Eudrilus Eugeniae: Detritivores and Ecologically Efficient Bio-Agents for Waste Management Technology

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Abstract

A few waste management technologies have been formulated and introduced, based on efficiency and sustainability, like vermiculture or vermicomposting technology, in which earthworms are the primary agents of decomposition and conversion of biodegradable waste into a soil amendment. Employing African nightcrawler (Eudrilus Eugeniae) to eliminate organic waste is ecologically efficient and environmentally sustainable. This study focuses on integrating the technology into biodegradable waste management in line with the Republic Act No. 9003 and other concurrent national and local environmental laws in the Philippines. Compared to other conventional methods, vermiculture or vermicomposting as waste management technology does not have any negative environmental impact. It typically reduces local and household waste. Transforms biodegradable waste into a rich soil conditioner that contributes to healthier plants and good produce. Promotes waste reduction at dumpsites and reduces greenhouse gas emissions of organic matter during the decomposition stage. Indeed, waste mismanagement can lead to significant environmental impacts that affect people's health and well-being, so continued development and strengthening of the remarkable benefits of vermiculture or vermicomposting technology in a broader landscape is positively encouraged. Future researchers may have to further investigate other valuable aspects of the African nightcrawler and its casting, besides agricultural advantages.

Keywords: african nightcrawler, vermiculture, organic waste, composting, substrate, earthworm

Introduction

Nature can exist without man, but without nature, no man can exist," is a popular saying about nature preservation, concerning the Local Government Code of 1991 or RA 7160, which provides the Local Government Units with the power to implement cleanliness and sanitation, and the Republic Act No. 9003, known as the Ecological Solid Waste Management Act of 2000 and the Local Government Code of 1991 or RA 7160. These acts are consistent with other solid waste management laws and regulations that foster the necessary institutional mechanisms and incentives to protect public health and the environment. Following the socially and ecologically acceptable disposal standards, the government sets guidelines and targets solid waste policies through source reduction and minimization measures, including sorting, recycling, recovery, and other household waste collection, treatment, and disposal at the appropriate material recovery facilities (MRF). Waste recovery facilities or landfills could not accommodate the continuous day-to-day outflow of waste. The best place where solid waste management must first occur is at the household level (Yoada et al. 2014). The growing population contributes to environmental damage than benefits (Akaateba and Yakubu 2013). People are encouraged to practice environmentally acceptable methods of using valuable resources, reducing waste, and conserving resources. Solid waste management must be a community's collective effort through the proper collection, transfer, recycling, and waste disposal (Bogoro Audu Gani and Bwala 2014).

Table 1. Salient Laws and Regulations Related to Republic Act 9003.

Year Enacted	Laws and Regulations
1938	**Commonwealth Act No. 383 – Anti-Dumping Law**
	Prohibits the dumping of refuse or substances of any kind into rivers.
1975	**Presidential Decree No. 825 – Garbage Disposal Law**
	Provides penalties for improper disposal of garbage and other forms of uncleanliness.
1978	**Presidential Decree No. 1152 – Philippine Environmental Code**
	Requires the preparation and implementation of waste management programs by all provinces, cities and municipalities.
1991	**Republic Act 7160 – The Local Government Code**
	Mandates the LGUs (Local Government Units) to exercise powers and discharge functions and responsibilities as necessary or appropriate and incidental to the efficient and effective provision of services and facilities related to general hygiene and sanitation, beautification, and solid waste collection and disposal systems.
1998	**Department Administrative Order No. 98-49**
	Provides technical guidelines for proper disposal of municipal solid waste.
1998	**Department Administrative Order No. 98-50**
	Provides procedure in identifying sanitary landfill sites and screening criteria for municipal disposal solid waste disposal facilities.
2001	**Republic Act 9003 – Ecological Solid Waste Management of 2000**
	Declares the policy of the state to adopt a systematic, comprehensive,, and ecological solid waste management program.

