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The science of vermiculture: Use of earthworms in organic waste management

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Abstract
Vermiculture has been practised for over a century, but in recent years it has gained popularity due to ecological demands such as waste management, soil purification, and sustainable agriculture. Earthworms serve as biological stimulators, chemical degraders, aerators, and crushers in the soil, among other things. They discharge a variety of enzymes, including proteases, lipases, chitinases, cellulases, and amylases, which swiftly biochemically transform the proteinaceous and cellulose components contained in the organic wastes that originate from farms, dairies, gardens, and homes. The process is odourless because earthworms create coelomic fluids, which are anti-bacterial and kill pathogens when added to the decaying waste biomass. Verm wash and vermicompost are products that act as biological pesticides and biological fertilizers, help to improve soil biological and physio-chemical parameters, and act as soil conditioners that subsequently improve food production and soil health.

Keywords: Cellulose, pathogens, enzymes, sustainability, and nutrients content

Introduction
The maintenance of a healthy ecosystem in nature depends on the management of solid waste. There are several issues with the environment related to the large production and buildup of organic waste. It damages the fertility of the land, pollutes the water and the soil, and has a negative impact on human health. All these environmental issues may be avoided by pre-processing the organic waste before releasing it into the natural environment (Devi P *et al.*, 2022) [2]. The process of organic biodegradation is required to produce high-quality goods and the safe disposal of organic waste. Using particular species of earthworms, a technique known as "Verm technology," it is possible to process the breakdown of organic waste by saprophytic organisms (eating dead and decaying stuff). Vermicomposting and vermiculture are two subcategories of verm technology. Earthworms' activity is employed in vermiculture to transform organic waste into beneficial fertilizer (vermicompost). Vermicomposting is a farmer-friendly method that produces fertilizer that is effective. The earthworms are fed while being cultured utilizing variables including temperature, moisture content, and pH.

About Vermiculture
Vermicomposting and vermiculture are two subcategories of Verm technology. Earthworms' activity is employed in vermiculture to transform organic waste into beneficial fertilizer (vermicompost). Vermicomposting is a farmer-friendly method that produces fertilizer that is effective. The earthworms are fed while being cultured utilizing variables including temperature, moisture content, and pH (Gopinath, K. A., *et al.*, 2010) [3].
The segmented, elongated, thin, cylindrical, bilaterally symmetrical, and boneless earthworms have no bones. The body has a thin cuticle layer, is lustrous, and is dark brown in color. They weigh between 700 and 1400 milligrams after ten weeks. Their strong gizzard grinds food down to a size of 2-4 microns. The intestines of the earthworm are home to millions of rotting bacteria. They are bisexual creatures; thus, they commonly cross-fertilize. Before parting, the worms may copulate for almost an hour. A cocoon is afterwards ejected by each worm's clitellum, into which sperms crawl to fertilize the eggs. Up to three cocoons per worm may be produced each week. In each cocoon, 10 to 12 tiny worms are produced (Patwa, A., *et al.*, (2020) [6]. Earthworms grow throughout their lifetimes, with new segments continually multiplying in a region called the "growth zone" directly in front of the anus. Up to 70 to 80% of the dry weight of earthworms is made up of protein rich in lysin.

They can be used as animal feed. A typical earthworm lives between three and seven years, depending on the species and the environment (Singh, S., *et al.*, 2022) [2]. Earthworms are commonly classified as saprophagous, although they can also be separated into geophages and detri-vores based on how they consume. At or near the soil surface, detri-vores eat dead roots, plant litter, other plant debris, or animal excrement.

Worms of the epigeic and anecic types are collectively referred to as humus formers and also known as detrivorous. Endogeic earthworms known as geophagous worms consume a significant portion of the biologically rich soil below the soil's surface while feeding. Examples of detritivorous and geophagous.

Table 1: Representing the earthworm species

Detrivorous	*Eisenia fetida, Perionyx excavatus, Eudrilus eugeniae, Polypheretima elongata, Lampito mauritii, Octochaetona serrata*, and *Octochaetona surensis*
Geophages	*Octochaetona thurstoni* and *Metaphire posthuma*

Earthworm Growth Stages

Vermiculture produces vermicompost using three main types of earthworms. Litter, topsoil, and subsoil are all common places to find these earthworms. Most of the criteria used to classify the groups are their behavior and habitat. Anecic, epigeic, and endogeic are the three types.

