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BIOREMEDIATION OF DOMESTIC ORGANIC WASTES USING EARTHWORM (*EUDRILUS EUGENIA)*

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Abstract

Vermiculture of wild earthworm, *Eudrilus eugenia* (African night crawler), and vermicomposting of organic kitchen wastes using both wild and cultured species of *Eudrilus eugenia* are investigated. Leached sandy soil is used in the vermicomposting to produce worm cast after which the nutrients are compared with the sandy soil. After two weeks of pre-composting, 4.7kg organic kitchen wastes are properly degraded (vermicomposted) by 0.12kg of earthworm for twelve (12) weeks. After eight (8) weeks of comparative vermicomposting between wild and cultured species of *Eudrilus eugenia,* it is observed that both showed equal vermicomposting ability. The worm cast produced shows 60% increase (enrichment) in nutrient when compared with the sandy soil used. The worm cast contains 20.3% nitrogen, 0.19% calcium, 5.0% potassium, 3.0% phosphorus and pH 7.0. The sandy soil contains 7.50% nitrogen, 0.03% calcium and 0.04% potassium with a pH 6.5. *Eudrilus eugenia* can be used to degrade organic kitchen waste and the worm cast produced can go a long way to increase soil fertility for maximum yield during agricultural activity.

Keywords: vermiculture, organic kitchen waste, worm cast, vermicomposting, earthworm

Introduction

Management of solid organic wastes has become one of the biggest problems developing nations are facing today. The rapid increase in the volume of waste is one aspect of the environmental crisis accompanying recent global development. Waste is a valuable material in a wrong place. Organic wastes comprise house hold food wastes, agricultural wastes, human wastes and animal wastes (Appelhof, 2007). As global population continues to increase, more organic wastes are bound to be produced causing increase in their environmental and agricultural challenges. These challenges are worse in developing countries due to poor waste management techniques. As a result, the waste turns out to cause health problems and the enormous nutrients in it get lost hence the need for efficient waste management technique.

The role of earthworms in the breakdown of organic debris on soil surface and soil turn over process was first highlighted by Darwin in 1881 (Kale and Bano, 2008; Berkelaar, 2009). Since then it has taken almost a century to appreciate their important

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contribution in curbing organic pollution and providing topsoil to impoverished lands. Worm or vermiculture is a useful technique for recycling kitchen and livestock wastes into a rich organic fertilizer, for producing high-protein feed for poultry and initiating a lucrative business, selling worms and worm castings for the small farm (Yarger, 2010). Vermiculture is an important bio-technique for converting the solid organic waste into compost enriched in nutrients (Ghosh, 2002; Asha-Aalok and Soni, 2008).

Vermicomposting, a bioremediation process in which worms are used to convert organic waste materials into humus-like material known as verimcompost, serves as a means of recovering organic waste nutrients through an efficient means producing organic fertilizer for agriculture purpose (Lazcano *et al.*, 2008; Berkelaar, 2009; Beetz, 2010; Rhonda, 2011). The goal of vermicomposting is to process organic materials as quickly and efficiently as possible using the product of vermiculture which its goal is to continually increase the number of worms in order to obtain a sustainable harvest (Glenn, 2006; Asha-Aalok, & Soni, 2008).

The African night crawler (ANC), known scientifically as *Eudrilus eugenia*, is considered as the most efficient epigeic or composting earthworm in the tropics (Guerrero, Illegas, & Guerrero, 1999). Even in 1981, Guestero et al. reported that the ANC was used for vermicomposting in the tropics. Kale and Bano in 1988 first used *Eudrilus eugenia* in converting organic wastes (agro waste and domestic refuse) into vermicompost (Kale and Bano, 2008). They noted that though as surface dwellers (epigeic), the worms are capable of working hard on the litter layer and can convert all the organic waste into manure, they are of no significant value in modifying the structure of the soil. The worm used in composting system feed most rapidly at temperatures of 15–25 °C (59-77 °F). They can survive at 10 °C (50 °F). Temperatures above 30 °C (86 °F) may harm them (Nancarrow and Hogan, 1998; Appelhof, 2007). Worms can survive in a pH range of 5 to 9 (Edwards, 1998). Most experts feel that the worms prefer a pH of 7 or slightly higher. Nova Scotia researchers found that the range of 7.5 to 8.0 was optimum (Ghosh, 2004). In general, the pH of worm beds tends to drop over time.

