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EARTHWORM DENSITY, BIOMASS AND VERMICOMPOST RECOVERY DURING AGRO-INDUSTRIAL WASTE TREATMENT

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ABSTRACT

The primary purpose of this study was to assess influence of cow dung and a biodynamic microbial consortium (*Jeevamrutha*) on the earthworm density, biomass and vermicompost recovery during the treatment of papermill and sugar factory sludge into beneficial product. The maximum earthworm net biomass, vermicompost recovery and earthworm density found in agro-industrial waste treated with Jeevamrutha and cow dung respectively. Furthermore, there was a significant relationship between earthworm density and biomass with treatment groups. The inoculation of microbial consortia like Jeevamrutha and cow dung to organic substrates significantly enhances the earthworm density, biomass and highest recovery of vermicompost during vermicomposting process.

KEYWORDS: **organic forming, biodynamic, earthworms, vermicompost, agro-industrial waste,**

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INTRODUCTION

Vermicomposting is a decomposition process involving interactions between earthworms and microorganisms. In this process the microorganisms are responsible for the biochemical degradation of organic matter whereas, earthworms act as crucial drivers of the process by fragmenting and conditioning the substrate, increasing surface area for microbiological activity and altering its biological activity dramatically[1]. Several workers modified the vermin-reactors by modifying the physical, chemical and biological characteristics during the process of vermicompost in order to enrich the nutrients, stabilization and to achieve in less duration. In the conventional vermin-reactors approximately 50% of the reactor volume consists of successive layers of sawdust, river sand and garden soil for the preparation of vermin-bed: leaving approximately 50% space for the reactor. Thus, only a small amount of composted solid waste can be accommodated on the vermin-bed. In order to utilize the full space of the verminreactor they have developed a new verminreactor by putting a thick moistened cotton cloth in the place of a thick vermin-bed so that a large space could be utilized for vermicomposting[2]. Tiwari *et al.,* reported that the inoculation of suitable cellulolytic and lignolytic strains has been reported to hasten the rate of composting, which in turn leads to the enrichment of nutrients in final product[3]. Pramanik *et al*. reported vermicompost from cow dung showed the highest nutrient content as well as enzymatic and microbial status. Lime addition in the vermi-bin was not significantly effective in terms of nutrient content as well as enzymatic activities of vermicompost, but combined effect of lime and some of the inoculated micro-organisms proved to have a significant effect on the quality of vermicompost[4]. Apart from these methods, some progressive farmers have developed biodynamic composting technologies. Steiner prescribed 9 different preparations to aid the fertilization of soil which are the cornerstones of biodynamic agriculture, and described how these should be prepared; he believed that these preparations transferred supernatural terrestrial and cosmic "forces" into the soil[5]. These prepared substances are numbered 500 through 508, out of which formulation-500 (cow horn compost) and formulation-501 (horn-silica) are very popular and are being used by a large number of organic farmers in India. Formulations-502 to 507 are used as compost enrichers and promoters[6]. Similarly, Subhash Palekar is one of the progressive farmers of Maharashtra, India; in his workshop on "Philosophy and Technology of Zero Budget Natural Farming he used a new biodynamic formulation termed Jeevamrutha[7]. Vanaja *et al*. stated that Jeevamrutha is a plant growth-promoting substance containing beneficial microorganisms that provides the necessary nutritional requirement for growth and yield of a crop. Microorganisms are well activated in soil following the addition of Jeevamrutha which also maintains soil productivity[8]. Manjunatha *et al.* reported that the use of Jeevamrutha treated organics, improves the physico-chemical and biological properties of soil, besides improving the efficiency of applied farmyard manure. They also confirmed that the potential of Jeevamrutha is to supply materials and to act as food support for beneficial microbes[9]. In view of the above, the current study focused on determining the influence of microbial inoculants such as conventional cow dung and a biodynamic formulation i.e., Jeevamrutha, on earthworm biomass, density and recovery of vermicomposting.

