Potential of Vermitechnology as an eco-friendly approach towards the sustainable management of agro-eco regimes: A Review

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Vermitechnology for the eco-friendly management of agricultural systems.

ABSTRACT

Improper practices of bio waste disposal collected from different resources has led to deterioration of soil regimes, water resources and the atmosphere besides accompanied serious health risks to the mankind. Vermitechnology is a technique for transformation of these biowastes into useful biofertilizer by employing earthworms. The present review discusses the vermiremediation of biowastes collected from weeds, garden refuse, kitchen waste, from municipal, biomedical, industrial and pharmaceutical sectors to produce a beneficial vermicompost that not only has the potential to control water, air and landfill pollution while maintaining soil profile and solving waste disposal problem but also having high nutrient value in terms of NPK to increase the yield of crops.

KEY WORDS: Vermitechnology, Vermicomposting, Vermiculture, Earthworm, Biofertilizer, Vermicast.

1. INTRODUCTION

Rapid Industrialization, urbanization and ever increasing human population has generated bio wastes at an alarming rate, the management of which is a matter of utmost concern. Improper disposal and handling of bio wastes originated from agriculture, industries, forests, rural and urban areas not only lead to nutrient loss, environmental pollution, landfills deterioration, disposal problem but also have accompanied serious health risks. (Elkington and Hartigan, 2008). Vermitechnology thus is a technology for vermitransformation of several kinds of biowastes into useful biofertilizers (Yuvraj et. al., 2020).

Vermiculture is a technique of raising earthworms, whereas vermitechnology is the practice of utilizing earthworms to solve solid waste problems by converting waste into vermicompost. Vermicomposting is the process of producing compost by use of earthworms in which organic wastes are converted into highly nutrient rich fertilizers (Gajalakshmi and Abassi, 2004). This fertilizer is known as vermicompost and it is a finely divided peat-like material with high aeration, porosity, drainage and moisture-holding capacity (Ismail, 2005; Edwards et. al., 2011) Vermicompost is an organic fertilizer rich in NPK, micronutrients, macronutrients, soil microbes like actinomycetes, phosphate solubilizing and Nitrogen fixing bacteria. It is an excellent growth promoter and protector for crop plants (Sinha et. al., 2011; Chauhan and Singh, 2015) Besides having high nutrient content, it has pesticidal properties too and releases nutrients slowly as compared to chemical fertilizers.

An important pre-requisite in vermitechnology is the segregation of wide array of biodegradable and non-biodegradable wastes, disposal of which poses a problem in itself. The present review focuses on the potential of vermicomposting in mitigating solid organic wastes of different kinds and producing biofertilizer of rich nutrient quality. Earthworm gut serves as a congenial space for the microorganisms and these microbes secrete enzymes which aid in decomposition of the complete organic compounds into simpler molecules. The nutrient value of the biofertilizer is very high in terms of NPK status which is like getting “wealth out of waste” (Elkington and Hartigan, 2008)

2. Different types of organic wastes: Vermitechnology is considered a safe, clean, economically viable, sustainable and effective technology to recycle food waste. This solves the problem of disposing off food wastes, less emission of green- house gases, reduced consumption of freshwater and energy in food processing otherwise and least occupation of land resources. Wastes often contain heavy metals or other organic pollutants that pose a challenge for adopting such biological treatments. At the same time a substance is produced that could be useful for agriculture and horticulture (Khan et al, 2019). Various organic wastes such as kitchen waste, sewage sludge, animal manure, fruit and vegetable wastes, soybean meal, sugarcane bagasse having rich lingo-cellulose content have been studied as feedback stock for vermicomposting (Alavi et. al., 2017; Khan et.al., 2019; Bhat et.al.,2015).

Fig.1. Various Inputs for preparation of Vermicompost

2.1. Detoxification of weeds: Vermicomposting is an aerobic degradation of organic compounds where earthworms convert organic compounds into humus like substance (Munroe, 2007). The issues of terrestrial weeds like *Parthenium hysterophorus* have been solved by Rai and Suthar, 2020; Sharma and Chowdhary, 2020; Devi and Khwairakpam, 2021, for *Lantana camara* by Devi and Khwairakpam, 2020 a, b and for *Mikania micrantha* by Kauser et.al., 2020 by simple vermicomposting which took an average 60-90 days to convert organic matter into vermicompost. After vermicomposting, total Nitrogen, phosphorus and potassium were found to increase with a percentage change of 74.74%, 91% and 47.2 % respectively as compared to the initial values (Devi and Khwairakpam, 2021). On the contrary, Kauser and Khwairakpam, 2021 succeeded in production of nutritional vermicompost within 30 days by a two- step composting technique including initial 10 days in vessel composting followed by a 20 days of vermicomposting process. These weeds can be used as organic inputs and vermicompost so produced can be used for soil remediation which is a good management practice for disposal of invasive weeds.