Vermicomposting has proven to have several benefits to the soil, plant growth, economy and environment (Appelhof, 2007). Vermicomposting facilities have already entered domestic and industrial marketing in countries like Canada, USA, Italy, Malaysia, the Philippines, and Japan (Asha-Aalok, & Soni, 2008). Now there is an all-round recognition that adoption and exploitation of vermiculture biotechnology, besides arresting ecological degradation, could go a long way towards meeting the nutrient needs of the agricultural sector in a big way. On another front, widespread use of vermicultural biotechnology could result in an increased employment opportunity and rapid development of the rural areas. The objectives of this study are: to carry out vermiculture of *Eudrilus eugenia* and evaluate the vermicomposting ability of cultured and wild *Eudrilus eugenia.*

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Vermiculture and Vermicompost

Vermiculture is the artificial rearing or cultivation of earthworms, and the technology is the scientific process of using them for the betterment of human beings. Thomas (2017) indicated that vermiculture or worm farming is the utilization of some species of earthworms such as *Eisenia fetida* (popularly referred to as red wriggler or manure worm), and *Lumbricus rubellus* to make vermicompost: nutrient-rich, natural fertilizer and soil condition which is the end-product of the breakdown of organic matter. Other species of worms used in vermiculture are the night crawlers.

Vermicompost, also called worm compost, vermicast, worm casting, worm poop or worm manure, is the excreta of earthworm which is rich in humus. Earthworms consume animal droppings or farm yard manure along with other farm wastes and pass them through their body, converting them into vermicompost or worm humus. The municipal wastes, non-toxic solid and liquid wastes of industries and household garbage (kitchen refuse) can as well be converted into vermicompost in the same manner (Anon, 2017). Therefore, earthworms not only convert organic wastes into valuable manure but keep the environment healthy.

Vermiculture can easily be done in any available space: balcony of an apartment, in the basement of a house or even in a heated garage if the worm bin used is suitable and well maintained to avoid odours. This technique can ultimately be used to fertilize home garden and produce a greater quality and quantity of crops for the family. Worm farming is a useful practice in developing nations where fertilizer is difficult to be accessed by peasant farmers, since it can easily be used to convert animal waste, food scraps and other dead organic matter into a nutrient rich fertilizer.

Vermicomposting, a conversion of the organic wastes or garbage by earthworms into vermicompost and the multiplication of earthworms are simple process and can be handled by even small farmers. Anon (2017) highlighted the advantages of vermicomposting as follows;

1) Vermicompost is an eco-friendly natural fertilizer prepared from biodegradable organic wastes free from chemical inputs.
2) It does not have any adverse effect on the soil, plant and environment.
3) It improves soil aeration, texture and tilt, thereby reducing soil compaction.
4) It improves water retention capacity of soil because of its high organic matter content.
5) It promotes better root growth and nutrient absorption.
6) It improves nutrient status of soil – both macronutrients and micronutrients.

Biology of Earthworms

As indicated earlier, vermiculture uses worms to break down organic matter into compost which can be added to soil to provide many benefits. Worm anatomy and physiology is an integral part of the design of a vermicomposter.

Earthworms are found throughout the world. They are small (10–300mm) tubular and cylindrical organisms that inhabit the top or inside the soil. Worms

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commence their life as a cocoon laid in the soil by the adult. The life span ranges from a few months to 10 years, but may not reach the latter age because of environmental hazards they may be exposed to. Some species of worms have the capacity to regenerate parts that are detached, although tests show that this is an uncommon trait (Edwards, & Lofty, 1977). All earthworms have both male and female reproductive organs in one body. The hermaphroditive nature enhances the chances of their survival and also promotes rapid sexual reproduction process.

