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Research Article

Sustainable Vermicomposting Using Earthworms for the Biodegradation of Agrochemical Residues

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ABSTRACT

The Earthworms play a significant role in sustainable wastes and ecological rehabilitation. This paper will explore the purpose of vermiremediation with the use of chosen earthworm species to lessen pesticides residues and heavy metals pollution in biodegradable wastes. The earthworms during vermicomposting change organic residues into nutrient-rich compost, and stabilize and transform toxic substances. The interaction of earthworms, the related microbial communities and organic material is also synergistic, leading to a faster degradation of the dangerous pollutants and soil improvement. It is carried out using earthworms to transform biodegradable agricultural and domestic waste into nutritious vermicompost that enhances soil fertility, crop yields and ecological stability. The opportunities provided through Vermicomposting also allow the rural development through the generation of additional income and encourages self-employment. Nonetheless, the conditions surrounding the environment, including temperature and moisture, influence the survival and productivity of earthworms, and financial and institutional barriers prevent the implementation on large scale. The extension services, training programs, and market linkages should be reinforced to enhance the broader usage of the vermiculose-based post technology. The current research considers the effectiveness of the chosen earthworm species towards the reduction of soil pollutants and enhancement of the soil fertility by the use of vermicomposting methods. The findings indicate that vermicomposting is a cost-effective and environmentally sustainable way of preserving soil and agriculture in a sustainable manner.

1. Introduction

In the current agricultural practice, pesticides and herbicides, artificial fertilizers and various other agrochemicals have led to the build-up of toxic remnants and heavy metals in the soil ecosystems. These pollutants have negative impacts on the fertility of the soils, microorganism diversity and environmental sustainability. Consequently, there has been need to develop green and sustainable technologies to clean up the soil.Vermicomposting is a biological process that is environmentally friendly where organic wastes are transformed to nutritive compost due to the combined effort of earthworms and microorganisms (Pathma&Sakthivel, 2012). Earthworms have also been called the eco system engineers since they are instrumental in enhancing soil structure, aeration, as well as nutrient cycling. In the process of vermiculostages, earthworms consume organic matter and chop it into smaller bits, which boost the microbial activity, thus, accelerating decomposition. The refurbished material is turned into vermicompost, a nutrient-rich, stable humus-like material, heavy in enzymes and useful microorganisms (Lim et al., 2015; Ray, 2016). Vermicompost enhances the physical properties of soil such as porosity, aeration and water-holding capacity, and chemical properties such as nutrient availability (Aksakal et al., 2016; Weber et al., 2007 as cited).

Besides the use in waste management, vermicomposting is a good bioremediation method. Earthworms also help in the decontamination of contaminated soil by building up the heaviness metals and enhancing microbial breakdown of the pollutants. Research has indicated that vermicomposting has the potential of greatly decreasing the level of toxic metals and enhancing the quality of soil (Sizmur et al., 2019). Moreover, the decomposition of toxic compounds like pesticides, hydrocarbons, etc. is increased by the earthworm-microorganism interaction (Luo et al., 2023; Arora and Kumar, 2014).

Ecigeic earthworms, including Eiseniafetida, Eudroluseugeniae and Lampitomauritii are commonly applied in vermicomposting due to their fast rate of feeding, versatility, and reproduction (Dominguez and Edwards, 2011). These species are effective in transforming biodegradable waste to high-quality compost and also play a great role in soil remediation procedures. Therefore, vermicomposting is a biodegradation method that is economical, ecologically friendly, and sustainable to dispose of the residues of agrochemicals and enhance soil health. The objective of the current research is to determine the efficiency of the chosen species of earthworms in the process of soil pollutants reduction and soil fertility improvement in the form of vermicompost.

2. Materials and Methods

The current research was carried out in the Jintur area of Parbhani district, Maharashtra, India as a representative of the normal agricultural environment wherein constant use of agrochemicals can cause the pesticides and heavy metals to find their way into the soil. The agricultural samples were taken as soil of the fields under cultivation and biodegradable organic wastes like crop residues, different types of leaves, vegetable wastes and cow dung formed substrates on which the vermicomposting was done. The organic materials collected were pre-decomposed in the shaded environment within the duration of 10-15 days before experimentation to increase the activity of the microbes and stabilize the substrate because pre-composting is reported to increase the efficiency of vermicomposting (Thirunavukkarasu et al., 2023; Saha et al., 2022).

The species of earthworms that were chosen to carry out the study are Eiseniafetida, Eudrillus eugeniae, and Lampitomauritii due to their ecological value and effectiveness in degrading organic waste. Epigeic species like Eiseniafetida and Eudroluseugeniae have a great level of preference in vermicomposting because they have a high feeding rate, reproduce quickly, and can adapt to organic materials (Saha et al., 2022).

A two-factor Completely Randomized Design (Factorial CRD) was used to design the experiment to assess the impact of application of vermicompost and earthworms' species on reducing soil pollutants. Earthen pots containers in good aeration and drainage were used to prepare vermicomposting units. Prepared substrate was added and earthworms were inoculated with a layer of bedding that was made of partly decomposed organic material at the bottom. The moisture level was kept at a range of 6070 percent and temperature at an optimal level of 25 to 30o C so that the earthworms could be in their proper state. Turning was frequently conducted and moisture addition was done to ensure that the whole process remained aerobic.

