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**PJBS**

ISSN 1028-8880

**Pakistan  
Journal of Biological Sciences**

**ANSI***net*

Asian Network for Scientific Information  
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

## Combined Compost and Vermicomposting Process in the Treatment and Bioconversion of Sludge

<sup>1</sup>H. Alidadi, <sup>2</sup>A.R. Parvaresh, <sup>2</sup>M.R. Shahmansouri,

<sup>2</sup>H. Pourmoghadass and <sup>1</sup>A.A. Najafpoor

<sup>1</sup>Department of Environmental Health, Faculty of Health,  
Mashhad University of Medical Sciences, Iran

<sup>2</sup>Department of Environmental Health, Faculty of Public Health,  
Isfahan University of Medical Sciences, Iran

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**Abstract:** Traditional thermophilic composting is commonly for treatment of sludge. A related technique as vermicomposting process, using earthworms to breakdown sludge, is also becoming popular. These two techniques have their inherent advantages and disadvantages. The combined approach suggested in this study to enhance the overall process and improve the products qualities. Two systems, vermicomposting and combined compost-vermicomposting processes, have been investigated in this study. The sludge used in this study was obtained from the drying beds of South Isfahan wastewater treatment plant. The sludge mixed with sawdust to provide C/N ratio of 25/1. *Eisenia fetida* was the species of earthworms used in the vermicomposting processes. The results obtained indicate reduction in the amount of volatile solids, total carbon and C/N ratio with the vermicompost age, which indicates the reduction in the biodegradable organic content and mineralization of sludge. Also increase in phosphorus concentration by the end process because of mineralization of organic matter. The results indicate that, a system that combines the two mentioned processes not only shortens stabilization time, but also improves the products quality. Combining the two systems resulted in a product that was more stable and homogenous; the product could meet the pathogen reduction requirements.

**Key words:** Sludge, vermicomposting process, *Eisenia fetida*, combined process

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### INTRODUCTION

There are large amounts of sludge produced continuously in most wastewater treatment operations. The produced sludge needs to be deal with carefully. Stabilization and disposal of domestic sludge produced from wastewater treatment plants is especially critical (USEPA, 2002). The importance of biological processes in the management of sludge has been widely recognized. Within the broad range of bioprocesses available, composting and vermicomposting are the most efficient for converting sludge into useful products. The sludge obtained from municipal wastewater treatment plants is usually suitable for compost and vermicompost because of the huge amounts of organic matter available (Fair and Geyer, 2002). The composting is an accelerated biooxidation of organic matter passing through a thermophilic stage (45 to 65°C), where microorganisms such as bacteria, fungi and actinomycetes liberate heat,

carbon dioxide and water. Hence, during the composting process kill of pathogens (Dominguez and Edwards, 1997). The heterogeneous organic material is transformed into homogeneous and stabilized humus like product through turning or aeration. The major problems associated with thermophilic composting are the long duration of the process, loss of nutrients during the prolonged composting process and the frequency of turning of the material.

In recent times, interest in the use of a closely related technique, known as vermicomposting has increased (Logsdon, 1994; Edwards and Bohien, 1996). The vermicomposting is a low cost technology system that uses earthworms in the treatment of organic wastes. The earthworms fragment the organic waste substances; simulate microbial activity greatly and increase rates of mineralization, rapidly converting the wastes into humus like substances with a finer structure than compost (Elvira and Giocoechea, 1996; Atiyeh and Dominguez,

2000). The earthworm's roles of turning and maintaining the material in aerobic condition in the vermicompost. The major drawback in the vermicomposting process is that it must be maintained at temperatures below 35°C and exposure of worms to temperatures above this will kill them. The vermicomposting process temperature is not high enough for acceptable pathogen kill and hence the product does not pass EPA rules for pathogen reduction.

An integrated system from both the thermophilic composting process and the vermicomposting process would be necessary to provide a product free of pathogens, and product with desirable characteristics at a faster rate than either of the individual processes. In England, Logsdon (1994) reported successful addition of worms after the heat of the initial decomposition subsides. The worms worked well in this situation and shortened the time for curing and stabilization of the compost. Furthermore, combining composting with vermicomposting also accelerated the composting process thus reducing the time required for composting (Frederickson and Butt, 1997; Nedgwa and Thompson, 2001).

