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Vermicomposting

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Abstract: Vermicomposting is a biological technique of converting organic wastes in to a rich soil amendment. In this paper a thorough literature is done regarding the impacting factors for a vermicomposting pit followed by design considerations for a vermicomposting pit and the number of earthworms required for the obtained amount waste. This is further continued with selecting of optimum range for parameters such as Temperature, Potential Hydrogen, Moisture content, TAN.

Keywords: Vermicomposting, Rich soil amendment, TAN, Moisture content, Temperature, Potential Hydrogen.

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I. INTRODUCTION

Given the increase in population in leaps and bounds, disposal of waste is a major menace that troubles humankind in this 21st century. According to the latest reports((Shekdar 1999)) nearly 38 billion metric tonnes of organic waste are being generated overall the world and India being the second most densely populated country in the world generates nearly 100000 metric tonnes ((Shekdar 1999, Costi, Minciardi et al. 2004)organic waste. According to the reports this waste generated is rapidly increasing at the rate of around 1% annually ((Shekdar 1999)) and by 2047 this would lead up to 260 million tonnes of waste((Costi, Minciardi et al. 2004)). But the blessing in disguise is that of this quantity of waste, nearly 40-60% waste is of organic. In order to develop India in to a super power this menace must be curbed in a eco-friendly manner.

And here comes the solution of modifying this organic waste in to a rich soil amendment. About 2300 years back a great man named Aristotle named Earth worms as intestines of the soil. And after nearly 2300 years his words gained prominence and the solution namely "VERMI-COMPOSTING" came in to picture given its viability, cost effective nature, and the eco-friendly way of disposing the waste. Especially in developing countries like India considering its low versatile capacity to new advancements for nutrient cycling vermi composting is the best aid. The word vermi is derived from Latin word which means worm((Edwards, Arancon et al. 2010) Vermiculture also called as sericulture means the production of earthworms used for a basement of organic material in to rich soil amendment known as VERMI-COMPOST.

SCOPE: This paper has been considered for bio-degradable wastes which primarily consists Paper and food waste. The climatic considerations also play a pivotal role in vermicomposting and this report primarily focuses on cool and humid considerations present in Dehradun. The design considerations depend on the amount of waste. Earthworm specie selected is Eisenia Fetida. The above factors might impose constraints on the wider applicability of the process.

II. PROCESSES UNDERGONE DURING VERMICOMPOSTING

There science of vermicomposting can be divided in to two types ((Ndegwa, Thompson et al. 2000)) namely,
(a) Mechanical and Physical
(b) Bio-chemical and Ecological

The mechanical and physical process involves the aeration of the organic matter followed by mixing of both organic material and earth worms. The bio-chemical and ecological process exhibit the inter relation of both the earth worms and micro organism. The interaction between earth worms and microorganisms takes place in three stages micro stage, meso stage, and macro stage. The macro stage interactions are not that prominent and hence importance was given to micro and meso stages of interactions. In the micro stage interaction food requirements for the earthworm are given preference. In the meso stage interactions the way in which the soil characteristics are swayed by the activity of earthworms are studied.

Advantages and Disadvantages of interaction between earth worms and micro organisms:

Advantages	Disadvantages
Nutrient Release	Dispersal of fungi
Breakdown of organic matter	Populations of Plant Pathogens
Dispersal of vesicular abuscular Mycorrhizae	Transmission of nematodes

III. EARTH WORM SELECTION

*** Individual study on the different earthworms coming under the umbrella of Epigeic type:**

1. Eisenia Fetida:

Named as tiger worm Eisenia fetida is the most common type of earthworm used for vermicomposting. Given its features like rapid rate of growth and easy handling nature it is most preferred for vermicomposting ((Katiyar, Suresh et al. 2017)).

Figure 1: The above figure depicts Eisenia Fetida

Characteristic features of Eisenia fetida((Katiyar, Suresh et al. 2017),(Katiyar, Suresh et al. 2017),):

1.	Moisture range	60-90%
2.	Temeprature Tolerance	up to 35^{0}C
3.	Life cycle	45 to 51 days
4.	Hatchling Time for sexual maturity	21 to 30 days
5.	Rate of cocoon production	0.4 to 1.3 cocoonday^{-1}
6.	Incubation period	18 to 26 days
7.	Life expectancy	4.5 to 5 years
8.	Average life survival rate at 18 to 28 ^{0}C	20 months
9.	Hatching viability	80%

2. Dendrobaena veneta:

Named as European night crawler Dendrobaena veneta is used for industrial vermicomposting given its large structure. However, it has share of disadvantages like low reproduction and maturity rates compared E. fetida, P. excavatus and E. eugeniae((Katiyar, Suresh et al. 2017)).