Vermicomposting took a time of 45-60 days to complete the process until the dark, granular, and stable compost was obtained which is a sign of maturity. In the course of this, earthworms consume organic material and transform it to vermicast by physical fragmentation and interactions with a microbe, which stabilizes organic wastes and transforms them into nutrient-rich compost (Rostami, 2011; Thirunavukkarasu et al., 2023).

Fig 1. Preparation of vermicompost

To determine the changes in the pollutant concentration and soil properties, soil samples were sampled by taking samples before and after treatment. The parameters analyses included; heavy metal concentration (cadmium, mg/kg), organic matter content and soil structure. It is reported that the Earthworm is known to increase microbial activity and enzymatic activity, which subsequently reduce the contaminated soil and enhance soil quality (Thirunavukkarasu et al., 2023). Factorial CRD was used to statistically test the treatment effects and interaction of the treatment effects using the experimental data.

3. Results and Discussion

The present study evaluated the effect of vermicompost and selected earthworm species on the biodegradation of agrochemical residues and improvement of soil quality. The results clearly indicated that both vermicompost application and earthworm activity significantly contributed to the reduction of soil pollutants and enhancement of soil properties.Application of vermicompost resulted in a noticeable decrease in pollutant concentration compared to untreated control soil. The treated soil showed improved physical structure, increased organic matter content, and enhanced microbial activity, indicating effective stabilization and degradation of toxic substances. Similar findings have been reported in previous studies where vermicomposting significantly reduced heavy metal concentrations and improved soil fertility (Sizmur&Hodson, 2009).

The effect of different earthworm species on pollutant reduction revealed significant variation among species. Among the tested species, Eudriluseugeniae exhibited the highest remediation efficiency, followed by Eiseniafetida, while Lampitomauritii showed comparatively lower efficiency. The increasing order of pollutant reduction efficiency observed in the present study was:

Lampitomauritii < Eiseniafetida < Eudriluseugeniae:

This variation may be attributed to differences in feeding rate, digestion efficiency, and microbial interactions associated with each species. Previous studies have also reported that earthworm species differ in their ability to degrade pollutants and enhance microbial activity during vermicomposting (Zhang et al., 2020).

The combined application of vermicompost and earthworms showed the maximum reduction in soil pollutant levels compared to individual treatments. This indicates a strong synergistic interaction between earthworms and microbial communities during the vermicomposting process. The enhanced degradation may be due to increased microbial proliferation and enzymatic activity stimulated by earthworm gut processes.

A significant reduction in cadmium concentration was observed in treated soil, indicating the effectiveness of vermicomposting in heavy metal stabilization and detoxification. Earthworms are known to accumulate heavy metals in their tissues and reduce their bioavailability in soil systems (Sizmur & Hodson, 2009; Mamidala et al., 2020). Similar studies have reported up to 90% reduction in harmful biological contaminants during vermicomposting processes, supporting the efficiency of earthworm-mediated biodegradation. The findings of the current research are clear to indicate that the process of vermicomposting involving the use of chosen earthworm species is a successful one in terms of the biodegradation of residual agrochemicals and the enhancement of soil condition. This observed decrease in pollutant level together with the increase in soil characteristics could be related to the concerted effort of earthworms and the microbial communities.

The pronounced reduction in soil toxins after the use of vermicompost has corroborated previous results that vermicomposting positively affects the stabilization and conversion of toxic materials. The earthworms are significant in increasing organic matter degradation by ingesting, digesting and inoculating micro-organisms. Earthworms have an important impact on the state of microbial communities, causing an increase in the degradation of contaminants and the creation of stable organic matter owing to the gut-associated processes (Dominguez et al., 2021). This implies vermiculite composting does not only decrease the amount of pollutants but it also enhances the biological quality of soil.

The difference between the different earthworm species regarding the efficiency in reducing pollutants is in line with the past research. Eudroluseugeniae was the most efficient in the current experiment followed by Eiseniafetida and Lampitomauritii. Such variations could be as a result of species-specific feeding habit, digestion rates and exposure to microbial communities. The epigeic species tend to be more effective in the waste degradation due to their high rate of consumption and reproduction (Luo et al., 2023).

The joint use of the vermicompost and earthworms exhibited the highest polluting reduction, which means that there was a high level of synergy. This synergy is largely attributed to the increased microbial activity, better aeration as well as the increased level of enzymatic activity that is instigated by earthworm activity. It has been demonstrated that high removal efficiencies of contaminants can be obtained with vermicomposting, and some organic pollutants will be reduced over 60. 90 percent under the optimal condition (Luo et al., 2023).

