European Journal of Applied Sciences 5 (2): 62-66, 2013
ISSN 2079-2077

DOI: 10.5829/idosi.ejas.2013.5.2.2399

# Nutrient Status of Vermicompost of Paper Mill Sludge with Different Wastes by Using *Eisenia fetida*

*Anjali Yadav and Sangeeta Madan*

Department of Environmental Sciences, Kanya Gurukul Campus,
Gurukul Kangri Vishwavidyalaya, Haridwar-249404

**Abstract:** In the present study, an effort has been made to utilize Paper mill sludge with different types of waste i.e. agricultural waste, municipal waste and poultry waste through vermicomposting by using *Eisenia fetida*. The experiments for vermicomposting were conducted in circular plastic pots. In each pot different combinations of paper mill sludge (PMS) and different wastes (DW) i.e. (agricultural, municipal solid waste and poultry waste) were taken in three proportions viz. ($T_1$) -1:1 ( paper mill sludge + different wastes), ($T_2$) - 1:3 (paper mill sludge + different wastes), ($T_3$) - 3:1 ( paper mill sludge + different waste) for composting and vermicomposting. In the experimental period (60 days), different chemical parameters were analyzed within a time interval of 15 days. The Total Kjeldahl Nitrogen (%), Available Phosphorus (%) and Total Potassium (%) increased while the % Organic Carbon decreased as the composting and vermicomposting processes progressed. 15 adult *Eisenia fetida* were introduced in each mixture. Among the three treatment units $T_1$, $T_2$ and $T_3$, $T_2$ showed the best results.

**Key words:** Paper mill sludge · Agricultural waste · Municipal solid waste · Poultry waste · Vermicompost · *Eisenia fetida*

## INTRODUCTION

Production of large quantities of organic waste all over the world poses major environmental (offensive odors, contamination of ground water and soil) and disposal problems [1]. Therefore, the disposal of different types of wastes has become very important issue for maintaining healthy environment [2]. As we know that disposal of industrial solids is becoming a serious problem. The sludges resulting from different industrial operation and waste water treatment plants are managed through destructive methods [3]. The sludge generated in enormous quantity creates the problem of safe disposal. Sludge is an inevitable, hazardous and odorous by-product from conventional water and waste-water treatment plants which eventually requires safe disposal either in landfills or by incineration incurring heavy cost [4]. In addition, sludge contains organic molecules and essential plant nutrients like nitrogen, phosphorus, potassium and various trace elements. When stabilized through a composting process, it can become a good source of organic fertilizer and soil additive, free of chemicals and pathogens. Paper making generally produces a large amount of solid waste. The waste generated from paper and pulp Industry includes; bark wood residues, screening rejects, paper sludge, lime sludge and incineration residues (flyash). Over 70% of solids wastes (by-products) generated in the manufacture of paper pulp are presently disposed of in landfills. Most of these by-products are compostable and reusable in horticulture, landscaping and agriculture [5]. The utilization of this paper mill sludge can be done by vermistabilization. Earthworms feed readily upon the sludge components, rapidly converting them into vermicompost, reduce the pathogens to safe levels and ingest the heavy metals. Volume is significantly reduced from 1 $m^3$ of wet sludge (80% moisture) to 0.5 m of vermicompost (30% moisture) [4]. Beside it we are facing major problem with the wastes like municipal solid waste, agricultural waste and poultry waste because these are highly organic in nature and pollute the water, air and soil environment. Thus vermicomposting has become an appropriate alternative for the safe hygienic and cost effective disposal of these wastes. Vermicomposting,

**Corresponding Author:** Anjali Yadav, Department of Environmental Sciences, Kanya Gurukul Campus, Gurukul Kangri Vishwavidyalaya, Haridwar-249404 .

through earthworms, is an eco-biotechnological process that transforms energy rich and complex organic substances in to stabilized vermicompost [6]. The promising technique that can be applied to treat the industrial sludge is vermicomposting by a specific composting worm. The use of earthworms in sludge management has been termed as vermistabilization. [7]. Some epigeic earthworms: *Lumbricus terrestris, Eisenia fetida, E andrei, Eudrilus eugeniae* and *Perionyx excavatus* have been appeared as key sources to combat the problem of organic waste disposal on a low-input basis[3,8,9]. Hence the aim of study was to determine the nutrient status of vermicompost prepared from Paper mill sludge with different wastes (poultry waste, distillery waste and municipal solid waste) by using *Eisenia fetida.*

## MATERIALS AND METHODS

**Collection of Earthworms:** *Eisenia fetida* species were collected from Devsanskriti Vishwavidyalaya Campus (Dehradun-Rishikesh road) 10 km. from the Kanya gurukul campus Haridwar, (Uttarakhand).

