Biodegradation of paper waste using Eisenia foetida by vermicomposting Technology

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Abstract. The paper wastes are being a big concern over past decades. The process of reuse of the paper wastes is employed by ‘eisenia foetida’ in Vermiculture. The paper waste in SASTRA is collected around 50kg and organic wastes like vegetable wastes and cow dung wastes are also collected. In the adjacent area of Nirman Vihar, SASTRA, the experimental setup is done in a Geo-synthetic polymer bag. The area is divided into three segments and in each segment appropriate amount of paper waste and organic waste were added along with 25 numbers of earthworms. The setup is watered daily and monitored periodically and it is kindled for proper aeration. The soil samples were collected on 20 days, 45 days and 60 days from the day the earthworms were added. After 60 days of the experiment, the paper wastes, compost and earthworms are separated. The quantity of the wastes was compared to the initial amount and the composts are collected. The elemental analysis of the soil used as Vermi-bed is analyzed for improvement of soil nutrients. The vermiwashed water of the setup is analyzed for total protein. The number of earthworm is also compared to initial quantity. Out of all, the loss percentage of the organic waste and paper waste shows the degradation of the paper wastes.

1. Introduction
Aristotle has said before 2350 years, “Earthworms are intestines of the earth”. Only in the twentieth century has the truth in this statement been verified and found correct[1]. Vermiculture is principally the science of breeding and raising earthworms. It defines the stimulating potential for waste reduction, fertilizer production, as well as an assortment of possible uses for the future. The population of the earth is increasing and with this increase comes an increased need for management of wastes especially paper wastes[2]. The process of waste paper recycling involves mixing used paper with water and chemicals to break it down. The share of ink in a wastepaper stock is up to about 2% of the total weight. The fundamental specifications of the experiment are re-cycle of paper, food wastes, environmental wastes, vermin-compost, enormous power of reproduction, rapid rate of multiplication, production of bio-mass[3]. From the environmental perspective, paper wasting is important as systematic collection and recycling of waste paper can significantly reduce the generation of municipal solid wastes. It is estimated to be around tons of waste paper recycling can lead to saving of mammoth part of raw materials and energy. The tiger Worm (eisenia foetida) is best suited for vermiculture researches and vermin-treatment for solid and liquid organic wastes. The earthworms are bisexual and so rapidly multiply[4]. Many studies found out that, earthworms double themselves within 60 days with respect to the environment they live in. The castings let out by earthworms are accountable for the change in soil nutrition[5]. So, they can be considered a nutritive plant food since it enriches the
basic nutrition like nitrogen, potassium, phosphorus and proteins too. The production of worm bio-
mass can be considered pro-biotic feed for fishery, poultry[6]. The main objective of the proposed
work is to study on the Bio-conversion of paper wastes through the process of Vermin-compost,
employing earthworm eisenia foetida with organic wastes like cattle dung and vegetable wastes to
stabilize the nutrient requirements and hasten the decompose of paper.

2. Materials and Methods

2.1. Materials Used

The following materials were utilized for this study

(i) Geosynthetic bag: A geo-synthetic polymer bag can accommodate a space of 4’*3’1’ to
evenly distribute for each pit of size 4’*1’*1’.

(ii) Soil: Concerning for finding optimum conditions for agricultural purpose, Sandy soil
(evacuated to a depth of 500cm to maintain chemical characteristics of the soil) is collected in
SASTRA University, Thanjavur, Tamil Nadu. In the allotted space, soils are filled for a height
of 15cm to act as Vermi-bed for the earthworms.

(iii) Earthworms: ‘eisenia foetida’ – Of 25 numbers weighing 25g are collected in Vallam, Tamil
Nadu. Each earthworm individually varied between 0.05g to 1.5g.

