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An Analysis of Vermicomposting

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ABSTRACT: Generation of the enormous quantity of solid waste across the world is a significant ecological and technological issue. Vermicomposting may be the feasible alternative to manage solid waste in an ecologically acceptable manner. This study offers a broad overview of feasibility of vermicomposting processes as an eco-friendly method. The combined strategy of composting and vermicomposting processes offers superior outcomes. Further, to improve the process of vermicomposting, codigestion of organic wastes offers greater chance for both microbes and earthworms to transform the organic portion of solid waste under regulated environmental circumstances. Feeding, stocking density, pH, C/N ratio, temperature, and moisture, by inference, appear to be the key variables that affect the vermicomposting process. Furthermore, the final result of vermicomposting, the nutrient-rich compost, may be utilized for biogas generation. Hence, the management of solid waste and energy generation may be accomplished at the same time with no additional expenditures.

KEYWORDS: earthworms, eco-friendly, solid, vermicomposting, waste,

1. INTRODUCTION

Various human activities, increasing urbanization, industrialization, and economic development are contributing to the creation of enormous amounts of solid waste across the world. The management of this solid waste has now become an ecological and a technological issue for everyone. Sustainable solid waste management techniques are essential to maintain the ecosystem healthy and clean. The issue of production of solid waste in all over the globe is worse. By extrapolation, it appears that just in Asia Pacific area, 1.8 million tons of solid waste production per day will be projected by 2025. It was unexpectedly rise of solid waste production in America when municipal solid waste (MSW) generation was recorded 243 tons in 2009. According to various research, an average of 0.77 kg/person/day solid waste is produced in 23 developing nations. Currently, it is projected to raise the world's solid waste production up to 3 billion tons by 2025.

These large quantities of trash have not been completely addressed due to technical and economic problems, since there is a dearth of suitable technology for their economical recycling in underdeveloped nations[1]. Although many strategies have been proposed and implemented for proper solid waste management, including source reduction, curbside recycling, material recovery, waste to energy, landfill dumping, incineration, and composting , some of these treatment and disposal methods could cause serious environmental issues. In several investigations, it was stated that the trash put in landfill or in open dumps caused groundwater pollution owing to leaching of organic and inorganic chemicals contained in waste.

Landfill dumping significantly increases the greenhouse impact as well. Similarly, cremation treatment is limited because of its low-fattening value and the expense of fuel additions. In the case of sewage sludge, it is immediately disposed of on agricultural lands because of its

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high nitrogen (N) and phosphorus (P) contents utilized as fertilizer; nevertheless, it may cause toxicity for soil and plants and have depressive effects on the metabolism of soil microorganisms. Under these circumstances, vermicomposting may be a feasible technique that is environmentally sound, and it not only becomes eco-friendly but also affordable for converting solid wastes into organic rich manure[2].

Vermicomposting is a waste management technique that includes breakdown of organic fraction of solid waste in an eco-friendly manner to a level at which it may be readily kept, handled, and applied to agricultural fields without any harmful consequences. Vermicomposting is a combined activity of microorganisms and earthworms under environment-controlled circumstances, thus to accomplish nonthermophilic breakdown and stability of organic component of solid waste. Simply, it is a biotechnological process in which organic waste is transformed into nutrient-rich vermicomposting by employing earthworms.

The microorganisms present in the system are responsible for biochemical breakdown of organic materials, while earthworms play their part in conditioning of substrate and also changing of biological activity. This is a relatively low-cost method for the treatment of organic wastes utilizing earthworms. In one acre of soil, various kinds of earthworm species exist having distinct types of nature and method of feeding owing to which the pace of deterioration is influenced. In the case of MSW, the method of vermicomposting would be highly suggested because of its safe and sanitary degradation of large quantity of organic waste contained in solid waste[3].

1.1 Composting And Vermicomposting Integration:

Microorganisms present in the stomach and intestine of earthworms receive their nutrition from organic material and degrade it into finer particles. In this manner, microbes give food to earthworms, and earthworms in turn encourage greater microbial activity by generating fecal material or casts that are microbially active than what they ingest . Composting is the process of aerobic breakdown of organic waste via microbes, while vermicomposting includes the combination of both the microorganisms and the earthworms. Although vermicomposting is considered to be the superior process over composting in terms of the ability to kill pathogens, some studies considered that the vermicomposting process lacks the ability to kill pathogens, hence it is considered as the major drawback of vermicomposting process when compared with thermophilic composting. The optimal temperature for earthworms in vermicomposting process is regarded up to 35C, while in traditional composting (including thermophilic composting), it may reach up to 70C. Therefore, vermicomposting process does not reach the ideal temperature to kill pathogens, and if the temperature surpasses 35C, it may lead to the death of earthworms which further halt the process of vermicomposting[4].