**Collection of Wastes:** Agricultural waste was collected from the agricultural fields of Devsanskriti Vishwavidyalaya, Haridwar and Municipal solid waste (MSW) from the dumping site of Chandi ghat situated in Haridwar city. Poultry waste was collected from the local poultry farm of Roorkee situated 27 Km. far from the Haridwar city.

**Collection of Sludge:** Paper mill sludge was collected from Star Paper Mill, Saharanpur, (Uttar Pradesh, India).

**Experimental Setup for Vermicomposting:** The experiments for vermicomposting were conducted in circular plastic pots. In each pot different combinations of paper mill sludge (PMS) and different wastes (DW) i.e. (agricultural, municipal solid waste and poultry waste) in three proportions viz. 1:1 (Paper mill sludge + Different wastes) ($T_1$), 1:3 (Paper mill sludge + Different wastes) ($T_2$), 3:1 (Paper mill sludge + Different wastes) ($T_3$) were prepared. 15 adult worms were introduced in each mixture. A set of control in each combination was also maintained without the earthworms.

**Collection of Vermicompost and Compost:** Samples of vermicompost and compost from all experimental units were collected at the interval of $15^{th}$,$30^{th}$, $45^{th}$ and $60^{th}$ day and were used for chemical analysis.

**Analysis of Macro Nutrient:** The total nitrogen (%N), available phosphorus (%P), total potassium (%K) and Organic carbon (% OC) were analysed [10].

**Statistical Analysis:** The statistical significance of difference was tested using One-way ANOVA at 0.05 level. ( SPSS 12.0).

## RESULTS

The performance of vermireactors with paper mill sludge and different wastes in terms of macronutrients during the study period are summarized in Table-1, 2 and 3. Results revealed a considerable increased amount of macronutrients at the end of $60^{th}$ day.

The total nitrogen (N) content of $T_1$ (C) showed 12.98% increase from the initial day while $T_1$ (E) has 18.18% increase in N content from the initial day. Likewise the $T_2$ (C) showed 19.48% increase while $T_2$ (E) showed 37.01% increase from the initial day. In the same manner in $T_3$ the % increase in N change was more in $T_3$ (E) unit which was 17.88% than that of $T_3$ (C) 12.58%. The higher % of N was found in $T_2$ as compared to the $T_1$ and $T_3$ which may be due to mineralization of organic matter. The final content of nitrogen in vermicomposting is dependent on initial nitrogen present in the waste and the extent of decomposition. Earthworm activity enriches the nitrogen profile of the vermicompost through microbial mediated nitrogen transformation, addition of mucus and nitrogenous waste secreted by earthworms [11-14]. The available phosphorus (P) content of $T_1$(C) showed 175.0% increase from the initial day whereas $T_1$ (E) has 193.75% increase in P content from the initial day. Similarly the $T_2$ (C) showed 173.68% increase and $T_2$ (E) showed 263.15% increase from the initial substrate. In the same manner $T_3$(C) showed 169.23% increment and $T_3$ (E) 230.76% increase from its initial mixture. The highest increase was found in $T_2$ (E) as compared to $T_1$ and $T_3$ which may be due to mineralization and mobilization of phosphorus as a result of bacterial and faecal phosphatase activity of earthworms [15]. The % increase in the Total potassium (K) content was 244.0% in $T_1$ (C) and 268.0% in $T_1$ (E) units. The similar trend was found in the $T_2$ and $T_3$. In $T_2$ (C) % increase was 253.70% and in $T_2$ (E) 309.25% from its initial mixture. Likewise in $T_3$ (C) % increase was 261.90% and in $T_3$ (E) the % increase was found to be 300.0 % from its initial mixture. The % increase was higher in $T_3$ (E) as compared to the $T_1$ and $T_2$ at the $60^{th}$ day. In the case of vermicomposting the enhanced number of micro flora present in the gut of earthworms

