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ORIGINAL ARTICLE

Comparative Evaluation of African Earthworms for Converting Kitchen Waste into Vermicompost

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ABSTRACT
The present study evaluates the efficiency of three African earthworm species, Eisenia fetida, Eudrilus eugeniae, and Perionyx excavatus, in converting kitchen waste into nutrient-rich organic manure. The composting duration and key physicochemical parameters such as pH, electrical conductivity, organic carbon, and the availability of essential nutrients including nitrogen, phosphorus, potassium, calcium, and magnesium were examined. Results revealed that Eisenia fetida significantly reduced composting time to 35 days, compared to 40 and 45 days for Eudrilus eugeniae and Perionyx excavatus, respectively. The pH of vermicompost from Eisenia fetida was the highest (7.8), indicating a neutral to slightly alkaline environment, favorable for plant growth. Electrical conductivity, an indicator of nutrient availability, was also highest for Eisenia fetida (3.7dS/m). Moreover, this species demonstrated superior nutrient content, with total nitrogen (1.92%), total phosphorus (2.17%), and total potassium (2.87%) levels significantly higher than those in vermicompost from the other two species. Organic carbon content was also highest in Eisenia fetida vermicompost (30.22%). The total and available forms of calcium and magnesium were higher in Eisenia fetida, further enhancing the compost's fertilizing potential. These findings indicate that Eisenia fetida is the most efficient species for vermicomposting kitchen waste, producing nutrient-rich organic manure in a shorter time frame compared to Eudrilus eugeniae and Perionyx excavatus. This makes Eisenia fetida a valuable candidate for large-scale organic waste management and sustainable agriculture.
Keywords*: vermicomposting, Eisenia fetida, nutrient content, organic manure, waste management.*

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INTRODUCTION

The escalating global population and the associated increase in food production and consumption have resulted in an unprecedented rise in organic waste generation. Kitchen waste, a major component of organic waste, poses significant environmental challenges if not managed effectively. Conventional methods of waste disposal, such as landfilling and incineration, are increasingly being recognized as unsustainable due to their negative environmental impacts, including greenhouse gas emissions and soil contamination. Thus, there is an urgent need for eco-friendly waste management strategies that not only mitigate environmental degradation but also contribute to resource recovery [1,2].

Vermicomposting, the process of utilizing earthworms to biologically degrade organic matter, has emerged as a promising solution for organic waste management. Through the action of earthworms and associated microbial activity, organic waste can be transformed into high-quality organic manure, rich in nutrients and beneficial microorganisms [3,4]. Earthworms play a crucial role in this process by breaking down organic matter, enhancing microbial decomposition, and improving the physical and chemical properties of the compost [5].

In recent years, African earthworms, particularly species such as *Eisenia fetida, Eudrillus eugenia and Perionyx excavates*, have gained attention for their potential in vermicomposting due to their high

biomass consumption rates, fast reproduction cycles, and adaptability to tropical climates. Comparative studies on the efficiency of different African earthworm species in converting kitchen waste into organic manure are essential to identify the most suitable species for large-scale vermiculture operations.

The disposal of organic waste, particularly kitchen waste, presents significant environmental challenges, with organic waste comprising up to 50% of municipal solid waste in developing countries. Improper disposal through landfilling contributes to methane emissions, while incineration releases toxic pollutants [6], prompting interest in sustainable alternatives such as composting and vermicomposting. Vermicomposting, an aerobic process involving earthworms and microorganisms, reduces waste volume and produces nutrient-rich organic fertilizer [7]. Earthworms, such as *Eisenia fetida, Eudrillus eugenia and Perionyx excavates* fragment organic material to enhance microbial activity, speeding up decomposition [8] and resulting in compost rich in nitrogen, phosphorus, and potassium [9]. *Eudrilus eugeniae*, favored in tropical regions for its rapid growth and nutrient cycling efficiency [10], has demonstrated superior organic matter conversion rates compared to other species, such as *Eisenia fetida* [11]. Although *Hyperiodrilus africanus* is less studied, it shows significant potential in tropical environments for processing organic waste. Earthworms also enhance nutrient cycling by increasing nitrogen mineralization and making phosphorus and potassium more bioavailable for plant uptake [12]. Comparative studies suggest that African species like *E. eugeniae* may outperform non-African species in vermicomposting, particularly in tropical climates [13]. The quality of vermicompost, enriched with growth-promoting substances such as plant hormones, has been shown to improve soil structure, microbial activity, and crop yield [14, 7, 9]. Consequently, African earthworms offer great potential for efficiently converting kitchen waste into high-quality organic manure, and further studies are required to optimize large-scale vermiculture practices in tropical regions. Therefore, present study was designed to conduct a comparative screening of selected African earthworm species for their efficiency in converting kitchen waste into nutrient-rich organic manure. By evaluating parameters such as maturation time of vermicompost, pH, electrical conductivity, organic carbon and nutrient content (NPK and Ca &Mg).

