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Review Of Literature On Bioremediation Of Organic Waste Through Vermicomposting For Sustainable Agriculture.

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Abstract
Vermicomposting Can Be Defined As "Bioxidation And Stabilization Of Organic Material Involving The Joint Action Of Earthworms And Mesophilic Micro-Organisms". Under Appropriate Conditions, Worms Eat Agricultural Waste And Reduce The Volume By 40 To 60%. Vermicompost Produced By The Activity Of Earthworms Is Rich In Macro And Micronutrients, Vitamins, Growth Hormones, Enzymes Such As Proteases, Amylases, Lipase, Cellulase And Chitinase And Immobilized Microflora. The Enzymes Continue To Disintegrate Organic Matter Even After They Have Been Ejected From The Worms.
Key Words: *Vermicompost, Bioremediation, Organic Waste Biomass, Bio Manure, Biofertilizer*

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I. Introduction

Improved agricultural practices and rapid industrialization have led to huge waste generation, and the management of this waste is becoming a global concern today . The process of vermicomposting has emerged as a method of choice for converting waste into useful manure, with evidence of increase in crop productivity. During vermicomposting, the collective activities of decomposing microorganisms and earthworms lead to the humification of organic/inorganic waste, thereby generating the final product called vermicompost. Different types of industrial wastes such as waste from paper industries, tanneries, sugar mills, and pulp and textile industries have been effectively converted to vermicompost and successfully used to improve plant growth. The vermicompost thus formed was also demonstrated to increase the production of pharmaceutically important plant secondary metabolites such as with anolides and polyunsaturated fatty acids. Microbial amendment with different bacterial and fungal strains during vermicomposting further proves to be beneficial by increasing nitrogen content, decomposing organic waste, providing aeration, and stabilizing the vermicompost. These microorganisms after passing through the earthworm's intestine increase in numbers in the vermicast, thus becoming enriched in vermicompost, which is particularly important for their use as biofertilizers.

II. Review of Literature

Following are the major efforts at research on the subject, which have been referred for this study purpose.

1.2.1 Ganti S (2018), investigated and opined a biological process that turns organic wastes into a beneficial soil supplement. Compliments and "vermi-composting," a viable, economical, and environmentally benign method of waste disposal, entered the scene. The practise of raising earthworms for use in the basementing of organic matter into a rich soil amendment known as Vermi compost is known as vermiculture.

Vermicomposting science can be separated into two categories: mechanical and physical science, and biochemical and ecological science.

The aeration of the organic matter is followed by the mixing of the organic material and earthworms in the mechanical and physical phase. Both earthworms and microorganisms have links to one another by the biochemical and ecological processes. Three stages—the micro, meso, and macro stages—are involved in the interaction among earthworms and microorganisms. The importance of the micro and meso stages of interaction was placed on them because the macro stage interactions are not so prominent. The earthworm's nutritional needs are prioritised during the micro stage contact. The influence of earthworm activity on soil properties is investigated at the meso stage interactions. The product produced has a high maturity rate and high respiration index, which is a crucial factor in determining the manure's quality. The elimination of disease-causing pathogens in organic waste is an essential goal of vermicomposting. Earthworms and microorganisms interact during the biological process of vermicomposting, which results in the production of both vermicompost and earthworm biomass.

1.2.2 Margit Olle, 2019 reported on a review, vermicompost is a peat-like substance that has a high water-holding capacity and porosity. The majority of the nutrients are present in forms that plants can easily absorb. Technology for vermicomposting is a useful technique for effectively converting wastes from agro industrial processing.

In addition to being a rich source of macro- and micronutrients, vitamins, growth hormones, enzymes like cellulase, amylase, chitinase, and lpase, vermicompost also contains immobilised microflora. It primarily consists of C, H, and O and includes nutrients like N, P, Ca, K, Mg, and S.

It was effective to vermicompost dry grass clippings, rice straw, and cow dung using Eisenia foetida. The resulting vermicompost was uniform, dark in colour. It included all of the necessary macro- and micro-nutrients for plants, including N, P, K, Ca, Mg, Mn, Cu, Zn, and Fe, showing that the goal of creating an environmentally benign, nutrient-rich fertiliser for agriculture.