Table 1: Pattern of nutrient changes during the vermicomposting of paper mill sludge with different wastes using *Eisenia fetida* Treatment-1, ($T_1$)-1:1, (PMS+DW).

| Elements | Control and experimental unit | Initial day | 15th day | 30th day | 45th day | 60th day | % Increase and decrease |
|---|---|---|---|---|---|---|---|
| %N | $T_1$ C | 1.54±.03 | 1.62±.56 | 1.66±.04 | 1.67±.04 | 1.74±.03 | +12.98% |
| | $T_1$ E | | 1.65±.02 | 1.68±.05 | 1.72±.02 | 1.82±.04 | +18.18% |
| %P | $T_1$ C | 0.16±.02 | 0.24±.04 | 0.31±.04 | 0.34±.03 | 0.44±.02 | +175.0% |
| | $T_1$ E | | 0.23±.04 | 0.35±.03 | 0.43±.05 | 0.47±.05 | +193.75% |
| %K | $T_1$ C | 0.50±.02 | 0.50±.02 | 1.33±.04 | 1.50±.04 | 1.72±.03 | +244.0% |
| | $T_1$ E | | 1.23±.04 | 1.44±.04 | 1.72±.04 | 1.84±.04 | +268.0% |
| %OC | $T_1$ C | 22.18±.52 | 20.75±.47 | 20.89±1.7 | 18.23±.27 | 15.85±.21 | -28.53% |
| | $T_1$ E | | 16.41±.39 | 17.38±.12 | 16.80±.09 | 13.65±.13 | -38.45% |

Mean±SD of 3 observations, C-Control without earthworm, E-Experiment with earthworm

ANOVA: One way factor ( SPSS 12.0)

| Analysis of Variation | SS | df | MS | F | Sig. |
|---|---|---|---|---|---|
| %N Between Groups | .151 | 8 | .019 | 12.167 | .000 |
| Within Groups | .028 | 18 | .002 | | |
| %P Between Groups | .272 | 8 | .034 | 22.808 | .000 |
| Within Groups | .027 | 18 | .001 | | |
| %K Between Groups | 4.396 | 8 | .549 | 374.652 | .000 |
| Within Groups | .026 | 18 | .011 | | |
| %OC Between Groups | 182.724 | 8 | 22.841 | 56.118 | .000 |
| Within Groups | 7.326 | 18 | .407 | | |

Sig. Indicates the significance level of the F- test. [a $\leq$ 0.05]

a-significance level at 95%

Table 2: Pattern of nutrient changes during the vermicomposting of paper mill sludge with different wastes using *Eisenia fetida* Treatment-2, ($T_2$)-1:3, (PMS+DW).

| Elements | Control and experimental unit | Initial day | 15th day | 30th day | 45th day | 60th day | % Increase and decrease |
|---|---|---|---|---|---|---|---|
| %N | $T_2$ C | 1.54±.03 | 1.59±.07 | 1.67±.06 | 1.75±.03 | 1.84±.03 | +19.48% |
| | $T_2$ E | | 1.67±.06 | 1.75±.04 | 1.84±.03 | 2.11±.13 | +37.01% |
| %P | $T_2$ C | 0.19±.03 | 0.30±.07 | 0.39±.04 | 0.45±.03 | 0.52±.04 | +173.68% |
| | $T_2$ E | | 0.39±.20 | 0.52±.05 | 0.58±.04 | 0.69±.08 | +263.15% |
| %K | $T_2$ C | 0.54±.03 | 1.23±.03 | 1.47±.05 | 1.83±.43 | 1.91±.03 | +253.70% |
| | $T_2$ E | | 1.28±.03 | 1.53±.03 | 2.00±.95 | 2.21±.20 | +309.25% |
| %OC | $T_2$ C | 27.97±.23 | 24.03±.40 | 22.40±.37 | 18.90±.52 | 17.28±.63 | -38.21% |
| | $T_2$ E | | 18.60±.14 | 15.25±.26 | 13.60±.29 | 10.50±.25 | -62.45% |

