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REVIEW ARTICLE **OPEN ACCESS**

Key insight to earthworm biotechnology and ecology

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ABSTRACT
The phylum Annelida is comprised of soft bodied soil inhabitating creatures called as Earthworms. These creatures possess immense capability of enhancing soil fertility by tilling soil and making it highly porous and available for gaseous exchange and nutrient absorption making it more fertile. They contribute majorly and indirectly to field of biotechnology through process of Vermiculture, Vermicomposting, Vermifilteration, Vermiremediation and Vermiwash formation. Through process of Vermicomposting earthworms performs bioconversion of plant's parts litter by breaking them down and further incorporating them into the soil, potentially effective economic fertilizers through inculcation of biotechnological approach as well. In this study, we summarize the function of earthworms as key role players in field of agriculture biotechnology and as ecosystem service providers.
Key words: *Earthworm, biotechnology, Vermicomposting, Vermiwash and Vermiculture.*

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INTRODUCTION

Annelida is the phylum that includes a vast number of species and Earthworms are of one of them. It belongs to the Class Chaetopoda, and Order Oligochaeta which occupies an ordinary stance in the animal kingdom. These are the first species that possess multicellular, eucoelomate, and invertebrates' structures that successfully in habituated to the terrestrial environment, and in return, they are very beneficial to the environment. These species generally live under the soil, some are in microscopic form and some can be seen by naked eyes. They lavish their life in the soil for completing their life cycle in return they are propitious for the top layer because of their great extent in abundance, richness, and distribution. They act as "bioindicators" which helps to know the current health of the biosphere. The indulge capability of tilling and shallow plowing helps in enriching the soil composition by making it more fertile and so-called "friends of farmers" which helps the farmers in intensifying their crop production [1]. They possess both male and female sexual organ hence called hermaphrodite with the segmented, bilaterally symmetrical body having external gland for producing egg case also called a cocoon, prostomium is present in front of the mouth which are sensory lobe of the species and the last one is anus which is located at the end of the animal body having setae on both segment[2].knowing their incompetence, the research in earthworms had taken a limitless place in animal science research in every country as they are efficacious to the environment in addition to the mankind. Soil community is itself a huge network that assists in forming the complex food web and functions of different decomposers and predators[3], To complete this food web earthworms are one of the most essential species which is required to take part in this whole process whether to help in the process of decomposition or providing nourishment to the soil.

Based on the morphology and anatomy depending upon their special features or how they react or act in the corresponding environment which parts that particular earthworm from other earthworms hence they are classified into three types:

1. **Anecic** (Greek for "out of the earth") – these types of earthworms are also called "Night Crawler" these are burrowing worms that come to the surface at night to drag food down into their permanent burrows deep within the mineral layers of the soil such as Canadian Nightcrawler.

They are one of the largest species among all the earthworms that can grow up to 14 inches. Some websites do sell them as they are used as live fishing bait in some countries.

2. **Endogeic** (Greek for "within the earth") – these types of earthworm come to the surface very rarely due to lack of exposer to the sunlight they lack pigment so they are mainly light in color like pink, grey or sometimes white. Their burrows are shallower as compare to the Anecic earthworms also their movement is parallel to the surface.
3. **Epigeic** (Greek for "upon the earth") – these are the most important earthworms among all the other earthworms as they live in surface litter and feed on organic matter. They do not have permanent burrows and these are mainly used for "vermicomposting" as they decompose organic matters [4]. Example. Eiseniafetida. They are also characterized under different names like red wiggler, red California, tiger worms, etc.

COMMON NAMES OF EARTHWORMS IN INDIA

India's richness in terms of caste, religion, the community is so vast to understand so people belonging to different groups of India have named earthworm according to their religion or language as shown in Table 1. [5]

Table 1. Name of useful earthworms in a different language

Name	**Language**
Kencho	Bengali
Yalisiya	Gujarati
Kechuva	Hindi
Munhulla	Kannada
Mannira	Malayalam
Gaandul	Marathi
Zia	Oriya
Mannpuzhu	Tamil
Vaanpaambu	Telegu
Gandoya	Punjabi

VERMICULTURE

Vermiculture (derived from the Latin "vermis" meaning worm and culture means to "grow something") by the name itself it reflects that it deals with the production of earthworms. Vermiculture is one of the most productive ways to use earthworms for humans as well as for the environment. As we all know their aptness of decomposing organic matter and converting it into compost which is useful for crop production is an inbuilt feature in them. The compost made by them is completely organic and have multiple benefits in the crop field and for making compost we need worms for decomposing the organic matters and it is not possible to wait for the natural production of worms in such an inordinate amount so, worms are grown by giving them artificial and favorable conditions during their cultivation and this whole process of growing worms in an artificial way is termed as vermiculture[6].