(iv) Wastes:
- Paper waste: 50kg of paper wastes are collected from SASTRA UNIVERSITY BOYS
  HOSTEL and cut down into pieces with the help of cutting machines in School Of
  Mechanical Engineering in SASTRA. 13.5kg is filled in each pit.
- Cow dung wastes(organic): 21kg of cow dung is collected in dairy farm, SASTRA
  University.
- Vegetables wastes(organic): 21kg of Vegetable waste is collected from Paramanadha
  Vihar and Kamadhenu hostel, SASTRA University.

(v) Shelter: A sheet of plastic mesh is used to cover the experimental setup in order to prevent
from predators and pests.

2.2. Methodology Adopted

Table 1. Test Programme

| Test Programme                                                                 |
|-------------------------------------------------------------------------------|
| In this pit, first layer is vermi bed of height 15cm and 25 earthworms are spread over the bed[7]. Then, Paper wastes of 13.5kg are spread over and cow dung wastes of 13.5kg are also added. The setup should not be compressed in order to maintain good aeration inside the setup. |

| Test Programme                                                                 |
|-------------------------------------------------------------------------------|
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In this pit, first layer is vermi bed of height 15cm and 25 earthworms are spread over the bed. Then, Paper wastes of 13.5kg are spread over and Vegetable wastes of 6.75kg and cow dung wastes of 6.75kg are mixed and spread above the paper wastes. The setup should not be compressed in order to maintain good aeration inside the setup.

Soil characteristics and nutrients contents
The soil characteristics such as Calcium Carbonate, electrical conductivity, pH and nutrient contents such as nitrogen, phosphorus, potassium, iron, manganese, zinc and copper are found for 0\textsuperscript{th} day, 20\textsuperscript{th} day, 45\textsuperscript{th} day and 60\textsuperscript{th} day in Rice Research Institute, Aadudhurai, Tamil Nadu.

Bio-chemistry auto analyzer for total protein
The total protein from the vermi-washing fluid of the earthworms is found from auto analyzer.

Growth comparisons
The physical properties of the earthworms are noted down on 0\textsuperscript{th} day and 60\textsuperscript{th} day to measure the intensity changes in the number and weight in each pit.

Weight loss on organic substrate
The difference in the weight of the organic substrates from initial and final stages shows the weight loss considering the fact that earthworm takes on in building its body[8].

3. Results and Discussion

| Contents      | 0\textsuperscript{th} day | PIT-1 | PIT-2 | PIT-3 |
|---------------|---------------------------|-------|-------|-------|
| TEXTURE       | Sandy clay                | Sandy clay | Sandy clay | Sandy clay |
| CaCO\textsubscript{3} | No                        | No    | No    | No    |
| EC            | 0.35                      | 0.18  | 0.26  | 0.21  |
| pH            | 6.7                       | 8.7   | 8.6   | 8.6   |
| Sodic land    | 500                       | 500   | 500   | 500   |
| N             | 32.2                      | 60.2  | 77    | 40.6  |
| P             | 117                       | 35    | 35    | 45    |
| K             | 325                       | 90    | 95    | 85    |
| Fe            | 3.89                      | 0.87  | 0.87  | 1.6   |
| Mn            | 2.0                       | 2.64  | 2.88  | 1.4   |
| Zn            | 0.8                       | 0.72  | 0.89  | 0.3   |
| Cu            | 1.21                      | 1.54  | 1.35  | 0.33  |
3.1. Impact of pH on soil:

- The accessibility of the micronutrients zinc (Zn), iron (Fe), manganese (Mn), copper (Cu) and boron (B) be likely to reduce as soil pH increases[9].

- Studies have shown that pH declination is occurring in the recent years rapidly in direct seeded land and continuously cropped land[10]. Seepage of alkaline salts can increase the pH above the optimum range. So, nowadays the pH of the soil with an optimum range could be too acid or alkaline.