Mean±SD of 3 observations, C-Control without earthworm, E-Experiment with earthworm

ANOVA: One way factor ( SPSS 12.0)

| Analysis of Variation | SS | df | MS | F | Sig. |
|---|---|---|---|---|---|
| %N Between Groups | .679 | 8 | .085 | 21.091 | .000 |
| Within Groups | .072 | 18 | .004 | | |
| %P Between Groups | .545 | 8 | .068 | 24.660 | .000 |
| Within Groups | .050 | 18 | .003 | | |
| %K Between Groups | 6.136 | 8 | .767 | 121.582 | .000 |
| Within Groups | .114 | 18 | .006 | | |
| %OC Between Groups | 706.192 | 8 | 88.274 | 620.855 | .000 |
| Within Groups | 2.666 | 18 | .142 | | |

Sig. Indicates the significance level of the F- test. [a $\leq$ 0.05]

a-significance level at 95%

Table 3: Pattern of nutrient changes during the vermicomposting of paper mill sludge with different wastes using *Eisenia fetida* Treatment-3,($T_3$) - 3:1 (PMS+DW).

| Elements | Control and experimental unit | Initial day | $15^{th}$ day | $30^{th}$ day | $45^{th}$ day | $60^{th}$ day | % Increase and decrease |
|---|---|---|---|---|---|---|---|
| %N | $T_3$ C | 1.51±.02 | 1.55±.04 | 1.62±.05 | 1.65±.03 | 1.70±.03 | +12.58% |
| | $T_3$ E | | 1.61±.06 | 1.66±.04 | 1.66±.03 | 1.78±.13 | +17.88% |
| %P | $T_3$ C | 0.13±.03 | 0.15±.03 | 0.23±.05 | 0.31±.03 | 0.35±.05 | +169.23% |
| | $T_3$ E | | 0.24±.20 | 0.28±.05 | 0.49±.04 | 0.43±.03 | +230.76% |
| %K | $T_3$ C | 0.42±.05 | 0.65±.03 | 0.72±.04 | 1.10±.43 | 1.52±.48 | +261.90% |
| | $T_3$ E | | 0.71±.03 | 1.23±.25 | 1.25±.27 | 1.68±.62 | +300.00% |
| %OC | $T_3$ C | 27.76±.03 | 21.06±.98 | 19.69±.09 | 13.74±.05 | 16.75±.04 | -19.31% |
| | $T_3$ E | | 19.72±.04 | 17.55±.17 | 18.58±.14 | 15.48±.25 | -25.43% |

Mean±SD of 3 observations, C-Control without earthworm, E-Experiment with earthworm

ANOVA: One way factor ( SPSS 12.0)

| Analysis of Variation | SS | df | MS | F | Sig. |
|---|---|---|---|---|---|
| %N Between Groups | .149 | 8 | .019 | 13.061 | .000 |
| Within Groups | .026 | 18 | .001 | | |
| %P Between Groups | .233 | 8 | .029 | 20.185 | .000 |
| Within Groups | .026 | 18 | .001 | | |
| %K Between Groups | 4.219 | 8 | .527 | 43.169 | .000 |
| Within Groups | .026 | 18 | .011 | | |
| %OC Between Groups | 147.481 | 8 | 18.435 | 125.241 | .000 |
| Within Groups | 2.650 | 18 | .147 | | |

Sig. Indicates the significance level of the F- test. [a $\leq$ 0.05].

a-significant level at 95%

plays an important role in this process resulting in increased potassium over the control [16]. The % of carbon decreased in all the treatment units including control and experimental units. The % Organic carbon content decreased as the decomposition progress [17]. The % decrease in organic carbon (C) content of $T_1$ (C) was 28.53 % and in $T_1$(E) was 38.45%. Similarly % decrease in $T_2$ (C) was 38.21 % and $T_2$ (E) 62.45%. In the same manner in $T_3$ (C) this % decrease was 19.31% and $T_3$ (E) was 25.43%.

