Journal of Research in Ecology

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# Capacity of fly ash and organic additives to support adequate earthworm biomass for large scale vermicompost production

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**ABSTRACT:**

To investigate the feasibility of utilization of vermiculture technology for large scale production of vermicompost from Fly Ash (FA) mixed with Press Mud (PM), Cow Dung (CD) and Crop Residue (CR) employing earthworms *Eudrilus eugeniae* and *Lampito mauritii*. Eight treatments namely FA alone ($T_1$), 1 part FA: 1part CD ($T_2$), 1 part FA: 1part PM ($T_3$), FA: 1 part FA: 1part CR ($T_4$), 1 part FA: 1part CD: 1part PM ($T_5$), 1 part FA: 1part CD: 1part CR ($T_6$), 1 part FA: 1part PM: 1part CR ($T_7$) and 1 part FA: 1part CD: 1part PM: 1part CR ($T_8$) were run under laboratory conditions. The growth and reproduction of earthworms in terms of biomass gain, cocoon and hatchlings production were measured at the end of experimentation. The data revealed that earthworms were unable to survive in 100% FA ($T_1$) treatment. However, Maximum worm biomass was observed in $T_5$ treatment than other treatments. Maximum cocoons and hatchlings production were also recorded in $T_5$ treatment for both species of worms. This study clearly indicates that fly ash amended with pressmud and cow dung in 1:1:1 ratio had no adverse effect on the growth and reproduction of *E.eugeniae* and *L.mauritii* as well as large scale vermicompost production.

**Keywords:**

*E. eugeniae, L. mauritii,* Cocoons, hatchlings, pressmud, cow dung.

**Article Citation:**
**Anbalagan M and Manivannan S.**
Capacity of fly ash and organic additives to support adequate earthworm biomass for large scale vermicompost production.
Journal of Research in Ecology (2012) 1: 001-005

**Dates:**
**Received:** 27 Dec 2011 /**Accepted:** 12 Jan 2012 /**Published:** 25 Jan 2012





Journal of Research in Ecology

## INTRODUCTION

Vermiculture is practiced for the mass production of earthworms with the multiple objectives of waste management, soil fertility, soil detoxification and vermicompost production for sustainable agriculture. The feasibility of using earthworms for waste management as well as a potential source for protein for animal nutrition depends on a fundamental knowledge of the basic parameters governing the survival, growth and reproduction of earthworm species. The reproductive potential of earthworms was influenced by the quality and availability of food (Bhattacharjee, 2002). Growth, reproduction and life cycle of different species of earthworms using different materials such as sludge and horse manure (Neuhauser et al, 1979), mixture of animal and vegetable wastes (Loher et al, 1985), sludge from paper and pulp industries (Elvira et al, 1998), pressmud (Parthasarathi and Ranganathan, 2000; Khwairakpam and Bhargava, 2009), paper waste (Gajalakshmi et al, 2001) and kitchen wastes (Adi and Noor, 2009) have been studied. Ramalingam (1997) has studied the growth, reproduction and life cycle of *L.mauritii* cultured in pressmud. *L.mauritii* with a wide choice of habitat and food preference that has the highest frequency of distribution, which are able to withstand wide range of temperature, soil moisture and various other physical factors (Kale and Bano, 1992).

In India, about 80 million metric tons of fly ash is generated annually from thermal power stations with only a minor part used now for preparing bricks, ceramics and cements. Unclaimed fly ash occupies an additional 100ha of land every year. Through washouts in each rainy season adjacent areas, including rice fields, inevitably become contaminated, thus potentiating grave problems (Mishra et al, 2007). Sugarcane mills mainly use activated sludge process for waste water treatment, which generates huge quantity of sludge commonly known as pressmud (Sangwan et al, 2008). Parthasarathi (2006) has reported approximately that 12 million tons of pressmud are produced in India annually. Pressmud generates intense heat (65°C), foul odour and takes long time for natural decomposition (Sen and Chandra, 2007) and its high rate of application to soil leads to soil sickness and water pollution (Bhawalkar and Bhawalkar, 1993). Pressmud has significant fertilizer value as it is a rich source of organic matter, organic carbon, sugar, protein, enzymes, micronutrients (Zn, Fe, Cu, Mn, etc.) and macronutrients (N, P and K) and higher microbial population (Prakash and Karmegam, 2010). However in the context of tropical countries, particularly India, our knowledge of the right type of food for the right type of earthworm for large-scale vermiculture, a prerequisite for vermicomposting, is inadequate. It is intended to test whether these wastes could be used for vermiculture and vermicomposting. The objectives of the present study is to determine the best mixture combinations of fly ash, pressmud, cow dung and crop residue that would support the maximum production of cocoons, rate of hatchlings and growth in epigeic and anecic worms like *E.eugeniae* and *L. mauritii*.