Vermicompost is a high nutrient biofertilizer with diverse microbial communities, it plays a major role in improving growth and yield of different field crops, vegetables, flower and fruit crops. Vermicomposting is a chemical and biological process for recycling nutrients with the aid of earthworms and microorganisms. It can be used to shift from chemical fertilizers to reduce the hazardous effect of chemicals to both crop and human being. Earthworms consume various organic wastes and reduce the volume by 40–60%. Vermicompost is a biofertilizer enriched with all beneficial soil microbes and contains all essential plant nutrients like N, P and K.

1.2.3 Pilii .K, in 2019 suggested vermicomposting is an alternative method for waste management through which vermicompost is produced with relatively high nutrient content than compost and manures. So it can be used to shift from chemical fertilizers to reduce the hazardous effect of chemicals to both crop and human being. Application of vermicompost either alone or in combination with fertilizers promotes crop yield. It is today's natural fertilizers as nature intended and it is the best solution to immediate problem of declining soil fertility and for production of food thus is the best means of abating pollution, soil degradation and discriminate use of chemical fertilizers. It improves the soil physical conditions which support better aeration to plant root, drainage of water, facilitation of cation exchange, sustained availability of nutrients, and thereby the uptake by the plants resulting in better growth. Use of vermicompost constitutes an important alternative source of fertilizer that has environmental benefits, productivity and crop quality as compared to inorganic fertilizers. Vermicomposting and its application could be a better option and farmers need to be educated about the importance of vermicompost.

1.2.4 Arancon et al., 2002 demonstrated that soils treated with vermicompost supplemented to recommended rates with inorganic fertilizers and planted with tomatoes, had amounts of total nitrogen, orthophosphates, dehydrogenase enzyme activity, and the microbial biomass, that were usually greater than those that received equivalent amounts of inorganic fertilizers only.

1.2.5 Arancon et al., 2002, have shown that soil amended with vermicompost are found to have significantly lower bulk density, highly porous & lighter and never compacted in terms of aeration. Vermicompost improves physical, chemical and biological properties of soil in the long run on repeated application. The concept of vermiculture of organic material with earthworms provides most useful organic manure on one hand and on the other hand it also minimizes the environmental pollution and health hazard. The composted organic wastes exert variety of physical, chemical and biochemical influences upon the soil faking the soil a favourable substrate for plant growth. It maintains the soil in a proper homeostatic state. It also removes excessive amounts of heavy metals such as copper and lead and there by served as a means of detoxification. Kumaresan et al., reported that there was a slight decrease in pH and the EC value was also altered due to the organic acids released during the decomposition of the various farm wastes. There was a significant increase in the available nitrogen, phosphorus and potassium status of soil due to the application of the various farm waste materials. Nutrient composition and physico-chemical parameters are subjected to greater changes due to activity of earthworms in food substrates, while mineralization of waste substrates is accelerated by ingested food materials passing through gut of earthworms, thus stabilizing NPK contents in plant available form in soil. Vermicompost is superior to normal compost in increasing the growth of cardamom seedlings.

1.2.5.Maheswarappa et al., 1999 reported that there was increase in amounts organic carbon, improvements in pH, decreased bulk density, improved soil porosities and water-holding capacities, increased microbial populations and dehydrogenase activity of soils in response to vermicompost treatments.

1.2.6 Chaichi Devi and Meena Khwairakpam, 2022, Vermicomposting is an extension of composting technology in which earthworms consume organic matter and accelerate the degradation process, resulting in nutrient-rich vermicompost. Vermicompost is an organic fertilizer with numerous benefits, such as soil health and plant growth. It is environment friendly and economical, with zero pollution and low cost. It has the potential to mitigate health, environment and society problems, and can be used as an organic fertilizer for organic farming. The Sustainable Development Goal (SDG) is to reduce hunger and ensure food security for all. Organic farming is a solution to these problems, and is in high demand in both developed and developing nations. Organic fertilizers make organic farming more sustainable, and vermicompost is a good resource for vermicompost production.

1.2.7 Vukovic et. al., 2021Terrestrial weed biomass is a good resource for vermicompost production, and proper management of it can resolve the demand for organic fertilizer globally Vermicomposting is an ecofriendly and economically favorable biotechnological process that involves the interaction of earthworms and microorganisms. This review aims to provide key insights and highlight knowledge gaps to enable wider utilization of vermicompost products.