MATERIALS AND METHODS

Agro-Industrial wastes such as press dug and press mud were obtained from industries (Mysore Paper Mill and Sugar Factory) located in Bhadravathi town, Karnataka, India. Other substrates like areca nut husk, cow dung and earthworms *Eudrilus eugeniae* (Kinberg) were collected from local sources of Bhadravathi taluk. The vermicomposting experiment was conducted in the laboratory. The materials used for composting such as press dug, press mud, areca nut husk and cow dung and their moisture content up to 60-80 % and also temperature of 25 to 28°C was maintained by supplying sufficient quantity of water.Jeevamrutha was prepared with thoroughly mixing 125 g of cow dung, 125 ml of cow urine, 25 g of dicotyledonous seed (mung bean, *Phaseolus mungo*) powder, 250 g of old jaggery (obtained from the jaggery house, Bhadravathi town), 1 handful of fertile soil and 2.5 L of tap water. Finally the total solution measure about 2.5 L. The mouth of the solution containing bucket was covered with wet gunny cloth and this bucket placed in the dark condition for 72 h. The content was mixed thoroughly with a wooden stick every 24 h. After the 72-h incubation period the solution was stored in a polythene bottle at 4°C until further use[10].After two days microbial cultures (Cow dung and Jeevamrutha) were introduced to agricultural residues. The proportions of agricultural residues used for preparation of different treatments were given in the Table 1. The control treatment made by without inoculating microbial culture and earthworms', Treatment T1 without microbial cultures inoculation but after partial decomposition earthworms were introduced. The microbial cultures like cow dung and Jeevamrutha inoculated to treatments T2 and T3 respectively and after the confirmation of partial decomposition of substrates earthworms were introduced. The all composting beds were maintained in rectangular plastic polystyrene tubs measuring 0.45 m × 0.30 m × 0.15 m (length × width × depth) at triplicates.

Table 1
Treatment for rapid vermicomposting process

Treatment	Ingredients	Weight (kg)	Total weight (kg)
Control	AH + PD + PM	0.5 + 2 + 2	4.5
T1	AH + PD + PM	0.5 + 2 + 2	4.5
T2	AH + PD + PM + CD	0.5 + 2 + 2 + 0.5	5.0
T3	AH + PD + PM + J	0.5 + 2 + 2 + 45 ml	4.5

where, AH = areca nut husk; PD = press dug; PM = press mud, J = *jeevamrutha*; CD = cow dung.
The growth rate of earthworms was recorded by calculating the quotient of the difference obtained from the initial total count of worms and the total number of living worms at the end of the study divided by the experimental time period[11].

$R = (N2 – N1)/ T$ ----- (4.1)

where, R = Growth rate, N1 = Total number of initial worms, N2 = Total number of living worms by the end of time T, T = Time period of the experiment in days The results of the present study was evaluated using statistical software SPSS, var.12. Paired sample *t*- test used to compare the characteristics of vermicompost between the control and other treatment groups. The probability levels used for statistical significance were $P < 0.05$ for the tests[12].

RESULTS AND DISCUSSION

1. Earthworm density

The maximum density (35.33 ± 3.06) and growth rate (1.18 ± 0.04) of earthworms were observed in treatments treated with cow dung (T2), followed by jeevamrutha treated group (24.00 ± 2.65 and 0.80 ± 0.00) and minimum density (19.33 ± 2.89) and growth rate (0.64 ± 0.04) noticed in treatments (T1) without any microbial consortium inoculation (Table 2). At the end of the vermicompost process analysis of variances of mean earthworm density showed significant ($F = 84.937$ and $P = 0.000$ at $\alpha \leq 0.05$) differences among the treated composting beds. The earthworm density was recorded highest in treatment T2, because the content of nitrogen was higher in treatment T2 compared to all other treatments. Suthar summarized that the factors relating to the growth of earthworms may also be considered in terms of physiochemical and nutrient characteristics of waste feed stocks. Thus organic waste palatability for earthworms is directly related to the chemical nature of the organic waste that consequently affects earthworm growth parameters[11].

Table 2
Earthworm density (no) during vermicomposting process

Treatment	Initial density	Final density	Net density achieved	Growth rate
T1	43.00 ± 1.00	62.33 ± 2.08	19.33 ± 2.89	0.64 ± 0.04
T2	50.00 ± 2.00	85.33 ± 3.06	35.33 ± 3.06	1.18 ± 0.04
T3	42.33 ± 1.53	66.33 ± 1.53	24.00 ± 2.65	0.80 ± 0.00