Growing worms is easy but if the process and artificial conditions are followed in a proper way than earthworms can be grown and used for crop production. These will hardly have disadvantages as they are made up of organic matter means fully organic. The requirements are listed below:

The requirement for vermiculture:

1. Earthworm
2. Water
3. Agricultural wastes
4. A place under the shed
5. Cattle dung
6. Organic and biodegradable materials

Though growing worms and letting it decompose organic matter is easy but sometimes the cultured worms may or may not be fit or decomposition process which may harm the other ongoing process. The following are the requirements for a perfect worm to undergo decomposition in its life.

Composting worms require the following features as per the given reference [7].

a) The life cycle must be short.
b) High potential for the consumption of all types of organic waste.
c) Forbearance under any change occurs in the environmental conditions.
d) Cocoon formation must be at a high rate.

VERMICOMPOSTING

Vermicomposting is a type of process in which certain species of earthworm are used in the process of degrading organic waste which results in forming organic compost. In this process, both earthworms and microorganisms equally participate for the better end-result. The conversion of organic matter takes place by earthworm feeding on organic materials and passing it to its digestive system by giving out in granular form (cocoons) which is known as vermin composting. This exceptional use of earthworms not only helped to decompose the organic wastes but also provide organic compost or fertilizers which are very useful in enriching the crop field. The most common worms which are used for vermin composting are *Eisenia fetida* and *Eudriluseugeniae* and for Indian conditions, *Perionyx excavatus* can be used. [8].

Eudriluseugeniae **,** these species are also called African Worm or Night crawler. Their growth is mainly rapid and is light in color as their name Nightcrawler itself reflects the fact that they only appear at night and during that time they drag food under their burrows from the surface.

1. It is an ideal specie for the production of protein.
2. It is a righteous species for use under tropical surroundings.[9]

Eisenia fetida are those worms that belong to the epigenetic earthworm group which live near or near the soil surface, typically can be found in the litter of forest soils or organic-rich materials (such as compost). They mainly found on surfaces like in organic matter or in forest litter means they don't make burrows to live in.

1. It is used as an organic waste decomposer.
2. It is even considered to have potential as a protein source [10]

Perionyx excavatus, the research study divulges that copulation is not an imperative feasible cocoon production. It specifies that it may be parthenogenetic feasibly proficient for alternating between modes of reproduction. It grows reasonably slow as compared to other vermin composting species.

1. It procures sexual maturity much earlier and the cocoon reproduction sustains at a high rate.
2. It is contemplated to be a potential waste decomposer.[11]

Preparation of compost as per protocol explained in [12].

1. Dig two pits in the backyard or take large drums.
2. Fill one of the pit or drums with biodegradable wastes.
3. To avoid any foul smell escaping cover the waste by a layer of soil.
4. To keep the soil and waste wet sprinkle water.
5. According to the availability of the waste time to time throw it in the pit or drum and layer it with sand.
6. Sprinkle water every time.
7. Repeat the whole process until the pit or drum is filled.
8. In case when the pit or drum is filled, sprinkle water at intervals of two or three days.
9. The sprinkling of water will continue till one month.
10. In the meantime, the procedure should be repeated for the other pit or drum.
11. In the case of drums provide a small hole at the top to removes excess water.
12. Cover the upper area if required.

VERMIFILTRATION

Vermifiltration is an economically inexpensive and environmentally feasible technology. In general, it used for the treatment of wastewater. This whole procedure is using various natural elements as a media still, there is abiding effective performance and field-scale utilization of this system. It can remain a provocation due to some structural and functional restrictions. Vermifilter was generally evaluated as they use vary based on technique using natural ingredients such as river bed material, wood coal glass balls, and mud balls and employing Eiseniafetida as an earthworm species. And the further study was probably carried for 90 days. In this technique there consists of a synchronous treatment of sludge of the multiple numbers of earthworms as a low-cost sustainable technology. Therefore, many recent types of research are being focused on integrating vermin filters with various macrophyte filters for the efficient treatment of wastewater, and its steady operation and large-scale applications are also focused. It includes low capital, operating cost, and simple process management.

The current review describes the procedure and benefits of vermin filtration alone and in other cases like amalgamation with macrophytes and other different kinds of microorganisms filter for detachment of various pollutants from wastewater such as organics, nutrients and pathogens [13].

Vermifiltration technology is a suggested solution for sewage wastewater treatment in emerging countries. Adding more resources to the design and construction of domestic vermifilters is essential for treating wastewater. Vermifiltration of sewage wastewater results in treated water which can be used for irrigation purposes and a bio-fertilizer, vermicomposting instead of unwanted sewage sludge is also obtained. Vermifiltration of sewage wastewater resulted in neutralized water pH, decreased BOD, COD, TDSS, and turbidity. Additionally, the wastewater treatment can also be helped by the microbial-geological system of the control bio-filter bed without earthworms. Sewage water treatment can be successfully treated by the merged effect of the Eiseniafetida worms and the microbial-geological system **[14]** [15].