The world is facing an escalation of solid waste generation due to the growing population and drastic human lifestyle and activities, which has led to environmental deterioration. The rising population is the primary cause of environmental degradation, with its people using unsustainable technologies and too engrossed in consumerism, which ultimately produces too much waste (Baula, 2010). According to the World Bank, the increasing population, especially in urban areas, correlates with the unavoidable increase in waste generation. In addition, (Licy et al. 2013; Bhada-Tata and Hoornweg 2012) pointed out that commercial establishments and thriving informal settlers also contribute to pollution and marine ecosystem destruction as they deliberately dispose of the untreated waste directly into bodies of water. Man's health is compromised when rivers become stagnant due to waste accumulation (Paghasian 2017; Villanueva 2013). Eventually, this condition invites dengue-laden mosquitoes and other pests. Some resort to incineration; however, burning garbage can accentuate respiratory complications and air pollution as well, a clear violation of the Republic Act 8749 or the Clean Air Act, which, according to McDilda (2007), contributes to global warming being heightened already by methane gas emissions from waste dumping sites.

Given its limited technical and financial support, developing innovative and potential waste management approaches is a major challenge for national and local governments (Atienza 2008). Sustainability may ideally be a reality for smaller groups living in relatively equal societies, adapting appropriate green technologies, responsible consumption, reuse, and lower waste production (Asokan et al. 2007). The campaign for zero-waste management was a long-standing wake-up call following the Republic Act 9003. This law is designed following the alarming effects of uncontrolled waste disposal in the environment, which poses imminent health risks and harm to the ecosystem. Hence, social awareness and collaboration are crucial to waste management programs and realistic waste management practices (Punongbayan et al. 2014). Young people must be critical to environmental issues because they ultimately contribute to knowledge-based solutions to emerging environmental problems (Arora et al. 2012).

On the other hand, this situation also offers opportunities to manage waste with limited costs but higher efficiency while simultaneously providing livelihood by recycling and composting, taking into account the characterístics of the waste produced. According to Perez (2013); Punongbayan et al. (2014), disposing of and composting waste materials properly to the environment free from pests and hazards must be considered. Food waste must be collected and processed separately by composting them into fertilizers to prevent infectious diseases and epidemics. Bryndin (2020); Visvanathan (2006) observed that composting in developing countries has long been practiced at the household to municipal levels to mitigate waste build-up in the community. For example, composting has been done successfully in Dhaka, Bangladesh. This process is an ideal alternative to reduce and minimize the likelihood of soil pollution, as the study by Singh et al. (2011) suggested. Another environmentally friendly means of waste management is vermiculture or vermicomposting technology, a cost-effective, clean, and safe way to dispose of organic waste using earthworms as detritivores of organic waste materials, given that the earthworms eat them and the excrement becomes a useful fertilizer for growing crops (Akanbi et al. 2007).

Aim of the Study

The study aims to acquire a better understanding of integrating vermiculture or vermicomposting technology, particularly to biodegradable waste management, concerning the effective enforcement of the Ecological Solid Waste Management Act of 2000 or the Republic Act 9003, the raising of African nightcrawlers using a variety of organic waste materials as food substrates, and the possible barriers and challenges of the technology. The consequences of waste mismanagement would indeed affect the community's overall image and well-being. Thus, acquiring the proper education is vital to how ecologically efficient waste management schemes should realistically be undertaken in different communities to maintain ecosystems and biodiversity through the consistent implementation of environmental laws and close monitoring of proper waste management practices for healthy and quality living.

Detritivores for Vermicomposting

The book "The Formation of Vegetable Mold: Through Action Of Worms With Observation of their Habits," published by Charles Darwin in 1881 just before he died, influenced the importance of earthworm for degrading organic waste matter and releasing vital nutrients from it. However, the only way to use earthworms as detritivores in the last several decades has been to break up organic waste, leading to several large-scale, globally successful vermicomposting facilities. **Vermiculture** is the propagation of earthworms. Its goal is to increase its quantity for a continued productive harvest. These earthworms are then used to initiate small or large-scale vermicomposting operations or sold to interested individuals for the same vermicomposting motivation. Furthermore, **vermicomposting** is the systematic procedure to decompose and transform organic matter into vermicast (Beetz 1998). The more earthworms, the more efficient the vermicomposting process would be. Earthworm casting or vermicast is the by-product of the process, a potent soil amendment for healthier plants. Since these tiny creatures feed on biodegradable substrates, the vermicomposting process could solve garbage disposal problems. With no expensive substrates or feeding materials required, earthworm availability is assured in local farmers and enthusiasts. The abundance of substrates like kitchen waste, grass cuttings, used papers, and garden waste is readily available. Both earthworms and casting have high market demand (Manohar et al. 2016).