## MATERIALS AND METHODS

Collection of Fly ash, pressmud, cow dung, crop residue and earthworms: Fly Ash (FA) was procured from the dumping site of thermal power station I, Neyveli Lignite Corporation (NLC), Tamil Nadu, India. Press Mud (PM) was obtained from effluent treatment plant of E.I.D. Parry Sugar Mill located at Nellikkuppam, Tamil Nadu, India. Fresh Cow Dung (CD) and Crop Residue (CR) were collected from the agricultural farm, Faculty of Agriculture, Annamalai University, Tamil Nadu, India. The main physico-chemical characteristics of FA, PM, CD and CR are given in **Table 1.** The earthworms *Eudrilus eugeniae* and *Lampito mauritii* ware cultured in the laboratory and were randomly picked for experimentation.

Treatment design: Fly Ash (FA) alone and in combination with Press Mud (PM) Cow Dung (CD) and Crop Residue (CR) were used as substrate for the studies. The PM and CD were dried in air at room temperature. FA was mixed with PM, CD and CR in different ratios in order to produce different

**Table 1. Physico- chemical characteristics of FA, PM, CD and CR**

| S. No | Parameter | FA | PM | CD | CR |
|---|---|---|---|---|---|
| 1 | pH | 8.8 | 7.3 | 8.1 | 7.5 |
| 2. | EC($dSm^{-1}$) | 0.75 | 1.19 | 1.21 | 1.05 |
| 3. | TOC($gkg^{-1}$) | 297.9 | 445.7 | 429.7 | 432.5 |
| 4. | TN($gkg^{-1}$) | 3.21 | 12.13 | 6.53 | 5.11 |
| 5. | TP($gkg^{-1}$) | 2.41 | 6.12 | 6.81 | 4.29 |
| 6. | TK($gkg^{-1}$) | 5.33 | 8.25 | 5.12 | 6.23 |
| 7. | Ca($gkg^{-1}$) | 15.15 | 44.31 | 31.23 | 35.52 |
| 8. | Mg($gkg^{-1}$) | 9.13 | 18.51 | 15.60 | 9.53 |
| 9. | Zn($mgkg^{-1}$) | 98.32 | 231.46 | 215.31 | 169.53 |
| 10 | Fe($mgkg^{-1}$) | 218.64 | 310.87 | 235.31 | 239.57 |
| 11 | Cu($mgkg^{-1}$) | 21.17 | 47.15 | 59.35 | 36.27 |

treatments (dry weight proportion). The composition of FA, PM, CD and CR in different treatments are described in **Table 2.** One kg of substrate material was added to each circular plastic container (Vol. 10L, diameter 38cm, depth 14cm) for experimental trial. All the treatments were kept for 21 days prior to experimentation for thermal stabilization, initiation of microbial degradation and softening of substrate material (pre-composting).

Twenty clitellated earthworms, *E.eugeniae* and *L.mauritii* were inoculated into each treatment, separately after 21 days of pre-composting. During the vermicomposting period, the moisture content of the substrate in each treatment was kept at 70 – 75% by periodic sprinkling of adequate quantity of water. The experimental treatments were kept in triplicate. Earthworms growth related parameters like biomass gain, cocoons and hatchlings production and total mortality were measured at the end of the vermicomposting process. The earthworm biomass gain was determined as live weight, taken after rinsing the adhering material off the worms and blotting them dry. Statistical analysis was carried out using SPSS11.0.1 computer software package. One way analysis of variance (ANOVA) was done to analyse the significant difference between treatments.

**Table 2. The composition of fly ash and other organic waste**

| S.No | Treatments | Composition[a] |
|---|---|---|
| 1 | $T_1$ | FA alone |
| 2 | $T_2$ | 1 part FA :1part CD |
| 3 | $T_3$ | 1 part FA :1part PM |
| 4 | $T_4$ | 1 part FA :1part CR |
| 5 | $T_5$ | 1 part FA :1part CD:1part PM |
| 6 | $T_6$ | 1 part FA :1part CD :1part CR |
| 7 | $T_7$ | 1 part FA :1part PM :1part CR |
| 8 | $T_8$ | 1 part FA :1part CD:1part PM :1part CR |

[a] **dry weight basis, FA-Fly ash; CD-Cow dung; PM-Pressmud; CR-Crop residue**

## RESULT AND DISCUSSION

The biomass production by *E. Eugeniae* and *L. mauritii* in different treatments has been given in **Tables 3 and 4.** In this study maximum worm biomass was observed in $T_5$ treatment (FA+PM+CD in 1:1:1ratio) and lowest in $T_4$ treatment (FA+CR in 1:1 ratio) for both species of worms. The growth rate (mg weight gained day$^{-1}$ earthworm$^{-1}$) has been considered as a good comparative index to compare the growth of earthworms in different feeds (Edwards et al, 1998). In the present study addition of CD in the substrates resulted in an increase in biomass of *E. eugeniae* and *L. mauritii.* Growth and reproduction in earthworms require OC, N and P which are obtained from litter, grit and microbes (Edwards and Bohlen, 1996). Earlier studies of Parthasarathi and Ranganathan (1999) have shown the higher nitrogen (1.6%) and phosphorus (2.5%) content of pressmud to support better growth (length and biomass) and bring about earlier maturation, earlier differentiation of the clitellum, lobulation in the ovary and release of cocoons in *L. mauritii* and *E. eugeniae* than worms fed with cowdung or clay loam soil.