1.2 Vermicomposting Through Co-digestion Of Organic Wastes:

The combination of substrate and substrate affects the physicochemical character of the waste, which may eventually influence the vermicomposting process. These organic substrates give such chemical character to the waste which improves the effectiveness of worms in vermicomposting system by improved rate of waste reduction. It also offers fertilizer value of the vermicomposting, development, and reproduction of the worms

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throughout the vermicomposting process. It has been observed that earthworms' ability to survive particularly in industrial wastes greatly reduced, and thus, there is a need of some nutrient-rich organic source, such as cow dung, biogas plant slurry, and poultry droppings, mix with industrial wastes to enhance the vermicomposting process by providing sufficient amount of nutrients and inoculums of microorganisms. When the saw dust and cow dung were supplemented with guar waste as organic amendments and supplements, they create ideal circumstances for worms and successfully enhance the degradation rate. In contrast to this, however, circumstances may not be suitable and can reduce the effectiveness of worms when distillery sludge is combined with cow manure as bulking agent. It was discovered that high percentage of distillery sludge impacts the decomposition efficiency of worms[5].

1.3 Vermisystems And Vermidiversity:

Different kinds of vermicomposting systems are suggested by researchers to create better environment for worms. It comprises windrow system, pits, piles, tanks, cement rings, and beds or bins (Glenn Munroe) (Glenn Munroe). Windrow systems are of various kinds, including continuous flow system, batching system, and wedge system. Different research revealed varied range of earthworms for different kinds of trash. Among these, Eisenia fetida is the mainly utilized specie for stabilization of organic waste. However, Dendrobaena veneta and Lumbricus rubellus from temperate areas and Eudrilus eugeniae, Perionyx excavatus, and Perionyx hawayana from the tropics are also among the species of earthworms which are possibly the most helpful specie for preserving organic waste. Generally, Eisenia fetida is extensively utilized all across the world, while Eudrilus eugeniae is popular in tropical and subtropical regions. Apart from this, polyculture worms are also employed using a mix of various species. Eisenia fetida, also termed as banded worms, are the most widely used species for the degradation and stabilization of different types of organic wastes, including neem leaves, dung of cow, buffalo, horse, donkey, sheep, goat, and camel , biogas slurry, cow dung, vegetable market waste, wheat straw , kitchen waste, agroresidues, and institutional and industrial wastes , cow manure , and textile mill sludge mixed with poultry dropping . Eisenia fetida also acts in the reduction of soil organic matter bigger than 2000 lm by between 97 and 27 percent (200–2000 lm) during digestion[6].

1.4 Role Of Vermicultures In Vermicomposting:

Earthworms played a significant part in organic waste system by colonizing organic waste coupled with ingestion, digestion, and absorption of high rates of organic wastes. They also have the capacity to withstand a broad variety of environmental stressors with strong reproduction rates. In an organic waste system, earthworms swallow, crush, and digest organic waste with the assistance of aerobic and anaerobic microorganisms found in the stomach of earthworms. The physical and biological activities are conducted in waste system by earthworms. The example of physical activities includes substrate aeration, mixing, and real grinding. Biochemical activities of earthworms include microbial breakdown of substrate in the gut of earthworms. As a consequence of this activity, fast mineralization and humification process begins, which transform the unstable organic matter into relatively stable and microbially active material. During this stabilization process, chelating and phytohormonal components are released, which turn the organic matter into stable humic compounds with high microbial concentration[7].

Vermicomposts generated after digestion and excretion by earthworms are really nutrient-rich organic soil amendment and has great potential in crop development. The joint activity of microorganisms and earthworms produces it finely split peat-like material with excellent porosity, aeration, drainage, water-holding capabilities, and low C:N ratios. In waste system, under aerobic circumstances, earthworms consume the organic solid waste and convert a part of it into biomass and respiration products. Microflora of organic waste and intestine together with stomach enzymes of earthworms are responsible in the breakdown of organic waste.

The remainder of the organic material that does not undergo full stabilization process is discreted by earthworms as residue, which is a partly stabilized substance called as "vermicasting". The enzymes produced via the digestive epithelium of gut of earthworms include cellulase, amylase, invertase, protease, and phosphatase. Although the mechanism of transformation of organic waste in the stomach of earthworms is not completely understood, the resultant worm castings (worms' dung) are said to be rich in microbial activity, plant growth regulators, and fortified with insect repellence. Some earthworm species may quickly eat the organic component of solid waste and break them into considerably smaller particles when passing through a grinding gizzard of earthworms. Earthworms receive their food from microorganisms, while microbial activity is affected by the castings generated by worms[8].