2. Earthworm biomass

Table 3 encapsulates the total earthworm biomass data of *E. eugeniae.* The maximum (38.67 mg) net biomass of *E. eugeniae* was found in T3 i.e., organic substrates treated with Jeevamrutha after 21 days of inoculation. Followed by treatments treated with cow dung T2 (35 mg) and without treatment replicate showed the less earthworm biomass i.e., 30.67 mg. Suthar hypothesized that quality of substrate/bedding or even fluctuating temperature range (at room condition) or both might be responsible for attaining maximum biomass. Another factor like microbial density also contributes the increase in earthworm biomass[13]. This observation supported by Carpenter-Boggs *et al*. reported the biodynamic preparations alters microbial community during dairy manure composting and from the higher microbial biomass recorded in biodynamically managed field plots than in organically managed plots[14]. In this study also observed similar results i.e., biodynamically (jeevamrutha) treated treatments showed higher microbial density as well as earthworms' biomass. The analysis of mean biomass variance among the treatment groups showed significant difference (F = 221.033 and P = 0.000 at $\alpha \le 0.05$). In this study reported the maximum increase in earthworm biomass compared to the earlier reports like Hallatt *et al*.[15], Reinecke *et al*.[16] and Edwards *et al*.[17]).

Table 3
Earthworm biomass (gm) during vermicomposting process

Treatment	Initial Biomass (mg)	Final Biomass (mg)	Net Biomass Gained (mg)
T1	45.00 ± 0.00	75.67 ± 0.58	30.67 ± 0.58
T2	50.00 ± 0.00	85.00 ± 1.00	35.00 ± 1.00
T3	45.00 ± 0.00	83.67 ± 1.53	38.67 ± 1.53

3. Vermicompost Recovery

Table 4 showed the recovery of vermicompost from the different treatments, the maximum (95.55%) vermicompost recovered from Jeevamrutha treated treatment (T3), followed by cow dung treated treatment T2 (93.00%) and the lowest (95.55%) recovered from the without microbial inoculated treatment (T1). The Jeevamrutha treated group had higher microbial density, hence earthworms gets more food compare to all other treatments therefore this treatment supported the earthworm growth. Earthworms feed more waste and released highest vermicompost. These findings supported by Zaller and Kopke results; they stated that the application of biodynamically prepared compost can significantly alter decomposition rates in soils[18]. Mader *et al*. reported that the organic and biodynamic treatments also showed a greater microbial activity and a greater potential than the conventional treatments to mineralise organic compounds[19]. Microflora in the intestine of worms and gut enzymes, as well as microflora present in the feed, are involved in the decomposition as stated by Whiston and Seal[20] and Kavian and Ghatneker[21]. The recovery of vermicompost from cow dung treated group also meagerly higher, because the density of earthworms higher compared to all other exposed treatment groups. The study indicated the rapid production of compost easily achieved by composting followed by vermicomposting with the incorporation of microbial consortium (cowdung or Jeevamrutha) to organic substrates. The similar results were reported by Singh and Sharma (2002) and they stated the role of bioinoculants i.e., *Pleurotus sajorcaju*, *Trichoderma harzianum, Aspergillus niger* and *Azotobacter chroococcum,* in pre-decomposition of a mixed solid waste and horticulture waste (70:30) for it's subsequent vermicomposting and observed that this system not only improved the quality of product but also reduced stabilization period[22]. James *et al*. stated that combining vermicomposting with existing green waste composting operations would seem to be useful in at least two respects; (i) the addition of vermicomposting enhances the stabilisation of green waste compared to composting alone; (ii) the initial thermophilic stage of windrow composting should result in effective pathogen control which vermicomposting alone may not achieve[23]. The total duration taken for the complete decomposition of agricultural wastes of this study; moistening of collected organic substrates 2 days, pre decomposition 15 days and vermicomposting process 21 days totally 38 days.

Table 4
Recovered vermicompost (gm) (Mean ± SD) from the different vermicomposting treatments

Treatment	Initial Substrate (gm)	VC Recovered (gm)	VC Recovered (%)
T1	4500 ± 12	4050 ± 26	90.00
T2	5000 ± 09	4650 ± 18	93.00
T3	4500 ± 06	4300 ± 31	95.55

CONCLUSION

The present study deals with the vermicomposting of agro industrial residues and crop harvest wastes in laboratory condition along with inoculation of microbial cultures. Inoculation of cow dung and microbial consortium like Jeevamrutha enhances the earthworm biomass, density and also higher recovery of vermicompost. Formers and vermicomposting industries can replace the cow dung with Jeevamrutha where lack of sufficient quantity of cow dung.

ABBREVIATIONS

AH, areca nut husk; CD, cow dung; cfu, colony forming unit; EM, effective microorganism; PD, press dug; PM, press mud

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