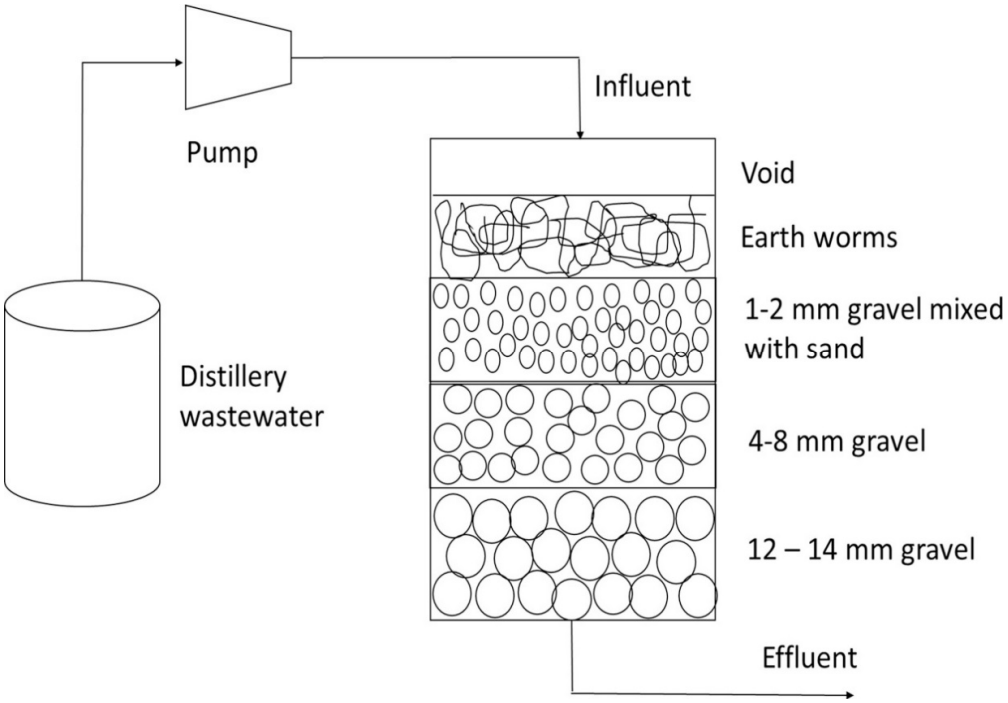

Fig. 1. Vermifiltration technology working principle [Source: M.M.Manyuchiab et al., 2018]

VERMIREMEDIATION

It is the technology that expands and uses earthworms to remediate organically and the soils which are contaminated and have been acquiring attention from researchers gradually. The amount of presence of micro-organisms is the feature of good and pure soil. Everything decomposes in the soil but these micro-organisms help plants and animals to decompose. It also helps in up taking the following minerals and nutrients into their protoplasm and resulting in them available for plants. There are many areas where the presence of nutrients in the soil is less because of the dumping of industrial waste so it is necessary to bring back the microbial life to that particular area for the basic flow of nutrients. These consist of various general aspects of term remediation which may include its concepts, process of organic polluted soils, its general advantages and disadvantages, and the different methods for enhancing term remediation and other several peripheral issues. Earthworms encourage and accelerate several microbial activities by creating their enthusiastic conditions for bacteria, and other microorganisms and virtuous soil aeration. This proficiency can be used to clean up tarnish sites, and can occur on- or off-site, or can be conciliated by the mixed microbial syndicate or pure microbial strains and plants also known as phytoremediation [16].

MERGED APPLICATION OF VERMIREMEDIATION AND PHYTOREMEDIATION FOR ENCOURAGEMENT OF SOIL

Although both Vermiremediation and Phytoremediation are perceptible and very efficacious techniques for soil management, if used in coalition this proficiency can bring prodigious results. In various vitiated environments (e.g. municipal dumpsites, industrially polluted lands, agro-chemically contaminated soils, etc.) where the soil is already contrived by various adulterants, phytoremediation furnish a feasible solution for deracinate out the pollutants and swabbing up the environment. On the other hand, term remediation provides an instrumental clarification for tackling the waste which can further vitiate that

environment. Vermiremediation also engenders very helpful contrivance such as vermicast and vermiwash]. These contrivances further supplement phytoremediation by providing non-polluting aliment sources for plants used in phytoremediation. It will escalate the growth rate of plants and thus their phytoremediation dormant. Also, the vermicast and vermiwash are very systematic alternatives for befouling agrochemicals used in agriculture. Thus, while fumigating the agricultural soil wielding plants, vermicast and vermiwash can be used to escalate and perpetuate the soil vittles pool. Thus, sensational results can be accomplished by using vermiremediation and phytoremediation in tandem [17].
Vermiremediations is a newly apprised technology that centers upon the postulate of strong environmental engineering. The present research determines that the earthworms are skilled in debased low concentration of hydrocodone consolidation in blight soil, also they could integrate with microorganisms and revitalize their activity and growth during their interplay with contaminants [18].