In the combine system, the traditional composting required temperature for ensuring adequate pathogen kill would be achieved free of pathogens. In the vermicomposting, worms are able to enhance the rate of decomposition of organic materials by fragmenting the substrate material and by providing the more microbial active casts. Thus if vermicomposting was used in combination with the traditional composting, the required temperature for ensuring adequate pathogen kill would be achieved. The resulting compost will not only be of high quality (with respect to pH, acceptable pathogen kill, homogeneity, higher nutrients, etc.) but also cheaper to produce and curing time is effectively reduced. The objectives of the present study included investigation of the vermicompost and combining compost-vermicompost in the stabilization of dewatered sludge and comparison of two methods for chemical and biological characteristics.

## MATERIALS AND METHODS

**Preparation of the pilot:** This study was conducted during the period from December 2003 to April 2004. The sludge used in this study was obtained from the drying beds of South Isfahan wastewater treatment plant. The methods of investigation were vermicomposting and combine compost-vermicomposting processes. The earthworms were used in this study collected in Mazandaran province in the North of Iran. *Eisenia foetida* was the species of earthworms used in the vermicomposting process. The ratio of sludge used was 3 kg of 80% moisture content mixed by 1 kg of sawdust of

5% moisture content to provide a suitable C/N ratio of 25. The vermicompost experiments were performed in two plastic worm bins of 1.1×0.9×0.5 m<sup>3</sup> (Length×width×depth). These plastic bins provide one m<sup>2</sup> of exposed top surface. From preliminary studies (Ndegwa and Thompson, 2001), an optimal worm sticking density of 1.6 kg worms m<sup>-2</sup> and an optimal feeding rate of 0.75 kg feed/kg worm/day were used in this experiment. The Eight hundred pieces of adult *Eisenia foetida* between 0.4 to 0.5 g were placed in the vermicompost plastic bin, to provide the optimal sticking density. The biomass loading was 1.6 kg. The experiments lasted two months; hence, we needed 72 kg of the substrate.

The windrow composting size was approximately 1.2 m in height and 1.5 m in width and 2.5 m length. The sludge used in the study have 80% moisture content, sludge mixed with the sawdust to control and adjust the moisture content to 60% and increased C/N ratio to 25/1. The windrow turning was done manually. The windrow was turned to ensure availability of sufficient amount of oxygen to be utilized by microorganisms at the start of the composting cycle. The windrow was turned five times, until temperature of compost reach to 55°C, then substrate was cooled and introduce of vermicompost plastic bin. The temperature was measured by thermometer. The temperature was measured at two thirds of the elevation of the windrow, at about eighty centimeters from surface of the windrow. The substrate material was maintained temperature by spraying the surface with water.

**Measured parameters:** The composite samples were taken from about three different points of bin for examination. The moisture content of the vermicompost samples was determined drying to a constant weight at 105°C for 24 h in oven. The ambient temperature and the plastic bins were measurements by thermometer. The determination of pH was made potentiometrically in a 1/10 suspension of the sample in deionized water; this suspension was placed on a mechanical shaker at 230 rpm for 30 min prior to pH measurement. Volatile solids (VS) were obtained by ashing the dried samples at 550 °C for 30 min (Anonymous, 2000). Total phosphorus using the ascorbic acid method, after digestion of the sample and reading at 880 nm on a Spectrophotometer (Anonymous, 2000). Total nitrogen was extracted by the Kjeldahl digestion method where the sample is pretreated with salicylic acid and thiosulphate (Mulvaney, 2000). The NH<sup>4+</sup> and NO<sup>3-</sup> using the KCL extraction method (Mulvaney, 2000). Fecal coliforms were determined using a Most Probable Number (MPN) technique in accordance with part 9221E, Standard methods for examination of water and wastewater (Anonymous, 2000). The helminth eggs such as ascaris were determined using by Yanko (2002) method.

**Statistical analysis:** All the reported results were expressed as mean of two replicates and all data were analyzed using of SPSS statistical analysis. The comparisons among means were made using the least significant difference test calculated at p-values.

**RESULTS**

The ambient and the plastic bins as measured daily varied between 8 to 15°C and between 10 to 17°C, respectively. The moisture content in plastic bins of vermicompost varied between 70 to 75% and the pH ranged between 5.8 to 7.6. A temperature range of 0 to 35°C, a moisture range of 60 to 90% and a pH range of 5 to 9 were utilized as suitable conditions for the growth of *E. fetida* (Edwards and Bohlen, 1996). Thus, favorable growth conditions for the growth of earthworms *E. foetida* were provided in this study.