## CONCLUSION

From the above study it has been concluded that 1:3 (Paper mill sludge + different waste) was more efficient in bioconversion of paper mill sludge and different wastes into nutrient rich vermicompost produced by *Eisenia fetida* than that of 1:1 and 3:1 because in these ratios mineralization could be decreased due to more concentration of paper mill sludge which had higher proportion of heavy metals, exerts toxicity and higher concentrations of paper mill sludge affected the population of microbes and microbial enzymes.

## REFERENCES


1. Edwards, C.A. and J.E. Bater, 1992. The use of earthworm in environmental management. Soil Biol. Biochem., 24: 1683-1689.
2. Senapati, B.K. and J.M. julka, 1993. Selection of suitable vermicomposting species under Indian conditions. In: Earthworm Resources and Vermiculture. Zoological Survey of India, Calcutta, pp: 113-115.
3. Garg, V.K. and P. Kaushik, 2005. Vermistabilization of textile mill sludge spiked with poultry droppings by epigeic earthworm Eisenia fetida. Bioresource Tech., 96: 1063- 1071.
4. Sinha, R.K., S. Herat, G. Bharambe and A. Brahambhatt, 2009. In: Vermistabilization of Sewage Sludge (Biosolids) by Earthworms: Converting a Potential Biohazard Destined for Landfill Disposal into a Pathogen Free, Nutritive and Safe Bio-fertilizer for Farms; J. of Waste Management and Research.
5. Das, K.C., E.W. Tollner and T.G. Tornabene, 2001. Composting by -products from a bleached kraft pulping process. Effect of type and amount of nitrogen amendments, Compost Sci. Util., 9(3): 256-265.

6. Bentize, E., R. Nogales, G. Masciandro and B. Ceccanthi, 2000. Isolation by isoelectric focusing of humic urease complex from earthworm *Eisenia foetida* processed sewege sludge. Biol. Fert. Soil. 31: 489-493.
7. Neuhauser, E.F., R.C. Loehr and M.R. Malecki, 1988. The potential of earthworms for managing sewage sludge. In: Edwards, C.A. Neuhasuer, E.F.(Eds.), Earthworms in Waste and Envirionmental Management.SPB Academic Publishing, The Hauge, pp: 9-20.
8. Dominguez, J., C.A. Edwards and J. Ashby, 2001. The biology and population dynamics of *Eudrilus eugeniae* (Kinberg) (Oligochaeta) in cattle waste solids. Pedobiologia. 45: 341- 353.
9. Suthar, S., 2006. Potential utilization of guargum industrial waste in vermicompost production. Bioresource Tec., 97: 2474-2477.
10. Trivedy, R.K. and P.K. Goel, 1986. In: Chemical and Biological methods for water pollution studies, (Environmental Publication). Karad, India.
11. Khwairakpam, M. and R. Bhargava, 2009. Vermitechnology for sewage sludge recycling. Journal of Hazardous Materials. 161(2-3): 948-954.
12. Khwairakpam, M. and R. Bhargava, 2009. Bioconversion of filter mud using vermicomposting employing two exotic and one local earthworm species. Bioresource Tech., 100: 5846-5852.
13. Suthar, S., 2009. Vermicomposting of vegetable market solid waste using Eisenia fetida: impact of bulking material on earthworm growth and decomposition rate. Ecological Engineering, 35: 914-920.
14. Suthar, S., 2009. Growth and fecundity of earthworms (Oligochaeta): Perionyx excavatus and Perionyx sansibaricusin cattle waste solid. Environmentalist, 29: 78-84.
15. Edwards, C.A. and J.R. Lofty, 1972. In: Biology of Earthworms. Chapman and Hall, London.
16. Kaviraj, A. and S. Satyawati. 2003. Municipal solid waste management through vermicomposting employing exotic and local species of earthworms. Bioresource Tech., 90: 169- 173.
17. Ananthakrishnasamy, S., S. Sarojini, G. Gunasekaran and G. Manimegala, 2009. Flyash - A Lignite Waste Management Through Vermicompostingby Indigenous Earthworms Lampito Mauritii. American-Eurasian J. Agric. and Environ. Sci., 5(6): 720-724.