The cocoon production by *E. eugeniae* and *L. mauritii* in different treatments is given in Table 3 and 4. After vermicomposting maximum cocoons (195.15±7.3 in *E. eugeniae* and 112.3±9.5 in *L. mauritii*) were counted in $T_5$ treatment (FA+PM+CD in 1:1:1ratio) than other treatment. Similarly the maximum number of hatchling (171.11±7.2 in *E. eugeniae* and 88.4±5.7 in *L. mauritii*) were produced in $T_5$ treatment (FA+PM+CD in 1:1:1ratio) and minimum (27.4±3.2 in *E. eugeniae* and 20.4±2.1 in *L. mauritii*) in $T_4$ treatment (FA+CR in 1:1 ratio). The difference between the rates of cocoons and hatchlings production in different treatments could be related to the nutrient quality of the feed mixtures, which is one of the important factors in

**Table 3. Growth and reproduction of *Eudrilus eugeniae* in different treatments of fly ash and other organic waste mixture.**

| Treatment | Mean initial biomass of individual earthworm(mg) | Maximum individual biomass achieved(mg) | Total number of cocoons at the end | Total number of hatc hlings production |
|---|---|---|---|---|
| $T_1$ | 319.21±13.5 | - | - | - |
| $T_2$ | 320.19±20.1 | 867.25±28.5 | 147.21±11.5 | 82.13±8.0 |
| $T_3$ | 317.15±15.3 | 859.18±19.4 | 130.18±5.3 | 75.11±5.1 |
| $T_4$ | 320.17±11.9 | 765.23±26.5 | 95.11±4.3 | 27.4±3.2 |
| $T_5$ | 320.21±7.5 | 987.29±32.3 | 195.15±7.3 | 171.11±7.2 |
| $T_6$ | 319.14±9.2 | 962.37±18.5 | 172.29±5.2 | 143.16±7.6 |
| $T_7$ | 323.25±16.5 | 965.41±41.7 | 181.18±9.6 | 147.11±2.7 |
| $T_8$ | 321.15±11.2 | 981.27±21.5 | 190.17±4.2 | 160.13±5.3 |

**Table 4. Growth and reproduction of *Lampito mauritii* in different treatments of fly ash and other organic waste mixture.**

| Treatment | Mean initial biomass of individual earthworm (mg) | Maximum individual biomass achieved(mg) | Total number of cocoons at the end | Total number of hatchlings production |
|---|---|---|---|---|
| $T_1$ | 305.8± 5.3 | - | - | - |
| $T_2$ | 309.3±10.5 | 735.5±19.8 | 81.6±7.5 | 43.7±7.4 |
| $T_3$ | 307.3± 9.8 | 718.3±35.3 | 73.5±4.3 | 35.6±3.5 |
| $T_4$ | 310.4± 7.3 | 690.3±19.7 | 42.3±9.5 | 20.4±2.1 |
| $T_5$ | 310.5±11.5 | 827.7±15.3 | 112.3±9.5 | 88.4±5.7 |
| $T_6$ | 306.7± 6.1 | 805.9±27.6 | 90.8±8.4 | 71.3±5.5 |
| $T_7$ | 308.6±13.4 | 801.7±40.1 | 89.5±3.1 | 55.6±3.1 |
| $T_8$ | 308.4± 4.2 | 815.5±21.5 | 101.4±7.1 | 75.6±6.2 |

determining the onset of cocoon production (Gupta et al, 2007). 100% mortality was observed in $T_1$ treatment (FA alone) during the study period after 69 days of experimentation. The FA alone treatment ($T_1$) was unable to support growth and reproductive success of both species of worms. The dependency of earthworm on soil moisture for their survival and activity and on organic matter rich in N for growth and reproduction is well known (Edwards and Bohlen, 1996). The physical structure of the substrate material depends on the chemical composition of the constituents particularly organic matter rich in N; it is only in such type of soil / medium that earthworms could reproduce (Manivannan, 2004). In the present study $T_5$ treatment provides such ideal physico-chemical conditions suitable for maximum reproduction. Hence it may be concluded that the enhanced reproduction shown by enhanced cocoon production and hatchability rate of earthworms in the $T_5$ treatment in the present study seems to be due to rich nutrient content, microbial population and activity and the enhanced water holding capacity which enable the substrate to maintain good and ideal moisture.

## CONCLUSION

The present study substantiated the feasibility of utilization of fly ash in vermiculture process. The results showed that maximum earthworm biomass and reproduction was observed in the $T_5$ treatment (1:1:1 ratio of FA+PM+CD) which was significantly higher from all other treatments. Hence, it was concluded that this study provides a platform for the utilization of fly ash amended with pressmud and cow dung for the process of large scale vermicompost production. Further studies are required to explore the potential of utilization of fly ash vermicompost in soil fertility and crop productivity.

## ACKNOWLEDGEMENT

The authors are very thankful to the University Grants Commission (UGC, New Delhi) for the financial support in the form of a Major Research Project (2010-2013) and also we thank Prof. Dr. M. Sabesan for encouragement.

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