1.5 Factors Affecting Vermicomposting:

1.5.1 Feeding:

Feeding has a significant function not only in the development and reproduction of earthworms during vermicomposting but also on the production rate of cocoon. The feeding rate is affected by various variables including moisture, particle size, and substrates organic content. According to Wright, the feeding rate is based on the feed type, preparation, or feed pretreatment. The technique used when feeding the substrate is essential to fight anaerobic conditions as stated by Reinecke and Viljoen. In a vermicomposting system, anaerobic bacteria are also eaten by worms together with organic waste. High organic content decreases the activity of worms, thus increasing anaerobic activity of microbes which produces anaerobic and bad odor conditions. Toxic metals if present in the organic diet become deadly for worms[9].

1.5.2 Temperature:

Although, earthworms have very complicated reactions to variations in temperature, the optimal temperature range may be 25–37C, which promotes the activity, growth, metabolism, respiration, reproduction, and cocoon formation for earthworms and also benefits the microorganisms associated with earthworms. Worms tolerate in a temperature range of 5–29C. Different tolerable temperature ranges are reported by different studies from 0 to 40C . At higher temperatures (over 30C), the chemical and microbiological activity increases in the substrate, which leads to the decrease of oxygen content and therefore has detrimental effects on earthworms. Varied earthworm species exhibited different reactions to temperature.

1.5.3 Stocking Density:

The density of earthworms is affected by many variables including initial substrate quality and quantity, temperature, moisture, and soil structure and texture. The copulation frequency of earthworms is high at low population density, while it falls as the density approaches the

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carrying capacity of the substrate. It has been observed that the stocking density of 1.60 kg worms/m2 is optimal for vermicomposting[10].

1.6 Growth And Cocoon Production:

The growth rate of worms and the production rate of cocoon throughout the vermicomposting process are essential for sustainable development of the process. The formation rate of cocoon is mainly related on the quality of feed and substrate. Physicochemical and nutritional properties are the primary variables in influencing the development of earthworms. High feeding usually leads in high production rates of cocoon, which is also a reflection of the quality of the waste as it may be the key element that influences the start of cocoon formation. Sometimes, severe circumstances of system may lead to reduction in cocoon formation and development rate of worms. For example, the production rate of cocoon and the reproduction rate of worms decreased with the increasing concentration of distillery sludge in the vermicomposting system owing to the presence of higher growth-retarding compounds like metals, higher salt concentration, and grease in the initial feed of worms. The decrease in worm's efficiency was linked to the presence of hazardous metals. The harmful copper ions enter the cocoon by diffusion since cocoon membrane is porous, and these copper ions interact with the proteinaceous material and reserve for growing embryos of worms. Similarly, chromium ions across the cell membrane decrease the transport capacity of important metabolites owing to electrode potential drop, which may be the cause of toxicity for developing embryo. Lead also impacts during cocoon formation by entering into cocoon via clitellar muscles and disrupts embryo development.

2. DISCUSSION

Solid waste, such as trash and household goods, flowers, and wasted food, must be handled correctly to prevent polluting groundwater supplies. Open dumping is the most common method of trash treatment. This method is cheap, but it is harmful to ones health. Vermicomposting is a common technique for disposing of residential and domestic waste. Earthworms consume everything biodegradable in this environment. High plant nutrients and plant growth stimulators may restrict seed germination and development to some extent,therefore additional care is needed to prevent plant damage. According to the results, total nitrogen, accessible phosphorus, and exchangeable potassium have all risen. Vermicomposting may offer employment possibilities. Compared to anaerobic digestion, it provides many benefits. The foul smell generated by anaerobic digestion disturbs people in the nearby region. The process of aerobic digestion is time-consuming, costly, and needs more space. This method is more acceptable owing to the added advantage of increasing soil fertility and soil amendment. Several topics relating to vermicomposting and earthworms utilized in this process have been addressed in this article.

3. CONCLUSION

Vermicomposting may be the feasible and a very low-cost alternative to manage solid waste in an ecofriendly manner. Vermicomposting is a waste management technique that includes breakdown of organic fraction of solid waste in an ecofriendly manner to a level at which it may be readily kept, handled, and applied to agricultural fields without any harmful consequences. Integration method of composting and vermicomposting processes offers superior outcomes by combining both processes and selecting one of the two forms as

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prevermicomposting followed by composting or precomposting followed by vermicomposting. Further, to improve the process of vermicomposting, codigestion of organic wastes offers greater chance for both microbes and earthworms to transform the organic portion of solid waste under regulated environmental circumstances. Feeding, stocking density, pH, C/N ratio, temperature, and moisture, by inference, appear to be the key variables that affect the vermicomposting process. Furthermore, the final result of vermicomposting, the nutrient-rich compost, may be utilized for biogas generation. Hence, the management of solid waste and energy generation may be accomplished at the same time with no additional expenditures. Thus, vermicomposting technology may be utilized for affordable recycling of solid organic waste in poor nations. It is highly suggested that this technique may be used to manage the trash put in landfill or in open dumps, sewage sludge, incinerator waste, and dumps in the agricultural fields to avoid/reduce groundwater pollution and toxicity of soils and plants via various pollutants.

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