Earthworms consume pre-composted biodegradable wastes efficiently, fragmenting them into minute particles as they pass through their gizzard. They maintain aerobic conditions during vermicomposting. Ingested organic waste would become worm casting through biomass and respiration products from earthworms. Vermicast is much more porous, fragmented, and microbially potent due to moisture and greater decomposition than the source material. The ANC (African Nightcrawlers) secrete some mucus and fluids, thus maintaining the surrounding pH between 6.5 to 7.5, which is favorable for soil microflora. Earthworms take their nourishment from the microorganism involved in the vermicomposting process. Microorganisms and earthworms work symbiotically to speed up biodegradable waste degradation. Vermicast makeup depends entirely on the source material introduced to earthworms. In this process, essential micronutrients such as nitrogen, phosphorous, and potassium (NPK), including micronutrients such as calcium, zinc, boron, magnesium, and the like in the source material, are transformed by microbial intervention into a soluble phase readily available to plants compared to those from the source of the parent substrate (Edwards et al. 2005; Pandit and Maheshwari 2012). Earthworms thrive in a diverse environment with sufficient water and low temperature. Sharma and Garg (2018) verified that humans highly attract worms as the source of organic waste materials.

Earthworms' multifarious benefits have drawn scientists' attention to vermiculture and vermicomposting, which employ earthworms as decomposition agents. Both can be done either indoor or outdoor, thus, allowing continuous composting. Indeed, based on many types of research, the technology is adaptable to anyone who has the heart to preserve the environment as it provides impact and reduction to the biodegradable waste problem the world is facing today (Ancog et al. 2012). Earthworms can turn the total waste collection into rich vermicompost. Vermiculture uses earthworms to minimize and turn organic waste into a rich soil conditioner that provides essential nutrients to maintain plant growth and abundant yields (Marcelo 2012). The technology is environmentally stable. It facilitates the absorption of water for the regeneration and fertility of the soil. Earthworms' ability to change organic waste to potent soil amendment may encourage people to avoid synthetic fertilizers. In an ideal environment, earthworms can turn leaves and other waste products into nutrient-rich fertilizer. They consume and digest rotting leaves and transform them into potent vermicast. Earthworms are beneficial terrestrial invertebrates because they play a vital role in improving soil fertility through humus production (Sinha et al. 2010). Other earthworm species may reproduce without partners, as they possess both male and female reproductive systems, but some species are parthenogenetic and may reproduce without fertilization. Earthworms are agents of decomposition of agricultural and waste materials beneficial to organic farming (Lim et al. 2015).

While vermiculture or vermicomposting can not be considered as modern technology, given the variety of biodegradable management strategies available, it is gaining interest in maintaining and further improving soil quality as a greener alternative for chemical fertilizers (Wang et al. 2009). According to Durano (2014), the potential for cattle, buffalo, pigs, goats, and poultry manures to be used for the production of African nightcrawlers has been demonstrated. Pregua (2016), on the other hand, used corn and banana stalks as substrates for earthworms, using bamboo as walls and sacks as bedding.

Vermicomposting: The Role of Earthworms

Vermicast and vermicompost (a mixture of vermicast and compost) are the ideal substitutes for synthetic fertilizer, reducing high crop production costs. Some advantages over synthetic fertilizers are the following.

- It regenerates and multiplies soil restored microbes. Supplies plant micro and macronutrients.
- It promotes water retention and soil aeration, where beneficial microbes thrive, controls harmful pathogens.
- Improves structural stability and increases the quantity and quality of sugar in crops.