With the help of vermicomposting, organic biomass of two weeds *Ageratum conyzoides* and *Parthenium hysterophorus* could be transformed into a quality end product, proper management of which after eradication would have been a problem. Different proportions of each weed with cow dung had been processed through vermicomposting. Enhanced values for nitrogen (2.83 %), phosphorous (10.91 g/kg) and potassium (3.93%) were observed. Weed management through vermicomposting was found to be a promising method as it is cost-effective and environment friendly to recover nutrients of organic wastes (Devi and Khwairakpam, 2022)

Another invasive weed *Mikania micrantha* biomass was converted into a benign fertilizer. The invasive weed causes phytotoxicity in surrounding plants. A ratio of 5:4:1 was used for *M. micrantha* weed, cow dung and saw dust along with the monoculture of earthworm namely, *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx ceylanesis.* Highest nitrogen of 3.08%, total phosphorus 13.24 g/Kg with *E. fetida* with its least mortality rate (Kauser and Khwairakpam, 2021). Sheikh et. al., 2021 unveiled the efficiency of psychrophilic *Aporrectodea caliginosa* in deciphering the nutrients from Dalweed and cow manure with biooptimization of coprolites.

2.2. Agro-waste: Different organic wastes once combined with cow dung results in better vermicomposting capacities (Gong et. al., 2019). Sugarcane bagasse and such lingo-cellulose rich materials enhance the C/N ratio of vermicompost (Bhat et. al., 2015). According to Zhang and Sun (2018) soybean meal having amphiphilic protein can act as surfactant in composting allowing exposure of lignin and cellulose to enzyme attack by reducing surface tension and producing an improved quality compost (Zhang and Sun, 2018). The microorganisms dwelling in the earthworm gut are held responsible for converting agricultural waste into organic fertilizer (El-Haddad et. al., 2014). Cai et. al., 2022 concluded that soybean meal and sugarcane bagasse in 1:1 ratio as feedstock for vermicompost could promote the mineralization and nitrification, improved pH, EC, nutrient-retention capacity, microbial numbers and enzyme activities, concentration of humic substance, phytotoxicity, growth and reproduction of *Eisenia fetida.*

2.3. Kitchen refuge: For conversion of kitchen waste into organic manure the most important species employed are *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavates.* Alshehrei and Ameen, 2021 suggested *Lumbricus rubellus* as a good type of vermicomposting worm. Setiani et. al., 2021 suggested 46% saw dust, 27% vegetable waste and 27% banana peels for vermicomposting method in their experiment. Banana peels and saw dust are otherwise not processed and their disposal in landfills and burning of saw dust causes environmental pollution. Katakulla et. al., 2021 reported high organic Carbon content in banana peels and saw dust so that vermicompost produced was found to have high C/N ratio. Mago et. al., 2021 reported the potential of residual mass from two cruciferous vegetables in vermicomposting. Cauliflower and cabbage residual biomass mixed with 60% cow dung was proved to be a promising input for vermicomposting leading to gain in earthworm biomass from 646 to 809 mg, number of cocoons from 84 to 108 and growth rate of 2.1-2.7 cocoons/ worm. Also, an increase in total nitrogen from 49.3 to 85.3 %, total available phosphorus from 68.2 to 98.1 % and total potassium from 91.8 to 120.3 % was observed.

2.4. Municipal waste: Khawairakpam and Bhargava, 2008 produced good quality vermicompost by *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavates* in individual and combinations and could successfully and safely reuse and recycle sewage sludge without having any adverse effect as the heavy metals Cu, Mn, Pb and Zn were found within permissible limits. Vermicomposting increased electrical conductivity 47-51%, total nitrogen 2.4-2.8 times, potassium 45-71%, calcium 49-62%, sodium 62-82% and total phosphorus 1.5-1.8 times when compared with the raw sewage sludge. Only reduction in C/N ratio was found from 25.6 to 6.9 after vermicomposting.

2.5. Garden Refuge: Indrani et. al., 2018 elaborated vermicomposting with the use of compost earthworm species *Eisenia fetida* and clippings of dry grass, rice straw and cow manure. According to her, a combination of rice straw and grass gave highest rate of vermicompost production @105 Kg/m^2 followed by grass only @ 102 Kg/m^2 and then rice straw only @ 87 Kg/m^2 at the end of 120 days of recovery.

2.6. Industrial waste: Even environment friendly management of textile mill waste water sludge could be possible by using epigeic earthworms though there was bioaccumulation of heavy metals and production of metallothionein in the process which was within permissible limits and to reduce that further, a varying proportion of cow-dung was recommended (Yuvraj et. al., 2020). Sohal et. al., 2021 assessed the nutrient changes, heavy metals and genotoxicity before and after vermicomposting of thermal fly ash using *Eisenia fetida*. After vermicomposting thermal fly ash was found to be transformed into an eco-friendly, nutrient rich and detoxified manure.

2.7. Pharmaceutical waste: Singh et. al., 2022 suggested vermicomposting as the cost effective, eco-friendly and efficient technology for treatment of the sludge from pharmaceutical industries, incineration of which could have led to addition of dioxin and other such toxic components and landfilling of these is capable of releasing leachate to further pollute soil and water. Vermicomposting is considered the most promising and viable solution to avoid these problems as it has double edged advantage of producing NPK rich biofertilizer and at the same time reducing pollution (Bhat et.al., 2015) Singh et. al., 2022 also reported vermiremediation of allopathic pharmaceutical industry sludge amended with cattle dung employing *Eisenia fetida* and production of a nutrient rich, stable, detoxified and mature vermicompost for agriculture purposes.