Worms have a relatively simple digestive system that runs along the length of their body. Organic matter is ingested at the anterior part where the mouth is situated. The organic matter is then passed through the gizzard, their strong muscle contract and grind up the organic matter. Enzymes are then secreted to breakdown the organic matter and release energy that the worm can use. Worms have a symbiotic relationship with some microorganisms in their digestive system. These microorganisms help in further breakdown of the organic matter while the worm provides shelter to the microorganisms. Consequently, both of them benefit from the relationship. Waste is excreted by the worm at the posterior end where the anus is located (Edwards, & Lofty, 1977). The waste excreted by worms is, therefore, referred to as worm cast (vermicast). Vermicasts contain more microorganisms, inorganic materials and organic matter in the form available to plants than regular soil.

Earthworms are sensitive to both temperature and pH. These two factors can determine how fast a vermiculture system operates. A study showed that *E. fetida* found in more acidic peats (3.6–4.2) burrowed less, respired less and produced less castings (Satchell, & Dottie, 1984). The metabolic activities (growth, respiration, reproduction) of earthworms are greatly influenced by temperature. Earthworm can be killed by extreme heat and extreme cold. They can also be killed by drying. Worms are usually found where there is much organic matter. Worms can eat a wide variety of organic matter for food. In adverse conditions, they can even extract nourishment from soil for short duration (Edwards, & Lofty, 1977).

Materials and Methods

Materials

Worm bin, bedding, water, sandy soil, worms, non fatty kitchen scraps and cow dung are the major materials used for the study, in accordance with Guestero *et al.* (1999); Appelhof (2007); Beetz (2010); and Yarger (2010).

Collection and Identification of Earthworm

The hand sorting method, as proposed by Glenn (2006), is used to collect earthworms from open refuse dumpsite located at Umueze, Enugu-Ngwo, Enugu North L.G.A., Enugu State, South East, Nigeria. The worms are identified as *Eudrilus eugenia* using the method required – Nancarrow, & Hogan (1998); Ansari, & Saywack (2010).

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Pre-composting of Organic Kitchen Waste

A collection of some organic kitchen waste comprising vegetables stalk (spinach, pumpkin, garden egg, water leaf etc), back of tubers (yam, cocoyam, potatoes) and food scraps are sliced and transferred into a transparent polythene bag to produce a total weight of 5.3kg. Thereafter, the polyethylene bag is tired and kept in a compost bin of 36cm width and 26cm depth inside a compost pen. The pre-composting lasted for two weeks in accordance with Glenn (2006). In precomposting of the organic waste for vermiculture, the pH is determined.

Vermiculture (Earthworm cultivation)

According to Appelhof (2007); Asha-Aalok, & Soni (2008); and Beetz (2010), shredded newspaper is introduced to cover the bottom of vermiculture bin 24cm diameter and height of 8 inches height and the process is completed, in accordance with Appelhof (2007) and Glenn (2006). Adult *Eudrilus eugenia* 0.04kg is introduced into 0.4kg of cooled precomposed organic waste in accordance to 1:10 ratio (Edwards, 1998; Glenn, 2006). The process lasted for 12weeks.

Vermicomposting

Three beddings are prepared in three separate bins as in vermiculture 0.5kg of dried pre-compost; and 0.1litre of water is introduced into each of the bin. *Eudrilus eugenia,* wild and cultured types, 0.05kg each, is introduced into Bin A and B respectively; and the bin C is without any earthworm (control). The bins are marked 0 to 10cm from top to bottom to determine rate of decomposition.

Nutrient content Analysis

The nutrient content of the leached sandy soil and the worm cast is determined using the methods of the Association of Official Analytical Chemistry (AOAC, 2005).

Results and Discussion

One of the identified earthworms (*Eudrilus eugenia)* is presented in Figure 1 with a length of 6.8cm. The African night crawler, according to Guestero *et al* (1999), is only one of the most common species of earthworm that has been identified worldwide as having the best potential for breaking down organic materials.

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Figure 1: Identified *Eudrilus eugenia* 6.8cm

After the 12 weeks precomposting process, 4.7kg of the organic kitchen waste is biodegraded by 0.12kg of wild *Eudrilus eugenia* and the rate of degradation is presented in Table 1. The variation in pH during the process is represented in Figure 2, according to Glenn (2006); Appelhof (2007) and Lazcano *et al*, (2008) who observed that pH can vary over a certain range during the precomposting process. The total weight of worm harvested after vermiculture is 0.12kg showing almost 100% increase in biomass. Edwards (1998) stated that it is possible to expect a 100% increase in population in the presence of adequate conditions.