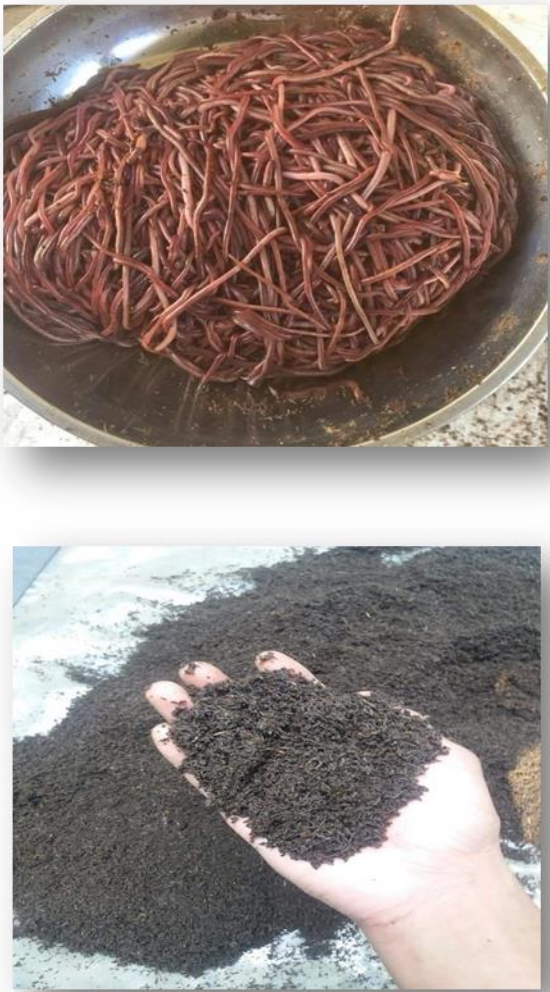

Figure 1. The Nutrient-rich excrement of the African Nightcrawlers

Non-toxic municipal, industrial, and household waste can be transformed into earthworm casting (Ugwoke et al.; Anon 2017). However, earthworms not only decompose these wastes into potent fertilizers, but these creatures also maintain the ecosystem's equilibrium as decomposers. Vermicomposting requires suitable bedding materials, the substrate as a food source, sufficient humidity and aeration, ideal temperature, and pH level. To thrive, multiply, and produce potent vermicast, these should be met. Regular input of organic waste materials into earthworms is a prerequisite for vermicomposting. In an adverse situation, they can take soil nutrition to survive. They feed on decaying biodegradable waste, in any case. Organic matters that rot in the dumping area and invite pests are suitable bedding and food sources for earthworms that become crop fertilizers.

Earthworms thrive and grow at temperatures 29-32 degrees Celsius. Earthworms require sufficient growth and survival moisture. Beds should be crumbly wet, not soggy. They should not be exposed directly to sunshine due to drying and adverse effects on them. Temperature ranging from 38-40 degrees Celsius is desirable for decomposition. It is covered with a plastic sheet to minimize evaporation until it reaches the ideal temperature before introducing earthworms. When the substrate is aged correctly, it could be placed in worm beds. In one cycle, they would produce an additional 25 percent of their kind. A moisture level of 60-80 percent is needed for efficient vermicomposting (Guerrero 2006).

For adequate aeration, material particle size and porosity should be considered. The smaller the particle size, the more aeration, and microbial action material surface is expected—the less compact, the greater the aeration. Vermicompost is different from compost produced using ordinary composting. Humus appears to be fine granules, smelling earthy and sweet that also apparent in compost (St. Martin and Brathwaite 2012). Earthworms can live with relatively low oxygen levels with high levels of CO_2 and can even survive if the water contains dissolved oxygen. Earthworms grow from 4.2 (acid) to 8.0 (alkaline) or higher.

However, according to the study of Salamanca and Aihara (2006), it is considered best to maintain bed pH around 7.0. Adhikary (2012) added that volumes of organic waste could be reduced from 40 to 60 percent by earthworms. The earthworm, which weighs 0.5 to 0.6 g. approximately could consume organic waste in proportion to its body weight. The casting produced by the earthworm is equal to half of the waste consumed for a day. The casting has a pH of 7.0 and a moisture content of 32 to 66 percent. Several research findings reveal various nutrients present in vermicompost that are beneficial to plants. Nitrogen in soil increased significantly with increased vermicompost levels, and the highest absorption of nitrogen is achieved. Furthermore, (Adhikary 2012) elaborated that vermicast composed of approximately 13 percent organic carbon, 1.6 percent nitrogen, 1.02 percent phosphorus, 0.73 percent potassium, 7.6 percent calcium, 0.6 percent magnesium, 0.2 sodium, 0.1 percent zinc, 0.005 percent copper, 1.3 percent iron, 0.2 percent manganese, and other trace elements. These nutrients are essential for plant growth and fruit production.