1.2.8 Rai et. al., 2019 has given a comparative study of earthworms suitable for vermiculture.

Family	**Fiji Islands**	**India**	**Other countries**
Moniligastridae	Drawida barwelli Beddard	Drawida willsi	
Acanthodrilidae	Amynthas critics A. capulatus A.esafatae Beddard A. gracillis, A. taitensis	Octochaetona surensis (Michaelsen)	
Glossoscolecidae	Panoscolexcorethrunus		
Eudrilidae		Eudrilus eugeniae Kinberg	Eudrilus eugeniae Kinberg
Lumbricidae		Eisenia foetida (Savigny)	Eisenia foetida (Savigny), Lumbricus rubellus Hoffmeister, Dendrobaenarubida Stop-Bovitz, Allolobophorasubur Bicunda. chlorotica
Megascolecidae	Metaphirehaulleti, Perionyx excavates (Perrier), Pheretima darnleiensis Fletcher, P. Montana, P. bicinta, P. godeffroyi, P. sedguickisedguicki, Polypheretima neglecta Easton,P. taprobanaeEaston	Perionyx excavatus (Perrier) Lampito mauritii Kinberg	Perionyx excavatus (Perrier)
Octochaetidae	Dichogaster affinis D. damonis	Dichogaster curgensis Michaelsen	

Earthworms live in the soil and perform following role –

- Earthworms eat plant biomass, which fall on the form of mulch.
- Earthworms are effective tool for speedy development of wastelands.
- Earthworms recharge ground water.
- Earthworms maintain soil aeration.
- Earthworms produce 10 mm soil per year, which is produced by nature in 200 years.
- Earthworms maintain soil temperature and moisture.
- Earthworms increase root volume and bacterial activity about 10 fold.
- Earthworms feed on soil and soil organic matter and convert it to compost, making the soil rich in nutrients.
- Earthworms are natural tillers of soil.
- Earthworms aerate and pulverize soil.
- Earthworms make soil porous, improving drainage.
- Earthworms increase water-holding capacity of soil.
- Earthworms encourage growth of useful microorganisms, which also make soil rich.
- Earthworms produce enzymes, hormones, vitamins and antibiotics, thereby increasing immunity of plants against some pests.

1.2.9.Charles Darwin 1881 carried out first systemic study on earthworms. Later on George Oliver and Barret taken the clue from Darwin's work and demonstrated that earthworms could be utilized to draw excellent benefits in agriculture.

1.2.10.Barret1947 was the first commercial worm grower and operated on a tonnage scale. Barret's success encouraged many others but it was only in the late sixties that some scientists felt the need to merge ecology with the concept of utilizing earthworms commercially to draw multifarious benefits.

There are about 386 varieties of earthworm. Earthworms can be classified into three types viz; Epigeic, Endogeic and Anisic (Diageic) according to their feeding habits, distribution in soil strata, defecation activities, and response to soil constraints. Worm can multiply 20 to 25 times with in 65 to 70 days in favourable conditions.

Epigeic: This species live on surface of the soil and have activity for limited period. They have high reproductive rate, but a short life span. High organic content is their dietary requirement. They are also known as surface feeders convert waste matter into humus, exhibit high metabolic activity and so are very useful for vermicomposting. Certain species introduced from Africa are very efficient humus producers. They can be brought from companies, which produce Vermicompost.

Some important species are: Eisenia foetida, Eudrilus euginae, Perionyx excavatus,Lumbricus rubellus and P. arborjcola .

Endogeic: This species reside beneath the topsoil surface where mineralized iron oxide, aluminum oxide and clay generally occur. They feet on humified organic matter, which is at different levels of degradation. They make extensive tunnels oriented obliquely and horizontally to soil surface. They enhance soil aeration. By mixing any of leached microbial or organic matter with clay, silt and sand particles. They also improve texture and structure of the soil.

1.2.11.Vyas et.al, 2022 Diageic : These worms are deep dwelling. They make extensive and permanent burrows. They line the burrows with their excrements and collect litter from the surface and store thin in their burrows for feeding. Therefore, they are useful in loosening the soil, mixing of surface organic matter into sub-terranian soil strata.

III. Literature on Process of vermicomposting:

Vermiculture is the science of raising and breeding earthworms to harvest their potential for waste reduction and fertilizer production. Vermicomposting involves biodegradation of organic waste with the help of earthworms to produce high-quality compost. Earthworms can be used for animal protein supplementation and as fish bait, but their castings remain the principal product**.**

IV. Vermicomposting of industrial waste

1.3.1.1 Yadav and Garg, 2019Vermicomposting can detoxify industrial waste and convert it into useful fertilizers. A recent study highlighted the conversion of coir industrial waste to enriched vermicompost (Karmegam et al., 2021). Earthworms increase the NPK content of sludge with a decrease in total organic carbon content, reducing the C : N ratio.