Table 1: Precomposted Organic Kitchen Waste Biodegraded during 12 weeks

Week	Worm bin A (kg)	Worm bin B (kg)	Worm bin C (kg)
1	0.4	0.4	0.4
3	0.3	0.4	0.3
6	0.2	0.2	0.1
9	0.5	0.6	0.5
12	0.3	0.4	0.3
Total	1.7	2.0	1.6
Undecomposted	0.2	0.2	0.2
Decomposted	1.5	1.8	1.4

Total Decomposed = 4.7kg

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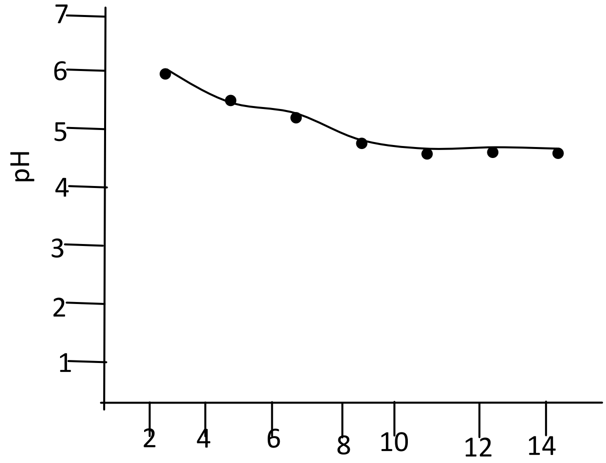

Figure 2: pH Variations

Table 2 shows the rate of vermicoposting abilities of wild and cultured species of *Eudrilus eugenia.* The result reveals that both showed equal ability which conforms to Glenn (2006; Asha-Aalok, & Soni (2008); and Beetz (2010), who indicated that the main aim of vermiculture is to increase the number of the worms. At the end of the vermicomposting process, the physical comparison of sandy soil used and the worm obtained is presented in Figure 3 (a and b). The appearance is like rich black soil rather than the bedding that is used (Nancarrow and Hogan, 1998; Norman *et al*, 2004; Yarger, 2010).

Table 2: Rate of Vermicomposting Ability of Wild and Cultured Species of *Eudrilus eugenia*

Week	Wild	Cultivated	Control
1	0	0	0
2	1.24	1.15	2.50
3	2.95	2.50	3.00
4	3.00	2.90	3.00
5	3.10	3.00	3.10
6	3.19	3.17	3.10

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7	3.20	3.20	3.10
8	3.20	3.20	3.10

a b

Figure 3 (a and b): Worm cast after vermicomposting and prepared compost before and after vermicomposting period, respectively

The worm cast showed 60% increase in nutrients when compared with the sandy soil as presented in Table 3. As a result of the high nutrient in worm cast, it is always a good alternative for fertilizer (Ghosh, 2004; Lazcano *et al*, 2008; Selden *et al*, 2005; Yarger, 2010).

Table 3: Nutrient and pH Composition of Worm Cast Produced and Sandy soil used for Vermiculture

Nutrients (%)	Sandy soil	Worm Cast
Nitrogen	7.50	20.30
Calcium	0.03	0.19
Potassium	5.0	0.04
Phosphorus	0.31	3.00
Fixed carbon	33.00	26.54

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Zinc	0.03	Nil
pH	6.5	7.0

Conclusion

Vermicomposting technology may be considered a widely spread, though not necessarily popular technology. It represents an alternative approach in waste management since it is a process for handling organic wastes. Some aspects of the process may be labour intensive when mechanized equipment is not available to handle large volumes of material but the small scale can be managed. Vermicomposting in developing countries could prove to be useful in many instances such as in the creation of low or semi-skilled jobs, it may supply an opportunity for employment. Secondly, accumulation and management of wastes are so such a huge problem, but composting and vermicomposting offer good potential to turn waste material into a valuable soil amendment. Therefore, developing nations such as Nigeria can use the advantage of vermitechnology not only in municipal waste management but its application in crop production to enhance agricultural produce since it can be started off on a small scale with little inexpensive materials and equipment.

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