Characteristic features of Dendrobaena veneta ((Katiyar, Suresh et al. 2017)):

1.	Temperature Range	9 to 30^{0}C
2.	Moisture Content	65 to 85%
3.	Life Cycle	100 to 250 days
4.	Sexual maturity Rate	65 days
5.	Cocoon Rate	0.28 cocoons day-1
6.	Hatchling viability	20%
7.	Incubation Period	42 days

3. Dendrobaena Rubida:

Although it is not commonly used for vermicomposting citing its preference for organic soil this specie can also be used in vermicomposting.

Characteristic features of Dendrobaena Rubida((Reinecke and Viljoen 1990)):

1.	Life Cycle	75 days
2.	Temperature Range	15-25^{0}C
3.	Sexual Maturity	54 days
4.	Rate of cocoon production	0.45cocoons day-1
5.	Hatching Viability	75%

4. Lumbricus Rubellus:

Found in moist surfaces Lumbricus Rubellus takes more time to mature and less rate of reproduction. Citing this disadvantage this is not suitable for vermicomposting.

Characteristic features of Lumbricus Rubellus (31,(Edwards, Arancon et al. 2010)):

1.	Life Cycle	120-170 days
2.	Temperature Range	15 to 18^{0}C
3.	Sexual Maturity	74 to 91 days
4.	Rate of cocoon production	0.1 cocoons day-1
5.	Maturation Time	74-91 days

5. Perionyx Excavatus:

It is found in tropical zones. Perionyx Excavatus is used in vermicomposting given its advantage of breaking up of organic matter under high range of temperatures.

Characteristic features of Perionyx Excavatus ((Reinecke, Viljoen et al. 1992)):

1.	Life Cycle	40-71 days
2.	Temperature Range	20 to 30^{0}C
3.	Sexual Maturity	55 days
4.	Rate of cocoon production	6.7 cocoons day-1
5.	Hatchling Rate	90%

IV. MATERIALS AND METHODS

Feeding Materials:

The waste is collected from food court, Nescafe, MDC and hostel, in and around UPES Bidholi campus.

Type of waste collected: Food waste and Bio-degradable waste.

Bedding:

Bedding plays a crucial role in vermicomposting by maintaining a proper amount of oxygen and bedding which is done by coarse materials helps in absorbing the oxygen thereby, maintaining the right amount of moisture in the bin. In order to facilitate this considerations a non-toxic, light materials must be considered for bedding.

Materials used for bedding:

News paper, Cardboards, dry leaves, saw dust, Animal manure, and dry grass clippings.

Necessary care:

1. The selected bedding material must be shredded so as to minimize the oxygen blockage. If the bedding materials block the oxygen from passing there is a chance of turning the vermicomposting bin in to anaerobic condition and in order to prevent this from happening the bedding material must be shredded.
2. Avoid paper with high chemicals
3. Top off the bedding material every couple of months.

Selected bedding material: Dry leaves, Animal manure

Reason: These selected bedding materials provide appropriate nutrients required for the earthworms.

Bedding Additives:

In order to support the bedding materials bedding additives must be added. These additives are used to neutralize the pH of the worm bin.

Materials used as Bedding Additives:

Egg shells, Calcium Carbonate and Rock dust.

Selected Bedding Additives: Dried Egg shell

Reason: Egg shell is freely available and it is good in neutralizing the acidic nature of the worm pit.

Parameters to be considered for Vermicomposting:

Temperature:

Temperature is the crucial factor in vermicomposting as its affects the metabolism, rate of reproduction and the growth of earthworms. Decrease in temperature below 10^0C increases the stress on the earthworms and freezing temperatures can kill the earthworms. Increase in the temperatures can also reduce the activity of the earthworms leading to the reduced reproduction rate finally affecting the activity of vermicomposting.

Optimum Temperature Range: $15 \text{ to } 30^0C$

Measurement Device: Thermometer.

Moisture content:

Earthworms contain nearly 75 to 90% of water in their bodies and they breathe from their skin and if they dry up earthworms cannot breathe and will eventually die. The drop in moisture content below 60% can reduce the earthworm breathing rate and in order to avoid this shedding materials must be placed to maintain the optimum range of moisture content. Maintaining of optimum level of moisture content is important and hence, moisture content must be measured at a weekly basis(Muyima, Reinecke et al. 1994).