VERMIWASH

Vermiwash is an organic percolation derives from units of vermicomposting. The water that passes through the vermiculture, generating in the washing of the live and lifeless earthworms, soil microorganisms, and mortified organic matter, carries all the deliquesce substances. It is rich in dissolved victuals and amino acids and therefore, is a good provenance for plant nutrients in biological agriculture. Vermiwash is rich in disintegrated nutrients and amino acids which are easily accessible for plants. It is also a benign and eco-friendly compound, which apprehend the bacterial thriving and forms a preserving layer for their quiddity and growth. Vermiwash at 5-10 percent dilution suppresses the mycelial growth of morbific fungi. It also can skirmish worms thereby saving the crops and their efficiency. As a foliar spray, it was delineated to initiate flowering and long-lasting inflorescence. It can also be cast-off as a liquid fertilizer pragmatic to the rhizosphere. No pathogen can persist in this fluid, thereby defending the earthworms from the diseases caused by pathogens. It acts as a plant tonic and thus helps in minimizing many plant pathogenic fungi. It expands the rate of photosynthesis in crops/plants. It also increases the number of micro-organisms in the soil which mitigates in decomposing soil organic matter [19].

ENVIRONMENTAL AND ECONOMIC BENEFITS OF VERMICULTURE

Sustainable agriculture is a procedure of learning new and creative methods developed by both farmers and the farm scientist and also learning from the historical knowledge and practices of the farmers and achieving what was good in them and also appropriate in present times. Vermiculture was rehearsing by historical and ancient farmers with boundless economic advantage for them and their acreage. There is a need to resuscitate this 'traditional concept' through voguish scientific knowledge-a 'Vermiculture Revolution'. It was stated that 'farmer's friends' by Sir Charles Darwin. There is great profundity when he stated this statement and recommended to use them for farmer's benefits. It is necessary to obtain an implementation for food and agriculture production system which must certify:

1. High capacity and rationality of yield over the years.
2. Productivity with the slightest use of water and even encourage sobriety or heavy rainfall.
3. Prolongation of crop diversity (biotopes).
4. Conservation of soil, water, and air standard in the farm environment.
5. Preservation of tolerant organisms (predators) flora and fauna in the farm ecosystem.
6. Preservation of groundwater table.
7. Preservation of good health for all.
8. Mitigation of water and energy use.

Sustained vermiculture execution and use of vermicompost in farm soil over the years would meet several of the above stipulations for truly sustainable agriculture. Vermicompost rich in the microbial medley and plant accessible nutrients; ameliorate the moisture dependency capacity of soil shorten water for irrigation. It also enhances physical, biological, and chemical patrimonies of soil; soil percolative, and softness. There are also ample opportunities in the depletion of uses of energy and GHG effusions in vermicompost production locally at farms by the farmers themselves [20].

CONCLUSION

All vermiculture technologies – vermicomposting (for solid waste management), term filtration (for wastewater treatment), vermiremediation (for land and soil decontamination) and vermiagro production (use of vermicompost for farm production) can be used as a most inexpensive and feasible surrogate to some of the 'environmentally unfriendly' civil engineering procedure to achieve those aspirations of inauguration while also significantly minimizing waste and pollution and the ejaculation of greenhouse gases (GHG). Accounting for the emission of GHG which persuades 'global warming' has become requisite

in all modern developmental programs. Vermiculture is an expanding industry all over the world and a 'waste-less' exploit as all by-products (earthworms biomass) and end products (nutritive vermicompost, treated clean and sustaining water and rectified fertile land and soil – all fumigated and detoxified) are economizing 'useful'. Earthworms are truly justifying the suspicion and gratifying the dreams of Sir Charles Darwin who called them as 'undiscovered soldiers of mankind' and 'friends of farmers' and said that 'there may not be any other personage in the world that has played so important a role in the history of life on earth'. It is also certified by the Great Russian scientist Dr. Anatoly Igonin who stated that 'Nobody and nothing can be collocated with earthworms and their positive ascendency on the whole living world. They create soil and amend soil's prolificacy and provide mordant ecosystem functions like decontaminating, neutralizing, protective, and productive.

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