MATERIAL AND METHODS

The screening of African earthworms (*Eisenia fetida, Eudrillus eugenia and Perionyx excavates)* was carried out such as to evaluate their vermicomposting potential. On the basis of the screening parameters such as pH, electrical conductivity, organic carbon, maturation of vermicompost and nutrient content (NPK, Ca & Mg) the best suitable species or single species was used for further studies (Figure 3.3).

Maintenance of stock culture of earthworms

Stock culture was maintained by the preparation of separate vermibeds in which seasoned dung for mass culture of different earthworms (*Eisenia fetida, Eudrillus eugenia* and *Perionyx excavates*). Adequate quantity of adults was released in the vermi-beds. The culture was constantly monitored throughout the period of study. From this maintenance mass culture earthworms were randomly separated from each vermi-bed and were further processed for the screening of suitable species of earthworms under the eco-climatic conditions (Figure 1).

Figure 1: Showing the preparation of different combinations of biodegradable kitchen waste and dung for culture and screening of African earthworms

Screening of African earthworm

The screening of the three species of African earthworms (*Eisenia fetida, Eudrillus Eugenia* and *Perionyx excavates)* was conducted to evaluate their vermicomposting potential. On the basis of the screening parameters such as maturation time of vermicompost, pH, electrical conductivity, organic carbon and nutrient content (NPK and Ca &Mg).

The vermicompost prepared from *Eisenia fetida* was found suitable under the climatic conditions of the study area due to overall maturation period of vermicompost and also from the analysis of various screening parameters. Therefore, *Eisenia fetida* was selected for further studies due to its outstanding performance.

The findings were derived from assessments involving Maturation time, pH levels, Electrical conductivity, Organic carbon content, as well as the levels of Total and available Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium. Each of these parameters was examined in detail below to elucidate their relationships and implications.

RESULTS

Time of maturity of vermicompost (days)

The vermicompost was obtained after 45 and 40 days from the vermiculture in which *Eudrillus Eugenia* and *Perionyx excavates* was introduced, whereas vermicompost was obtained after 35 days from the vermiculture in which *Eisenia fetida* was introduced. These results indicated that *Eisenia fetida* significantly reduced the composting time and also showed best potency (table 1).

Assessment of physical parameters

pH

Use of *Eisenia fetida* recorded maximum pH (7.8) in vermicompost and was significantly more than other worms *Perionyx excavates* (5.6) and *Eudrillus Eugenia* (6.3). The reason for high pH in vermicompost may be due to release of various bases during the process of composting (Table 1).

Electrical conductivity (dSm^{-1})

Use of *Eisenia fetida* recorded maximum electrical conductivity (3.7 dSm^{-1}) in vermicompost and was significantly more than other worms *Eudrillus eugenia* (1.91d Sm^{-1}) and *Perionyx excavates* (2.3dSm^{-1}) (Table 1).

Organic carbon (%)

Use of *Eisenia fetida* recorded organic carbon content (30.22%) in vermicompost and was significantly higher than other worms *Eudrillus eugenia* (28.34%) and *Perionyx excavates* (23.4%) (Table 1).

Assessment of Chemical parameters

Total phosphorus (%)

Eisenia fetida recorded maximum total phosphorus content (2.17%) in vermicompost and was significantly more than other worms *Eudrillus eugenia* (1.58%) and *Perionyx excavates* (1.55%) (Table 1).

Available phosphorus (%)

Eisenia fetida recorded maximum available phosphorus content (1.65%) in vermicompost and was significantly more than other worms *Eudrillus Eugenia* (1.03%) and *Perionyx excavates* (1.12%) (Table 1).

Total nitrogen (%)

Eisenia fetida recorded maximum total nitrogen content (1.92%) in vermicompost and was significantly more than other worms *Eudrillus Eugenia* (1.32%) and *Perionyx excavates* (1.82%) (Table 2).