The Nature of Vermiculture Technology

Vermiculture is defined as earthworm propagation or "worm farming." It aims to use worms to make vermicompost or vermicasts, an organic fertilizer and soil conditioner full of nutrients. Its purpose is to convert organic materials to quick and efficient fertilizer production using a massive earthworm population (Aalok et al. 2008). No vermicomposting without vermiculture vice versa. There are around 4,000 earthworm species worldwide. The African nightcrawler (*Eudrilus Eugeniae*) is one common local species. This earthworm is native to West Africa and is now widely used in the Philippines. Earthworms are hermaphrodites and mate side-by-side with a sperm exchange mucus ring. The mucus ring passes the earthworm's head as it becomes a cocoon. They start to lay eggs in 7-10 days. Their eggs are usually transparent yellow, then turn into transparent orange, and later become brownish as it would age. Eggs fertilization occurs in the cocoon after being released from the parent earthworms. It takes about three weeks to three months for earthworms to become adults depending on substrate intake and bedding conditions. If fully grown, mature earthworms can reach twelve inches in length.

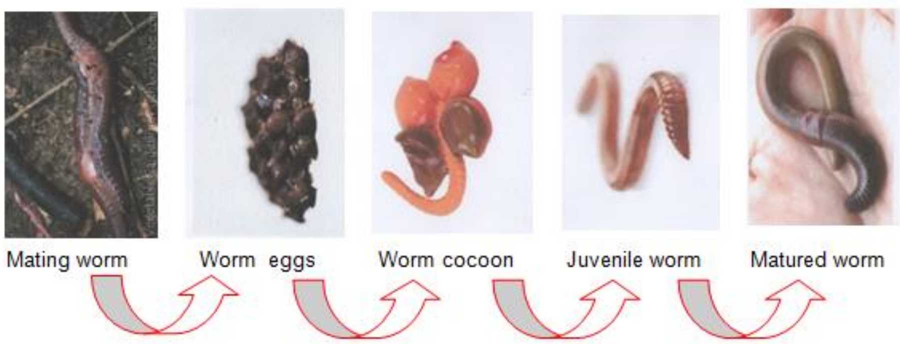

Figure 2. The Life-cycle of Earthworm

Earthworms eventually ingest substrates that serve as bedding as they decompose. Bedding must be pre-composted as the initial decomposition process emits heat to kill them. Bedding pre-composting should be at least two weeks. The researchers considered the importance of establishing a balance between its advantages and disadvantages. It is in knowing both the advantages and disadvantages that defines the right knowledge of the technology.

Table 2. Common Substrates for Vermiculture

Food (Substrates)	**Advantages**	**Disadvantages**
Organic waste partly composted	Partly composted organic matter is of great benefit to earthworms. Meat and greasy waste may be incorporated. Since the composting process is taking place, the heat is lower.	Less nutrition compared to food scraps (Frederickson et al. 1997).
Human waste	It is an excellent food source for earthworms to produce better casts.	Susceptibility of chemical and heavy metal contamination is high when it comes from municipal sources; emits foul odor on bed application; the possible presence of harmful pathogens when composting is incomplete.
Seaweed	The presence of micronutrients and beneficial microbes would lead to excellent nutrition for earthworms.	Seaweeds contain salt that could harm the earthworms. Wash it thoroughly before putting it in the worm beds.
Legume hays	Composted legumes have a high nitrogen content, which is best suited for feeding and bedding.	The humidity level is low compared to other feeds; therefore, monitoring the worm bed is essential for the materials' continuous input.
Variety of grains	Characterized as odorless and easy to use. Composted grains promote balanced nutrition for earthworms.	Grain composting takes time and is difficult for earthworms to break down. Characterized by low moisture content and quite expensive.
Paper and cardboard	The glue used to hold cardboard layers and compact paper is believed to be high in protein. These materials are common waste; therefore, their management and disposal mean higher revenues.	Papers/cardboards must be well shredded or soaked in water for earthworms to break them down quickly.
Fish, poultry, animal, and other wastes, including mortalities	Good nutrition due to higher nitrogen content. Such waste must have been harmful to the environment, but turning it over to a vermicomposting facility helps to manage waste .	Pre-composting is necessary as heat produced during the thermophilic stage may be harmful to earthworms.