Tannery waste can be used to increase plant height, stem girth, and leaf numbers of tomatoes when mixed with animal manure and vermicomposted by earthworms

1.3.1.2.Ravindran et al., 2019 Vermicompost produced from paper sludge increased ginseng root yield by 40 t/ha, but had no effect on increasing the concentration of ginsenosides in plant roots. (Eo and Park, 2019). Vermicomposting grape marc is an effective way to return nutrients to the soil, and a continuous feeding system has been demonstrated to enrich the microbial biomass, dissolved organic carbon, and N- $NH4^+$/N- $NO3^-$ contents were enriched in the top layers of this feeding system after 12 months, thus imparting it good fertilizing properties .

1.3.1.3 Částková and Hanč, 2019(Rupani et al., 2017, Vermicomposting of wastes from palm oil mill has been found to increase the concentration of NPK and decrease the C : N ratio, as well as improve seed germination of mung bean

1.3.1.4 Amouei et al., 2017 Vermicomposting converts household and wastewater waste into high-quality compost. Earthworms are beneficial for recycling industrial waste and producing high-quality vermicompost, which can serve as a source of plant nutrients and soil conditioner. However, pilot- or field-scale studies are needed to commercialize vermicomposting of industrial waste.

V. Vermicomposting of agricultural waste

1.4.1 Sharma and Garg, 2019 .Agricultural lignocellulosic waste can be vermicomposted successfully to provide high-quality manure. After 105 days of vermicomposting, this lignocellulosic waste was combined in varied proportions with cow dung and vermicomposted by introducing Eisenia fetida earthworms, resulting in decreased total organic carbon (268-320 g/kg) and increased NPK content in the waste. It also boosted heavy metal content, with benefits ranging from 0.06 to 5.1 In another research, a combination of wheat straw and rice straw (2:1) was composted aerobically with cow manure or the fern Azolla pinnata or the fungus Aspergillus terreus, followed by vermicomposting. SEM study of their surface-structural-morphological properties revealed decreasing particle size, increased porosity, and compaction as vermicomposting progressed.

1.4.2. Arora and Kaur, 2019 expressed combinations including agricultural waste, cow dung, azolla, and fungus degraded faster than other mixtures After composting this combination for 60 days, the final product had lower organic carbon (37.78 to 50.97%) and higher NPK content (26.72-78.17%). The combination of seaweed and cow dung vermicomposting resulted in microbial population enrichment and higher growth/reproduction of the earthworm Perionyx excavatus compared to cow dung alone .

1.4.3. Ananthavalli et al., 2019, Garden waste contains a high concentration of lignin, which inhibits the growth of both microbes and earthworms during vermicomposting. However, combining wasted mushroom substrate and bovine manure with garden waste was found to increase earthworm development and improve vermicompost quality by boosting earthworm biomass and survival rate (both cocoon and juvenile)

1.4.4.Gong et al., 2019.The mixture accelerates nitrification and increases NPK concentration in the final vermicompost by significantly increasing the activities of urease, cellulase, dehydrogenase, and alkaline phosphatase in comparison to the control. The mixture of garden trash, wasted mushroom substrate, and bovine manure in a 2: 1: 1 ratio had the highest organic matter decomposition, the highest growth rate of E. fetida, and the highest germination index of tomato seeds and Chinese cabbage

Soil fungus are thought to be a major source of food for earthworms. Several fungal species have been documented for the preparation of organic waste before vermicomposting (Cladosporium cladosporioides, Rhizoctonia solani, Mucor sp., Trichoderma viride, Fusarium nivale, Phlebia radiate, Aspergillus niger, and Coriolus versicolor). Fungi digest organic wastes that are dry, acidic, and contain little nitrogen. Fungi are also capable of degrading complex polymers such as polyaromatic compounds and plastics

1.4.5. Edwards and Bohlem, 1996, Temperatures ranging from 21 to 24 degrees Celsius, Fungi offer aeration and drainage by breaking down the compost into tiny pieces. Despite the fact that earthworms devour fungus inside organic materials to meet their nitrogen requirements, the viable count of distinct fungal species in earthworm castings was often higher than that of the initial substrate during vermicomposting