Epigeic is a Greek word that means "from the soil." This species, which inhabits places with a lot of organic materials, feeds on decaying plant roots, leaf litter, and animal excrement. These earthworms don't dig long-term burrows. Due to their black skin, epigeic species' worms are highly pigmented. The vermicomposting process primarily uses these kinds of earthworms. For instance, Perionyx excavates and *Eisenia fetida* excavates (Khan, A. H., *et al.*, 2022) [4].

Greek for "inside the ground," endogeic. This species subsisted underground and consumed decayed organic materials and dirt. To travel around, they dig horizontal burrows in the ground. For instance, *Octochaetona thurstoni* and *Metaphire posthuma*.

Anecic: A Greek name meaning "from the earth." This species digs long-lasting vertical burrows in the ground and emerges at night to feed. They have darker heads and are paler toward the end of their tails. Consider *Lumbricus terrestris*.

Fig 1: Life cycle of earthworms

Ecology of the earthworms

As burrowing creatures, earthworms physically eat their path through the soil to create tunnels. Earthworm dispersal in the soil is influenced by things like soil moisture and the availability of organic matter. The amount of available organic matter and the soil's pH (6.5-7.5) all affect the dispersion of earthworms in the soil. They may be found in a variety of environments, especially those that are moist and dark. Some species find a great attraction in organic materials like humus, cow dung, and kitchen scraps. The touch, light, and dryness are all particularly sensitive to earthworms. They may rise to the surface of the soil and become waterlogged conditions. Temperature plays a key role in earthworms' sustainability and their metabolism, rate of reproduction, and growth of earthworms. The temperature below 10 °C leads to stress on earthworms and affects their growth. The temperature is more than 35 °C, which leads to the death of earthworms. The optimum temperature range of earthworms is 15 °C to below 35 °C and the earthworms have high growth and reproductive at 25 °C. The earthworms take a breath through the skin with the help of moisture in the soil, which contains 75 to 90% water. Less than 50% of water can reduce the respiration rate of earthworms because need to maintain the moisture. The optimum moisture for earthworms is 70% to 80%.

The use of earthworms in organic waste management:

At present days organic waste accumulation is the most drastic problem in the world and it causes pollution and health problems and affects the water bodies. Improper management of organic waste like the burning of organic waste. This type of condition leads to global warming. To avoid such problems earthworms help us. A significant portion of the weight or biomass of invertebrates in soil was contributed by earthworms. They were initially referred to as the intestines of the earth by Aristotle, who highlighted their function in aerating the soil. We can control environmental pollution and manage our trash by using a variety of vermiculture approaches. Composting's main goals are to break down organic waste without losing too many nutrients and to create a finished product that is full of nutrients for plants. Vermicompost replacement with fertilizers will lower the financial input in agriculture. The primary food material for earthworms is organic waste like weeds, forest leaf litter, agricultural industry waste, etc. They also excrete pellets of feces known as vermicompost. This is abundant in macro and secondary elements, advantageous microflora, and plant growth regulators, among other plant nutrients. Environmental variables that affect earthworm growth and reproduction include temperature, bed moisture, rainfall, and relative humidity. These factors also affect the population in the field. Despite all other conditions being favorable, worm growth is adversely affected by a constant high temperature. In open-field vermicomposting sites, seasonal variations have an impact on the production of worm biomass and vermicompost. Diverse non-toxic organic wastes are composted using vermiculture technology. Earthworms perform as adaptable natural bioreactors, harnessing beneficial soil microflora and destroying pathogens to produce products such as biofertilizers, bioinsecticides, enzymes, vitamins, growth hormones, antibiotics, and proteinaceous worm biomass. In cities and towns around the nation, hundreds of tons of biodegradable organic waste are produced, which poses disposal issues. The use of vermicomposting technology may transform this trash into useful compost. This method lessens pollution and offers a beneficial alternative to chemical fertilizers. For ages, earthworms have been utilized to break down garbage and enhance soil structure. Vermicompost is being successfully marketed to farmers and gardeners throughout the world as a superior soil conditioner by an increasing number of companies using vermiculture technology.