Cow/horse manure	Natural source of high nitrogen for earthworms	Pre-composting is necessary as heat produced during the thermophilic stage may be harmful to earthworms.
Chicken manure	Good nutrition for earthworms due to high nitrogen and protein content.	It must be used with caution as high protein levels are hazardous to earthworms. It is therefore advisable to apply it in small quantities and gradually.
Goat/Sheep manure	Good nutrition for earthworms	Pre-composting is a requirement, as the manure may contain weed seeds.
Hog manure	Produces high-quality vermicast as commercialized feeds are packed with nutritious ingredients for hogs with healthy litters and meat.	Hog manure is watery by nature; therefore, a small or large volume of highly absorbent bedding material is required.
Rabbit manure	Rabbit manure is second to poultry manure in terms of nitrogen content; therefore, it supplies vitamins and minerals (Gaddie and Douglas 1975).	It must be drained first from urine as it may emit heat that can harm the earthworms.
Kitchen and food scraps	Acceptable moisture content and excellent nutrition for earthworms. It could be a potential revenue from waste sources	Kitchen and food scraps may smell and attract pests. The high level of nitrogen emits heat; therefore, it must be pre-composted well

Integrating vermiculture into biodegradable waste management begins during bedding preparation. Waste materials could be unsightly garbage if carelessly disposed of elsewhere. Moreover, earthworms' contribution to continuously reducing biodegradable waste as it propagates. To thrive, grow, and multiply in numbers and produce valuable vermicast, earthworms need a good food source. Biodegradable waste materials must undergo the pre-composting stage to avoid earthworm mortality due to heat build-up during the two weeks' decomposition process (Munroe 2007). Bedding must be monitored by manual moisture or moisture meter control. Earthworms breathe oxygen and can not survive anaerobically. Instances such as fat or oil in the substrate or too much humidity and inadequate aeration combined would shut the inflow of oxygen, resulting in anaerobic bedding. High fatality would push the earthworm out of its habitat. Deprivation of oxygen is not only the factor that causes fatality; earthworms die from toxic substances and effluents, e.g., ammonia caused by microbes in this condition. Oxygen requirement is vital to them. Earthworm casting has a high and diverse healthy microbial content that revitalizes the soil and can remove pathogens harmful to the plant. It contains both plant development hormones and humic acids, which can be used as growth and yield enhancers. Besides, most decomposers are soil microorganisms, which also contribute to further degradation of organic materials. Farm residues such as straw rice, grass clippings, garden waste, and animal manure are suitable for vermicomposting. This process produces vermicompost, which can increase soil fertility and sustain long-term productivity. Biodegradable waste recycling has the advantage of promoting clean and fertile soil.

Figure 3. Vermiculture and Vermicomposting Facility

There are, however, barriers to successful outcomes and optimum reproduction rates. The following might be a lack of knowledge and experience. "Knowledge is power." Training and seminar-workshops are naturally essential for those who are into vermiculture or vermicomposting. The lack of dedication. "The heart is essential." The heart of success relies on who is taking care of the worms. The increasing worm population requires close attention. To monitor, evaluate, and respond accordingly. Like any other venture, vermiculture or vermicomposting should be given time and effort. Worms, if neglected, would not be productive as expected. The lack of preparation for hot weather and heavy rainfall. Hot weather conditions dry up worm beds quickly, which is detrimental to worms if moisture is below 50 percent, and there is a high probability of various problems such as pests infestation and predators. Heavy rainfall conditions may also destroy earthworms through abrupt flooding that they do not have time to escape from their beds, which would result in massive drowning and the killing of the entire population instantly.

Lastly, parents must be role models for their children to be environmentally conscious. Children at their tender age should learn how to segregate, recycle, and properly dispose of waste, thus knowing the interrelationship of plants, soil, and earthworms. They should be exposed to gardening to understand how to handle growing food, maintain it, and make the waste beneficial. Some children are afraid of earthworms, perhaps because no one has taught them that these tiny wiggling creatures play a significant role in soil fertilization and convert every piece of decomposing trash back to its humus-like form, which is beneficial to plants (Sim and Wu 2010; Yih et al. 2010). The school also has a significant influence on strengthening the values learned at home. Teachers usually allow their students to maintain gardens and nurseries, and composting facilities that are ideal for integrating vermicomposting activities. This creates an understanding and appreciation of the food they eat. In this particular experience, children recognize the importance of the environment and the food source of humankind and all living organisms. People in urban areas may know about earthworms but lack interest in learning, internalizing, and understanding vermicomposting technology's benefits.