The compost so produced was found to have decreased electrical conductivity from 29.18 to 18.70 %, total organic carbon from 47.48 to 22.39 %, total organic matter from 47.47 to 22.36 % whereas, increased pH from 12.94 to 17.80 %, total nitrogen from 69.57 to 139.58 %, total available phosphorus from 30.30 to 81.56%, total potassium from 8.82 to 22.22 % and total sodium from 50.56 to 62.12%. Heavy metals like Cr, Cd, Pb and Ni were found to decrease while Zn, Fe and Cu increased significantly. This could prove a stepping stone in the management strategies of allopathic pharma industry sludge.

2.8. Biomedical wastes:

Vermicomposting with biomedical waste ash employing *Eisenia fetida* was done to obtain a nutrient rich, detoxified and physico chemically stable product to be used for agricultural practices while solving the problem of management of waste ash. Levels of total nitrogen (0.26-1.82), total available phosphorus (0.22-0.64), total potassium (2.05-12.08), total sodium (47.5-92.2) were found to increase within permissible limits (Sohal et. al. 2021).

2.9. Medicinal herbs: Waste biomass of two medicinal herbs *Zingiber officinale* and *Curcuma longa* were vermicomposted with an epigeic earthworm *Eisenia fetida* that caused neutral pH, enhancement in micronutrients, total nitrogen, potassium, available phosphorus, total magnesium and calcium. This also reduced the phytotoxicity of the waste biomass (Das et. al., 2021).

3. RESULTS

In another study it was found that in pot experiments, addition of vermicompost from cow dung and mineral vermireactor promoted the growth of celery cabbage and reduced the content of lead in its edible parts and also reduced the availability of Pb in the soil. Hence arising the possibility of use of cow dung and mineral vermireactors to optimize the properties of vermicompost for use as a soil amendment practice which can remediate lead contamination (Wang et. al., 2022).

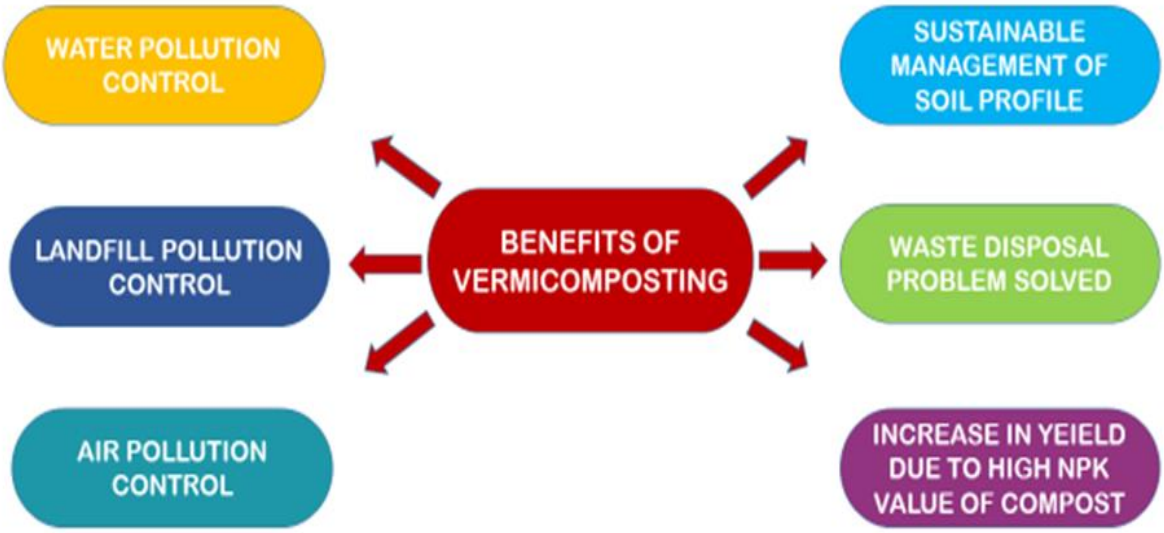

Fig.2. Advantages of Vermicomposting

4. CONCLUSION

Vermicomposting is the need of the hour as it leads to conversion of waste into wealth while solving the problem of waste disposal. The vermicompost produced is rich in NPK, micronutrients, macronutrients, enzymes, organic and inorganic minerals. This is a cost effective method to curtail the use of xenobiotics. It can be used both in-door and out door and least management is required in the process and can be adopted as the best practice for promoting agro-eco-regimes towards a greener and safer future. At the same time improper disposal and handling of bio wastes of the origin from agriculture, industries, forests, rural and urban areas no more leads to nutrient loss, landfill deterioration, environmental pollution, serious accompanied health risks rather by employing vermicomposting there is successful and efficient transformation of several kinds of biowastes into useful biofertilizers (Yuvraj et.al., 2020).

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