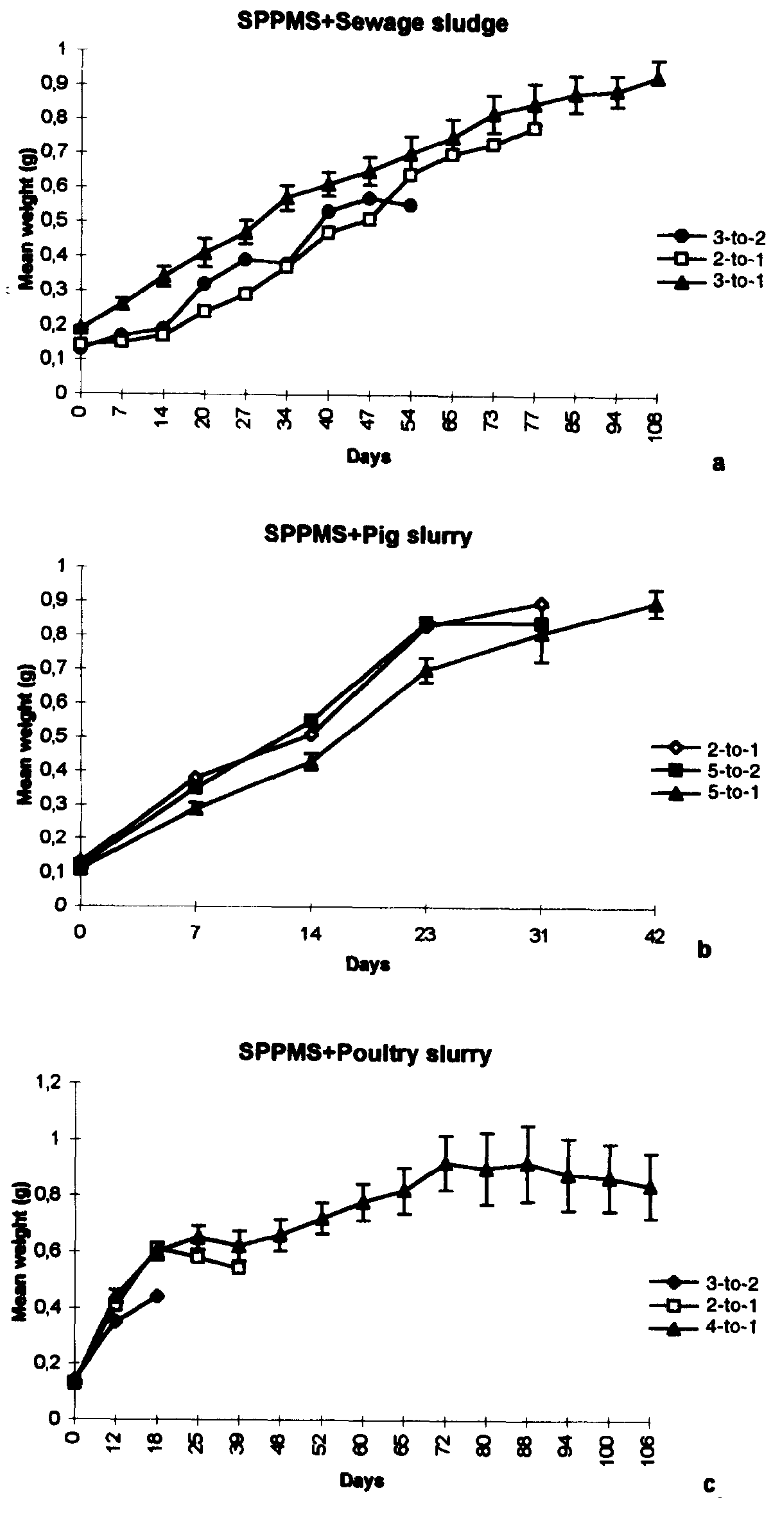

Fig. 1. Survival and growth of *E. andrei* in the three mixtures of pulp mill sludge with: (a) sewage sludge, (b) pig slurry and (c) poultry slurry.

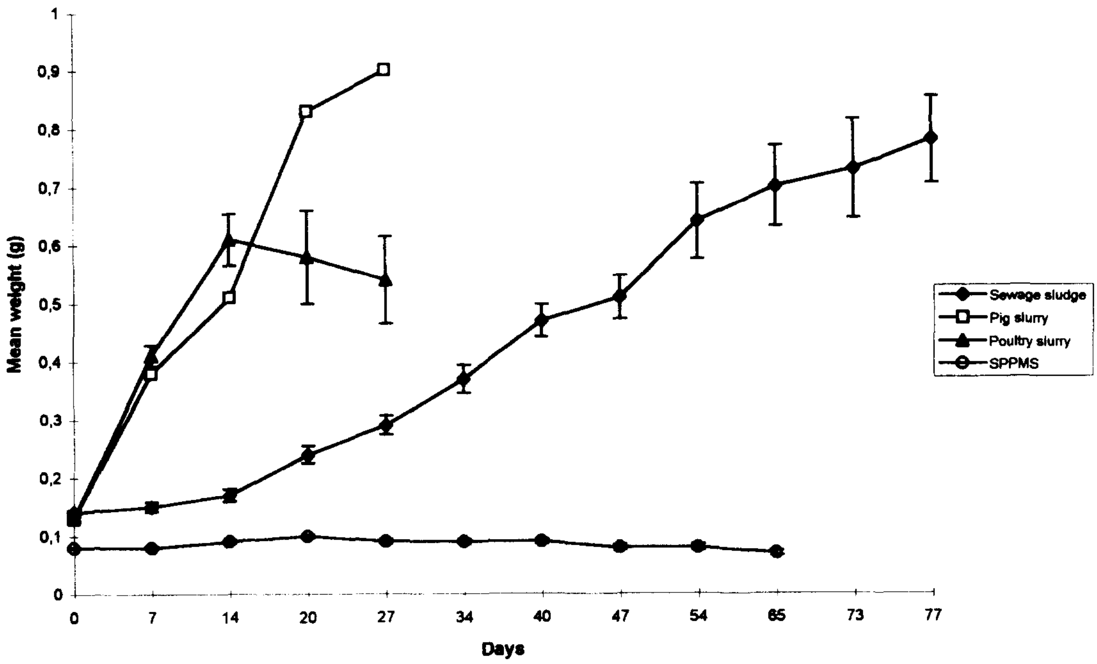

Fig. 2. Growth and survival of *E. andrei* in the three 2:1 mixtures and in the control.

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