According to published researches, below are some salient challenges and barriers, descriptions, and findings on vermiculture or vermicomposting technology from different parts of the world, precisely in India, Indonesia, Nigeria, and the USA.

Table 3. Challenges and Barriers of Vermiculture or Vermicomposting Technology

Challenges/Barriers	Description	Findings
Feeding poultry dropping to earthworms	Ideal ANC nutrition is a high nitrogen diet.	Chicken manure can be hazardous to earthworms, so use it with extra caution. Pre-compost it well and mix it with other substrates (Kumar et al. 2008).
Pollution/Contamination	Contaminants like heavy metals, industrial, electronic, household, and human waste could penetrate the facility.	Earthworms could accumulate heavy metals in their bodies, so they should be taken from their castings before using vermicompost. Indonesia (Yih et al. 2010; Lakhdar et al. 2011).
Presence of unnecessary light and low temperature	Earthworms are light and heat-sensitive. These may affect their biological activity	A dark, warm, but humid environment could make earthworms thrive well (Sinha et al. 2002).
Earthworm mortality in the area of operation	Non-food is lethal to earthworms	A pound of worms can consume up to half a pound of the substrate or organic waste a day or 3.5 pounds a week, so keeping the facility monitored for food availability is recommended (Sinha et al. 2002)
Rodents and Moles	Attack and devour earthworms at night	The best solution is to install a rigid barrier, such as screen wire or alternatives, to prevent worm predators' entry (Sherman 2000).
Presence of centipedes and other insect pests	Feed on cocoons and earthworms	The solution is flooding beds to bring out centipedes. Water forces them and other pests

		to surface (Sherman 2000).
Ants	Usually consume worm feeds	Refrain from putting food attracting ants in worm beds. Maintain pH7 or slightly higher (Myers 1969 as cited by Bognadov et al.)
Mites	Compete for food and are considered earthworm and cocoon parasites.	Maintain neutral pH in bedding. Keep moisture levels below 85% by adding calcium carbonate (Sherman 2000).
Protein Poisoning or sour crop	Overfeeding can lead to protein build-up in bedding, causing a toxic environment.	Maintain good quality feed and micro-environmental conditions that exclude the sour crop (Myers 1969 as cited by Bognadov et al.)
Lack of knowledge in vermiculture or vermicomposting.	It was noted that most Asian students lack awareness and environmental protection attitude.	A school-based training program is recommended for students to improve their knowledge of the importance of biotechnological vermiculture or vermicomposting to reduce waste and protect the environment. (Paengkaew et al. 2006; Arora et al. 2012).
Pre-composting substrate	Ammonia, carbon dioxide, methane, and nitrous oxide emissions could be apparent during the early stages of decomposition.	Aeration and moisture must be maintained throughout composting process. Compost piles must be drained to prevent nutrient movement into ground or surface water (Subbulakshmi and Thiruneelakandan 2011).
Uninstitutionalized. The technology may be widely adapted but not necessarily famous.	Vermiculture or vermicomposting is an alternative to organic waste management. In the absence of adequate equipment to handle massive waste turnout, the process may be labor-intensive; thus, the small scale could be carried.	The technology could provide job opportunities to create low-and semi-skilled jobs. Therefore, developing nations can take advantage of the technological advantages of waste management and enhance agricultural production. With low-cost materials and small-scale equipment, the technology can be initiated (Ugwoke et al.)

CONCLUSION

As an eco-friendly, sustainable, and viable waste management scheme, vermiculture or vermicomposting technology contributes to promoting environmentally sound household and agricultural waste management practices. The technology encourages waste reduction and sustainable crop production. The earthworms propagated through vermiculture, and their casting demands a higher price in the market to generate potential income for farmers and enthusiasts. To reiterate, vermiculture or vermicomposting technology has no significant impact on the leaching of surface or underground water. Farmers and gardeners have tested the stunning effects of worm casting on their crops, which gave them overwhelming satisfaction. The aforementioned challenges and barriers to vermiculture or vermicomposting technology could be further examined by future researchers, who could also formulate effective solutions to sustain the propagation of the technology. Moreover, they may pursue scientific research to unlock the other natural properties of earthworms and their casting that may be valuable in different aspects, apart from the agricultural benefits.

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