Earthworm hatching, multiplication, and utilization of castings have all emerged as significant waste recycling techniques around the globe, and they are currently gaining popularity in various parts of the nation. Worms are used as versatile natural bioreactors in the vermiculture technique to effectively recycle non-toxic biological both solid and liquid wastes in the soil. It's more effective, cost-effective, ecologically friendly, and logistically possible than other recycling processes (Lim, S. L., *et al.*, 2015) [5]. It may be used to manage weeds and garbage from factories, the kitchen, and other places. It has been demonstrated that earthworm composting is a quicker, nearly odorless form of waste breakdown and composting than traditional composting technologies. since the result is "disinfected," "detoxified," and "very nutritious" vermicompost and vermi-wash.

Vermicompost is an organic matter, a biological process in which earthworm species are used to convert organic matter into manure. Vermicompost is rich in nutrients and thus used as a biofertilizer. Compost contains key nutrients for plants available form nitrogen, phosphates, potassium, magnesium etc.

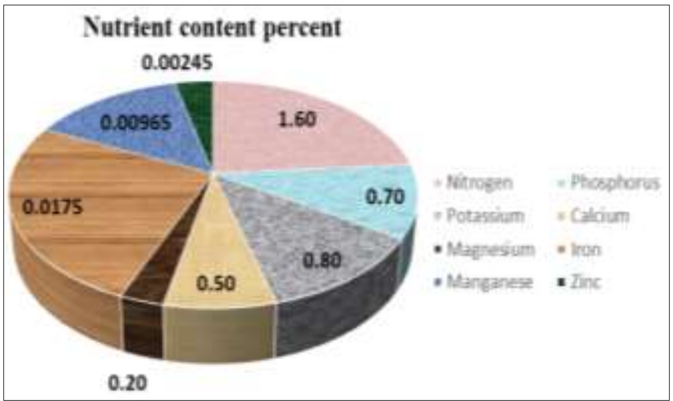

Fig 1: Showing the different nutrient content percent in vermicomposting

Verm wash is an extract collected from the passage of water through a column of earthworm action. This liquid contains water wash from the body of the earthworm and vermicompost Adhikary, S. (2012) [1]. Verm wash is a liquid fertilizer used as a foliar spray and used as a liquid manure. Vermi wash includes a variety of enzymes, plant growth hormones, vitamins, and micro and macronutrients that improve crop development and production and raise the resilience of crops to various diseases. The sustainability of soil and water is seriously threatened by the widespread use of inorganic fertilizers, pesticides, and herbicides in the current agricultural system. Furthermore, fertilizers contain macronutrients, Nitrogen, Phosphorous and Potassium micronutrients which include iron, copper, zinc, Boron, Molybdenum, Manganese, and Chlorine. The pH was 7.48.

Table 2: showing the different components and quantity percent and ppm amount

Component	Quantity
pH	7.48
Organic carbon	0.008%
Nitrogen	0.01%
Phosphorus	1.69%
Potassium	25ppm
Sodium	8ppm
Calcium	3ppm
Copper	0.01ppm
Ferrous	0.06ppm
Magnesium	158.44ppm
Manganese	0.58ppm
Zinc	0.02ppm

Other uses of earthworms

Earthworms have greater economic importance in the world. Earthworms look small but are directly or indirectly useful to humans. They are used as bait for fishing all around the world. They are forced out of their burrows to make massive collections using a variety of techniques. They make the greatest fish meal for aquarium fish. *Enchytraeus albidus*, a tiny white earthworm, is frequently seen growing in soil and is fed to aquarium fish and small lab animals. In many areas of birds, particularly robins and hens, are really consumed as food by primitive humans. Frogs, moles, lizards, tiny snakes, centipedes, and other predatory invertebrates consume large quantities of them. Some countries used earthworms as human food. The earthworms are used for preparing medicine in Ayurvedic and Unani systems for bladder stones, gout, impotence, piles, diarrhea, piles and jaundice. They are now employed in a variety of expensive medications in India, China, and Japan.

Conclusion

In vermiculture culturing the earthworms provide favorable conditions like temperature (15 °C to 35 °C), and moisture (50% to 80%). Earthworms play an important role in nature reducing the organic matter in nature and producing humus (black gold) which is the product of organic waste, it gives nutrients to plants. Earthworms reduce the pollution that comes from organic waste and pathogenic diseases. Earthworms are used in other purposes, such as they are used as bait for fishing all around the world and used as food for aquarium fish and small lab animals and used in ayurvedic medicines for bladder stones, diarrhea, and jaundice etc.

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