The results of parameters (TC, TN, C/N ratio, VS, TP, FC, NH<sub>4</sub>/NO<sub>3</sub> and Ascaris egg) of the dewatered sludge and the products from two systems are summarized in Table 1. The percentage changes of each parameter after 60 days of processing were calculated and are shown in Table 2, also the results of analysis of variance among the two systems are shown Table 2.

**DISCUSSION**

The results obtained indicates reduction in the amount of volatile solids with the vermicompost age, which indicates the reduction in the biodegradable organic content of sludge. The Table 1 shown that the extent of reduction of volatile solids in vermicomposting and combined compost-vermicomposting processes were

decreased 26.68 and 33.48%, respectively. Higher reductions were observed in combine process than vermicomposting process. The decrease in volatile solids was significantly different (p<0.05) between two systems. This finding indicates that the combined compost-vermicomposting process is more efficient in stabilizing sludge than the vermicomposting process. Present results confirmed the results of Hassouneh and Jamrah (1999).

The results obtained indicates reduction in the amount of total carbon with the vermicompost age, which indicates the mineralization of sludge, but decomposition of the sludge during vermicomposting process was slow as compared to combined compost-vermicomposting process. Also higher increase in the amount total nitrogen because the more microbial activity in the beginning of combined compost-vermicomposting than vermicomposting process, thus decreasing the C/N ratio. The decrease in C/N ratio was significantly different (p<0.05) between two systems. Present results confirmed the results of Eiland and Klamer (2001).

According to Table 1, increase in phosphorus concentration by the end process possibly because of mineralization of organic matter. Higher increase was observed in combined process than vermicomposting process. The increase in phosphorus was significantly different (p<0.05) between two systems. Present results confirmed the results of Ndegwa and Thosmpson 2001.

The temperature during the composting phase in the combined systems reach to 55°C, to provide the temperature required for pathogen kill, thus it satisfy the EPA requirements for class A compost, but vermicomposting process satisfy the EPA requirements for class B compost. Present results confirmed the results of Hassouneh and Jamrah (1999).

The results presented above suggest that, the combined systems are better treatment options than the vermicomposting system because higher reductions of C/N ratio, volatile solids, NH<sub>4</sub>/NO<sub>3</sub> and fecal coliforms observed. The higher reductions in volatile solids suggest that more stable products were obtained from combine system; it would be possible to achieve the required compost within a shorter time, thus effectively reducing the overall processing time for the combine system. In addition, the product from combine system seems to be better met the EPA criterion and was the most homogenous.

Table 1: Characteristics of dewatered and final product of two systems analysis

Parameters	Dewatered sludge	Vermicomposting process	Compost-vermicompost process
Total carbon (%)	41.00	32.42	29.71
Total nitrogen (%)	1.71	2.18	2.24
C/N ratio	24.00	14.87	13.26
Volatile solids (%)	90.26	67.98	60.04
Total phosphorus (g/kg)	1.17	2.54	2.71
NH <sub>4</sub> /NO <sub>3</sub>	4.45	1.95	1.46
Fecal coliforms (MPN/g ds)	1810 <sup>6</sup>	5905	904
Ascaris Egg (Number/4 g ds)	0.38	0.015	0.00

Table 2: Comparison of the average variation parameters in final product of two systems

Parameters	Total carbon	Total nitrogen	C/N ratio	Volatile solids	Total phosphorus	NH <sub>4</sub> /NO <sub>3</sub>	Fecal coliforms	Ascaris eggs
Vermicomposting process	-20.92	21.56	-38.04	-24.68	53.94	-56.18	-99.967	-96.05
Compost-vermicompost	-27.54	23.66	-44.75	-33.48	56.83	-67.19	-99.995	-100.00
p-values	0.0011	0.45	0.0018	0.001	0.0027	0.00009	0.9998	0.85

#### ACKNOWLEDGMENTS

The authors would like to thank vice chancellor of Researches of Isfahan University of Medical Sciences for their financial support in this research. We would like to thank for helps of Isfahan Water and Wastewater Company and M. Mousavi for his contribution in this study.

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