Optimum moisture range: $70 \text{ to } 80\%$

Calculation of Dry Moisture Content:

Procedure:

Take 15 grams of waste without any earthworms and dry it for about one day at a temperature in excess of about 100^0C and measure the dried weight and calculate the dry moisture content using equation(1).

$$\text{Dry Moisture \%} = \frac{(\text{Weight}_{\text{After Drying}} - \text{Weight of Aluminium tray})}{\text{Weight}_{\text{Before Drying}}} \text{ x } 100\% \quad ......(1)$$

Potential Hydrogen (pH):

PH is the crucial parameter in vermicomposting and an optimum range of potential hydrogen must be maintained. The problem in maintaining pH is that the organic waste presence leads to the increase of acidic content in the pit which is a potential danger to the survival of earthworms(Katiyar, Suresh et al. 2017).

Optimum Range: 6.5 to 7.5

Measuring Device: pH meter

Design Considerations:

The design of the worm pit depends on the organic waste generated.

BASIS: For 1 pound of waste generated per week $1\,ft^2$ of surface area is to be considered(Sherman-Huntoon 2000).

Month	Total Weight(kg)	Weight per week(kg)
July	25484	6371
August	37281	9320.35
September	30704	7676
October	26808	6702
November	31280	7820
December	32390	8097.5

Average weight: 7664.4 kg/week (or) 16861.803 pound /week

Surface Area Required: $16861.803\,ft^2$

Depth: 2 feet

Reason: Earthworms are surface dwellers and their activity is mostly confined to the top surface of the soil and hence, more depth reduces their level of activity.

Also suitable aluminium plates with pores are placed for better aeration.

Materials Used for construction of pit: Bricks, concrete

Earthworms:

Type of earthworm to be used: Eisenia fetida

Weight of earthworm: 0.25 to $0.4\,g\,worm^{-1}$

Worm Length: 2.5 to $5\,cm\,worm^{-1}$

Number of worms Required:

Basis: $\left(\frac{\text{Number of worms Required}}{\text{Waste per week}}\right)=\frac{2}{1}$ (Katiyar, Suresh et al. 2017)

$$\left(\frac{\text{Number of worms Required}}{\text{Waste per week}}\right)=\frac{2}{1}$$

$$\left(\frac{\text{Number of worms Required}}{\text{7664.4 Kg waste per week}}\right)=\frac{2}{1}$$

$$\text{Number of worms Required} = 15329$$

Pre-Treatment(Reinecke, Viljoen et al. 1992):

Factors influenced by Pre-treatment:

1. Duration
2. Earthworm survival
3. Nutrients availability

Advantages: Pre-treatment has the advantage of reducing the duration required and also eliminates the disease causing pathogens.
Dis-Advantages: Pre-treating is known to reduce the nutrient quality of the compost.
Pre-treating is employed in two ways:
(1) Thermophillic Pre-composting: It is known to reduce the toxic substances in the feed and also allows for the proper mixing of the feed.
(2) Mixing pre-composting: In this method several materials are mixed in different proportions basing on their composition.
Method of vermicomposting(Reinecke and Viljoen 1990):

1st layer	Bedding material(1 inch)
2nd layer	Finely chaffed organic waste(9 inch)
3rd layer	Bedding material+water in equal proportions(2 inch)

Method of Approach: Heap Method

Duration: 90 daysAdd half of the earthworms in the above mentioned ratio and maintain all the parameters in optimum range as mentioned above. Add remaining earthworms on 45th day without disturbing the pit. And the entire material will be turned in to a rich soil amendment. This output is dried sieved and packed for varying utilities.

V. RESULT AND DISCUSSION

Place	UPES
Average waste$\left(\text{kg/week}\right)$	7664.4
Surace Area$\left(\text{ft}^2\right)$	16861.803ft^2
Worms Required	15329

The obtained output has high maturity rate and high respiration index which is the important parameter in the evaluation of the quality of the manure. The important goal of vermicomposting is the reduction disease causing pathogens in the organic waste. According to reports the organic waste is known to contain 120 virus and bacteria which are harmful to human beings. The compost reduces 75% of the disease causing pathogens. Apart from increasing the nutrients the compost also increases the physical structure of the soil and the water holding capacity(Reinecke and Viljoen 1990).
Germination testing is the method of testing in which the growth rate of plant is tested. Germination of plant seed shows increased growth in vermicompost rather than commercial yielding. Adding to this there is also evidence that the vermicomposting leads to increased rate of flowers, growth and fruit yielding capability.

VI. CONCLUSION

Vermi composting a biological process which involves the interaction between earth worms and micro-organisms leading to the formation of earth worm biomass and the vermi-compost(Edwards, Arancon et al. 2010).In this paper a thorough research is conducted which involves the entire parameters required for vermicomposting, the design consideration which involves the surface area of the pit required and the type of earth worms required, their criteria for selection and the number of worms required are all included in this paper. This paper provides the basis for the process of vermicomposting.

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