Available nitrogen (%)

Eisenia fetida recorded maximum available nitrogen content (1.02%) in vermicompost and was significantly more than other worms *Eudrillus Eugenia* (0.98 %) and *Perionyx excavates* (1.00%) (Table 2).

Total potassium (%)

Eisenia fetida recorded maximum total potassium content (2.87%) in vermicompost and was significantly higher than other worms *Eudrillus eugenia* (1.98%) and *Perionyx excavates* (1.78%) (Table 2).

Available potassium (%)

Eisenia fetida recorded maximum available potassium content (1.88%) in vermicompost and was significantly more than other worms *Eudrillus eugenia* (1.32%) and *Perionyx excavates* (1.39%) (Table 2).

Total calcium and available calcium

Eisenia fetida recorded maximum total and available calcium content (1.34%) and (0.98%) in vermicompost and was significantly more than other worms *Eudrillus eugenia* (1.1%) and (0.55%) and *Perionyx excavates* (1.12%) and (0.54%) (Table 2)

Total magnesium and available magnesium

Eisenia fetida recorded maximum total magnesium content (0.43%) and (0.35%) in vermicompost and was significantly more than other worms (0.30%) and (0.21%) and *Perionyx excavates* (0.24%) and (0.18%) (Table 2).

Table 2: Comparative screening of African earthworms (*Eudrillus Eugenia, Perionyx excavates* and *Eisenia fetida*) on the basis of maturation time and physical parameters for the optimization of vermicomposting.

Species	Maturation of Vermicompost (days)	pH	Electrical conductivity (dSm^{-1})	Organic carbon (%)	Total Nitrogen (%)	Available Nitrogen (%)	Total Phosphorus (%)	Available Phosphorus (%)
Eudrillus Eugenia	40	6.3±0.47*	1.91±0.75*	28.34±4.54*	1.32±0.73*	0.98±0.4*	1.58±0.48*	1.03±0.83*
Perionyx excavates	45	5.6±0.58*	2.3±0.63*	23.4±3.44*	1.82±0.91*	1.00±0.43*	1.55±0.65*	1.12±0.76*
Eisenia fetida	35	7.8±0.69**	3.7±0.88**	30.22±6.25**	1.92±0.71**	1.02±0.65**	2.17±0.78**	1.65±0.65

Table 2: Comparative screening of African earthworms (*Eudrillus Eugenia, Perionyx excavates* and *Eisenia fetida*) on the basis of chemical parameters for the optimization of vermicomposting.

Species	Total K (%)	Available K %	Total Ca (%)	Available Ca (%)	Total Mg (%)	Available Mg (%)
Eudrillus Eugenia	1.98±0.87*	1.32±0.34*	1.1±0.65*	0.55±0.87*	0.30±0.82*	0.21±0.87*
Perionyx excavates	1.78±0.76*	1.39±0.65*	1.12±0.71*	0.54±0.92*	0.24±0.72*	0.18±0.65*
Eisenia fetida	2.87±0.66**	1.88±0.73**	1.34±0.56**	0.98±0.78**	0.43±0.49**	0.35±0.69**

Abbreviations: MC=Moisture content, EC=Electrical conductivity, pH=Potential of hydrogen, OC= Organic carbon , N= Nitrogen, P=Phosphorus, K=Potassium, Ca=Calcium, Mg=Magnesium

DISCUSSION

In 2003 Sharma reported that *Perionyx excavatus* shows adaptability in broad range of substrate pH. However, *Eisenia fetida* showed maximum reduction in acidic pH. This reveals that *Eisenia fetida* stabilizes the waste with minimal processing time, because substrates having acidic initial pH were found to be less suitable for vermicomposting. Electrical conductivity (EC) showed variation among the earthworms (*Eisenia fetida, Eudrillus eugenia* and *Perionyx excavates*), however *Eisenia fetida* showed significantly higher EC than other worms, this might be due to the loss of organic matter and release of various mineral salts in available forms (such as phosphate, ammonium and potassium). Results coincide with findings of the previous studies of Sharma (2003) [15] who reported that electrical conductivity (EC) increases during the period of the composting and vermicomposting process.

Organic carbon (OC) showed variation among the three species of worms (*Eisenia fetida, Eudrillus eugenia* and *Perionyx excavates*), whereas *Eisenia fetida* showed significant higher organic carbon, which might be due to the incorporation into the tissues of *Eisenia fetida* as well as leaching of nutrients into the bedding materials. Hence organic carbon content showed an incremental pattern with the progression of vermicomposting process. Results of our study coincides with previous studies who reported that organic carbon in vermicompost release the nutrients gradually and steadily into system and enables the plants to absorb these nutrients [16].