The mechanisms through which the reduction in the heavy metals including cadmium was witnessed in the present study include bioaccumulation, immobilization, and transformation of the earthworm body and vermicompost matrix. It has been known that earthworms store metals in their tissues and lower their bioavailability in the soil hence lowering toxicity (Sizmur & Hodson, 2009). Besides that, vermicomposting enhances such physicochemical characteristics as pH, organic matter content, and nutrient availability that also helps stabilize heavy metals (Banupriya & Kanmani, 2024).

The results also justify the vermicomposting as a sustainable bioremediation measure. Past research has shown that Earthworm mediated processes can highly decrease biological contaminants (including pathogens) and their removal efficiency is greater than 90% (Jafari et al., 2021). This indicates that vermicomposting can be used not only in the detoxification of chemicals but also in enhancing the general health and safety of the soil.

In general, the current research paper establishes that vermicomposting is a cheap, natural and effective technology of agrochemical residues management and soil fertility restoration. The symbiotic relationship between earthworms and microorganisms has a central role in complementing the biodegradation rate and the quality of soil. Thus, the process of vermicomposting may be regarded as one of the most promising strategies of sustainable farming and environmental protection.

5. Conclusion

The present study conclusively demonstrates that sustainable vermicomposting using selected earthworm species is an efficient, eco-friendly, and economically viable approach for the biodegradation of agrochemical residues and improvement of soil health. The significant reduction in pollutant concentration, including heavy metals such as cadmium, along with improvement in soil physicochemical properties, highlights the effectiveness of earthworm-mediated bioremediation processes. Earthworms enhance degradation through ingestion, bioaccumulation, and stimulation of microbial activity, leading to transformation of toxic substances into stable and less bioavailable forms, thereby reducing environmental risk (Singh & Kalamdhad, 2013; Poojari et al., 2014). The ability of earthworms to immobilize and detoxify heavy metals through physiological mechanisms such as metallothionein production further supports their role in sustainable soil remediation. Additionally, vermicomposting not only reduces pollutant toxicity but also produces nutrient-rich organic manure containing essential macro- and micronutrients, beneficial enzymes, and microbial populations that enhance soil fertility and crop productivity (Abad & Shafiqi, 2022: Kumar Thatipamula et al., 2017). The synergistic interaction between earthworms and microorganisms plays a critical role in accelerating organic matter stabilization and contaminant degradation, resulting in improved soil structure, aeration, and nutrient availability. Furthermore, the reduction in bioavailability and leachability of heavy metals during vermicomposting ensures that the final product is safe for agricultural application and does not pose a threat to plants, animals, or human health. Overall, vermicomposting emerges as a sustainable biotechnological solution for managing agrochemical residues, promoting organic farming, and supporting rural livelihoods. Therefore, its large-scale adoption, supported by proper awareness, technical training, and policy initiatives, can significantly contribute to sustainable agriculture, environmental protection, and circular bioresource management systems

Competing interests:

The authors declare that they have no competing interests

References

[1] Abad, M., & Shafiqi, M. (2022). Vermicomposting and its role in sustainable agriculture. Journal of Research in Agriculture and Biology Science, 8(2), 45–52.

[2] Gajalakshmi, S., &Abbasi, S. A. (2004). Earthworms and vermicomposting. Indian Journal of Biotechnology, 3(4), 486–494.

[3] Gupta, R., Yadav, A., & Garg, V. K. (2007). Influence of vermicompost on soil fertility. Bioresource Technology, 98(2), 364–368.

[4] Jafari, A. J., Zazouli, M. A., &Mahvi, A. H. (2021). Investigating the effects of vermicomposting using Eiseniafetida on parasite reduction. Journal of Environmental Health Science and Engineering, 19(2), 1623–1633.

[5] Kumar Thatipamula, R., Narsimha, S., Battula, K., Chary, V. R., Mamidala, E., & Reddy, N. V. (2017). Synthesis, anticancer and antibacterial evaluation of novel (isopropylidene) uridine-[1, 2, 3] triazole hybrids. Journal of Saudi Chemical Society, 21(7), 795-802.

[6] Luo, Y., Li, G., & Wang, X. (2023). Vermicomposting of organic and inorganic wastes: A review. Applied Sciences, 13(18), 10239.

[7] Mamidala, E., Davella, R., Gurrapu, S., & Shivakrishna, P. (2020). In silico identification of clinically approved medicines against the main protease of SARS-CoV-2, causative agent of covid-19. *arXiv preprint arXiv:2004.12055*.

[8] Poojari, S., Porika, R., & Mamidala, E. (2014). Phytochemical analysis and in vitro antidiabetic activities of Physalis angulata fruit extracts. *Natl. J. Integr. Res. Med*, *5*, 34-38.

[9] Singh, J., & Kalamdhad, A. S. (2013). Reduction of heavy metals during vermicomposting. Environmental Science and Pollution Research, 20(6), 369–379.

[10] Sizmur, T., &Hodson, M. E. (2009). Do earthworms impact metal mobility and availability? Environmental Pollution, 157(7), 1981–1989.

[11] Zhang, L., Sun, X., & Tian, Y. (2020). Effects of earthworms on pollutant degradation during vermicomposting. Environmental Science and Pollution Research, 27(5), 1

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