3.2. Biochemistry auto-analyzer results for total protein:

Vermiwash, a liquid bio-fertilizer that is collected through the column of activated earthworm[11]. The vermiwashed fluid is given for Bio-chemistry Auto analyzer to find the total protein contents after 60th day is shown in the Table 3.

| Total Protein in vermin washwater | Sample 1 | Sample 2 | Sample 3 |
|----------------------------------|----------|----------|----------|
| Vermiwash                        | 0.52     | 0.55     | 0.56     |

The reason for increased total protein content in vermin wash is due to the presence of photolytic enzymes, which are secreted in earthworms gut.

3.3. Growth comparisons of earthworms:

The earthworms coming out of the cocoon will be of size 0.02cm and within 5 to 6 weeks earthworms mature to the size of 18cm approximately[12]. Earthworms start reproduction by the week of second. At the end of 60th day, composts are separated and earthworms are harvested. Total number of earthworms in each pit is calculated and mentioned in the Table 4.

| Number of earthworms in each pit | PIT 1 | PIT 2 | PIT 3 |
|----------------------------------|-------|-------|-------|
| Total number                     | 136   | 214   | 432   |
| Total weight (g)                 | 108.8 | 175.5 | 341.3 |
| Initial weight (g)               | 22.2  | 21.1  | 24.7  |
At the end of 60\textsuperscript{th} day, 25 numbers of earthworms in each pit has risen to 136, 214 and 432 respectively. And the difference between the initial weight and final weight of earthworms shows the tremendous increase in population\cite{13}.

3.4. Impact of vermicomposting on weight loss of organic substrate

Paper wastes and organic wastes were separated from the set up and the loss percentage is calculated from the final weight attained on the 60\textsuperscript{th} day.

| Type of waste | Initial Weight of Substrate (kg) | Final weight (kg) | Loss % |
|---------------|---------------------------------|-------------------|--------|
| Paper Waste   | Pit 1 13.5 Pit 2 13.5 Pit 3 13.5 | Pit 1 11.6 Pit 2 10.2 Pit 3 8.6 | Pit 1 14.1 Pit 2 24.4 Pit 3 36.3 |
| Organic waste | Pit 1 13.5 Pit 2 13.5 Pit 3 13.5 | Pit 1 1.45 Pit 2 5.8 Pit 3 76.6 | Pit 1 89.2 Pit 2 42.9 |

In the comparison, paper wastes are decreased of 36.3\% in PIT 3. Because, the variety of foods is more in PIT 3 comparing to PIT 1 and PIT 2. The bacteria in the decaying process of vegetables will be multiplied in numerous amounts and hence, the other wastes are also easily decayed and appeared to be abundant food for earthworms\cite{14}. So, the number of earthworms has also increased in more numbers. In PIT 3, the organic wastes loss percentage seems to be less comparing to the other three, because the lost quantity are converted into compost.

In the PIT 2, the loss percentage of organic wastes is very high, because, vegetables are always comprised of 80\% to 95\% of water content. And, the loss percentage of paper wastes is also in reasonable quantity. In PIT 3, the loss percentage of organic wastes is medium and paper wastes less comparing to the other two PITS\cite{15}.

4. Conclusion

Taking worms out of earth and placing them in the vermi beds is a human responsibility. With their own unique needs, they live under the earth. So it is important to provide healthy habitat to do their work. Providing the right conditions for the worms will thrive and ensure us excellent results. Vermiculture and vermicomposting is a substantial way of reducing paper and organic wastes. The process is capable of producing high quality fertilizers and also maintaining the balance of the ecological environment.
In this experiment, from the results of organic substrate loss percentage, pH change, growth comparisons, biochemistry analysis and soil characteristics, we can infer that

- The second combination, vegetable waste and paper waste is best suitable for improving paper degradation and also helps in soil enriching.
- The third combination, can be exclusively used for harvesting earthworms as it shows enormous growth in its size and number, the notable amount of compost reaped also shows the rate of decomposition of paper and other waste.
- Though the yield and soil nutrients are comparatively less in the combination of cow dung and paper wastes, the same can be used when no other options are available.

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