Earthworm species also showed variation in total nitrogen (%) content which most probably might be due to the presence of considerably increased quantity of total nitrogen might be due to the nitrogen rich waste, and could be because they contain nitrogen supplement in the form of organic waste (kitchen waste, rice straw and dung) which are rich sources of nitrogen. Higher nitrogen content in vermicompost prepared by using *Eisenia fetida* might be due to the mineralization of the organic matter and increased transformation of ammonium into nitrate [13]. In addition to this *Eisenia fetida* treatment of which higher nitrogen content was recorded might be due to its individual capability and efficient adaptability to the local temperature conditions.

Results of the present study noted that all the vermi-compost samples prepared by using three different species of African earthworms viz *Eisenia fetida, Eudrillus eugenia* and *Perionyx excavates* showed variation in total and available phosphorus (%) content. These variations include *Eisenia fetida* (2.17 % & 1.65%)*, Eudrillus eugenia* (1.58% & 1.03%) and *Perionyx excavates* (1.55% & 1.12%) respectively. Among all these three species *Eisenia fetida* showed significantly higher level of nitrogen total (2.17%) as well as available (1.65%) in vermi-compost, this significantly higher quantity of total phosphorus could be due to the combustion and protein contents of earthworms tissues which increase phosphorus concentration during recycling depends on the feeding substrates of earthworms during decomposition [17].

The significantly higher phosphorus content in vermi-compost prepared by introducing *Eisenia fetida* might be due to presence of organic carbon combustion, presence of mineralogical composition and protein contents present within the tissues of earthworms and also by the surplus supplementation of phosphorus in the form of organic waste (kitchen waste) [18].

Moreover, results of the present study revealed that the total and available potassium (%) content varied from vermi-compost samples to another prepared by the introduction of the three different species viz *Eisenia fetida* (2.87% & 1.88%)*, Eudrillus Eugenia* (1.98% & 1.32%) and *Perionyx excavates* (1.78%&1.39%). Among the three species *Eisenia fetida* showed significantly higher increase in total (2.87%) as well as available (1.88%) potassium content, this significant increase in vermicompost prepared by the introduction of *Eisenia fetida* might be due to the presence of surplus supplementation of potassium through kitchen waste, rice straw and dung. Results of the present study coincide with the previous studies, who reported that during this bioconversion process of organic waste products into vermicompost through the addition of surplus nutrients [16].

Total and available Magnesium (Mg) content also varied from one vermicompost sample to another sample prepared by the introduction of the three different species viz *Eisenia fetida* (0.43% & 0.35%)*, Eudrillus eugenia* (0.30% & 0.21%) and *Perionyx excavates* (0.24% & 0.18%). However, *Eisenia fetida* showed significantly higher increase in total (0.43%) as well as available (0.35%) magnesium content this might be due to additional surplus of magnesium by organic waste [19]. This may be also explained that higher content of available magnesium might be due the calcarious nature of organic residues used as feed to earthworms. It has been studied that earthworm works efficiently when they supplemented nutrients in the form of organic wastes [20]. Therefore, results revealed that *Eisenia fetida* might be suitable species for the recycling of kitchen waste into biomanure. Hence, *Eisenia fetida* was used in experiments.

CONCLUSION

The study reveals that *Eisenia fetida* is the most efficient species among the tested earthworms for vermicomposting, as it significantly reduced composting time and improved various physical and chemical parameters. Vermicompost produced by *Eisenia fetida* showed the highest values for pH, electrical conductivity, organic carbon, total and available phosphorus, nitrogen, potassium, calcium, and magnesium, compared to *Eudrillus eugeniae* and *Perionyx excavatus*. These results indicate the superior efficiency of *Eisenia fetida* in producing nutrient-rich vermicompost, which could enhance soil fertility and support sustainable agricultural practices.

FUTURE PERSPECTIVE

Future studies should explore optimizing the composting process using *Eisenia fetida* under varying environmental conditions to further reduce processing time and enhance nutrient content. Additionally, large-scale field trials could be recommended to evaluate the impact of vermicompost produced by *Eisenia fetida* on different crops and soil types. Exploring the potential for combining *Eisenia fetida* with other organic amendments may also provide insights into maximizing soil health benefits and improving crop productivity.

DECLARATION

The authors declare that they have no conflict of interests.

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