VI. Vermicast and Vermicomposting:

Vermicast

Ingestible soil is ejected as globular soil aggregates known as Vermicast after passing through the earthworm gut. Earthworm castings are earthworm excreta. These castings have five times the nitrogen of regular soil, seven times the phosphorus, eleven times the potash, twice the calcium and magnesium, and eight times the Actinomycetes (beneficial bacteria). Organic elements are extensively shredded and combined with mineral soil components as they move through the earthworm's intestines. Earthworm castings are often abundant in polysaccharides, which are attributed with stabilising the granular structure, owing to increased bacterial activity. Earthworm castings are a significant source of plant growth stimulating chemicals such as Auxins and Cytokinins. Earthworm casting behaviour therefore typically improves aggregate stability, exchangeable calcium and potassium of the soil.

Vermi compost preparation

- Basic raw material: Any organic material generated in the farm like bhusa, leaf fall etc.,
- Starter: Cow dung , Biogas slurry, or urine of cattle
- Soil animal: Earth worms (Species: *Eisenia foetida)*
- Thatched roof/vermished.
- pH: Range between 6.5 and 7.5.
- Moisture: 60-70% of the moisture below and above range mortality of worms taking place.
- Aeration: 50% aeration from the total pore space
- Temperature: Range between 18 0C to 35 0C.

Procedure:

- It is mostly prepared in either pit or heap method. The dimensions either heap or pit are 10 x 4 x 2 feet. The length and width can be increased or decreased depending on the availability of material but not the depth because the earthworms' activity is confined to 2 feet depth only.
- At the day of 24th, 4000 worms are introduced in to the pit [1m2 =2000 worms] without disturbing the pit by regular watering the entire raw material will be turned into the vermicompost in the form of worm excreta
- The turnover of the compost is 75% [the total material accommodated in the pit is 1000 kg; the out turn will be 750 kg]
- Stop watering before one week of harvest
- Sometimes the worms spread across the pit come in close and penetrate each other in the form of ball in 2 or 3 locations
- Heap the compost by removing the balls and place them in a bucket. However, under most instances, top layer has to be disturbed manually. Earthworms move downward and compost is separated After

collection of compost from top 28 separated. layers, feed material is again replenished and composting process is rescheduled

- The material is sieved in 2 mm sieve, the material passed through the sieve is called as vermicompost which is stored ina polythene bags.
- Vermicomposting is done under thatched roof to protect worms against rain and sun.
- Recomposting is done in the same pit or bed. Similar to the above described pit/heap method, vermicompost can be prepared in wooden box or brick column in similar way

In situ vermicomposting be done by direct field In-can application of vermicompost at 5 t/ha followed by application of cowdung (2.5 cm thick layer) and then a layer of available farm waste about 15 cm thick. Irrigation should be done at an interval of 15 days.

Vermicompost in comparison with cowdung / cattle dung.

Raw cow dung should not be put on plants because it includes greater levels of salts and ammonia, which can burn the roots of plants. Composting must be used to turn the excrement into manure, and vermicomposting is when composting is done with the aid of earthworms.

Vermicompost enhances soil structure, prevents erosion, and raises and maintains soil pH. Furthermore, vermicompost promotes soil moisture retention by increasing moisture penetration.

Benefits of vermicompost

- Vermicompost has biofertilizers, social issues, and a profitable enterprise.
- Vermiculture and vermicompost both improve soil fertility and reduce the use of harmful chemicals, with a higher nutritional profile than traditional compost.
- Vermicomposting is essential for social and environmental protection, as it reduces the use of chemical fertilizers and reduces the amount of waste produced by urban areas. Earthworms feed on industrial, urban, domestic, agricultural, animal, paper and solid waste, and wastewater.
- Vermicompost has a better benefit-cost ratio and net profits, increasing technical efficiency and productivity, and reducing the need for chemical fertilizers.

VII. conclusion

Although there is a plethora of research literature on “Bioremediation of Organic waste through Vermicomposting for Sustainable Agriculture” most of the studies have been done for the efficient of developed world. In India, a very limited research has been done on this burning topic. None of the few studies conducted in India have explored the detail of the performance so far. The present study makes an attempt to fill the voids and aims to investigate to highlight the potential of microbial amendment during vermicomposting for bioremediation of industrial and agricultural waste.

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