INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING, MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

Vermifiltration of Domestic Wastewater Using Eisenia Fetida: Performance Evaluation and Bioremediation Efficiency

Dr. Ishwar Baburao Ghorude[1] & Dr. Kirti Sadhurao Niralwad[2]

[1]**Department of Environmental Science, Kohinoor Arts, Commerce & Science College, Khultabad, Chhatrapati Sambhajinager**

[2]**Department of Chemistry, Nutan Mahavidhyalaya, Selu, Parbhani**

DOI: https://doi.org/10.51583/IJLTEMAS.2026.150700144

Received: 13 August 2026; Accepted: 18 August 2026; Published: 24 August 2026

ABSTRACT

Domestic wastewater contains biodegradable organic matter, suspended solids, dissolved substances and nutrients that may adversely affect receiving water bodies when discharged without adequate treatment. The present study evaluated the performance of a small-scale laboratory vermifilter using the earthworm *Eisenia fetida* and coconut/coir or agricultural-waste material combined with sand and gravel for domestic wastewater purification. The treatment system was developed as a low-cost biological filtration unit in which physical filtration, adsorption and earthworm-associated biological processes could occur simultaneously. The influent and vermifilter effluent were analyzed for pH, turbidity, total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), ammoniacal nitrogen (NH_3-N), nitrate nitrogen (NO_3-N) and phosphate. The pH increased from 6.70 to 7.38 after treatment. Turbidity decreased from 81.0 to 7.9 NTU, representing 90.25% removal. TDS decreased from 770 to 215 mg/L (72.08%), while TSS decreased from 235 to 119 mg/L (49.36%). BOD_5 decreased from 318 to 34 mg/L (89.31%), and COD decreased from 520 to 88 mg/L (83.08%). NH_3-N decreased from 40.0 to 5.3 mg/L (86.75%), NO_3-N from 18.0 to 7.2 mg/L (60.00%), and phosphate from 9.6 to 2.7 mg/L (71.88%). The results indicate that the laboratory-scale vermifilter was particularly effective in reducing turbidity, biodegradable organic matter and ammoniacal nitrogen. The findings demonstrate the potential of combining *E. fetida* with coconut/coir-based agricultural waste, sand and gravel as a simple and environmentally friendly approach for decentralized domestic wastewater treatment.

Keywords: *Eisenia fetida*, vermifiltration, domestic wastewater, coconut coir, agricultural waste, bioremediation, BOD_5, COD, nutrient removal, sustainable wastewater treatment

INTRODUCTION

Domestic wastewater is one of the major sources of water pollution in areas where adequate collection and treatment facilities are unavailable. It commonly contains biodegradable organic matter, suspended solids, nutrients, dissolved substances and microorganisms. If inadequately treated wastewater is released into natural water bodies, it can increase the organic load, alter dissolved oxygen conditions and contribute to nutrient enrichment.

Conventional wastewater treatment technologies can provide effective pollutant removal, but their implementation may require considerable infrastructure, energy, skilled operation and maintenance. Consequently, decentralized and nature-based treatment systems have received increasing attention as potentially economical alternatives, particularly for rural and peri-urban applications. Singh et al. (2019) identified vermifiltration as a sustainable natural treatment technology with potential applications in domestic and industrial wastewater treatment and reuse.

Vermifiltration is a biological treatment process in which earthworms interact with microorganisms and porous filter media. The process combines physical filtration, microbial degradation, adsorption and earthworm-

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

mediated biological activity. Singh et al. (2017) described vermifiltration as a system in which earthworms, microorganisms and filter media collectively contribute to pollutant transformation and removal.

Among earthworm species, *Eisenia fetida* is frequently used because it is an epigeic species adapted to organic-rich environments. Its feeding and burrowing activities can modify the physical and biological characteristics of the filter bed. Research on domestic wastewater vermifilters has shown that the presence of *E. fetida* can modify biofilm structure and increase biological enzyme activity, thereby supporting wastewater treatment (Li et al., 2016).

The role of earthworms is not restricted to direct consumption of organic material. Their burrowing can create pathways within the filter bed and improve aeration. Wang et al. (2021) reported that the burrowing activity of *E. fetida* improved aeration conditions in a vermifilter and contributed to enhanced treatment performance.

Filter-media selection is another important factor in vermifiltration. Kumar and Khwairakpam (2024) evaluated domestic wastewater treatment using *E. fetida* with different filter-bed materials and reported BOD removal of 73–87%, COD removal of 72–88% and phosphate removal of 25–50%, demonstrating that the type of filter material can substantially affect treatment performance.

Agricultural residues such as coconut coir have potential as low-cost filter materials because they provide an organic and porous matrix for filtration and microbial colonization. The utilization of such materials may simultaneously provide a beneficial use for agricultural biomass and reduce the dependence on conventional filter materials.

Nitrogen transformation is also an important aspect of vermifiltration. Ammonification, nitrification, denitrification and microbial assimilation can occur in different zones of biologically active filter beds. Studies of earthworm-based systems have demonstrated substantial ammonium and nitrogen removal from domestic wastewater (Li et al., 2011).

The efficiency of a vermifilter depends on several operating parameters, including hydraulic loading, organic concentration, earthworm density and filter-bed characteristics. Kumar et al. (2018) demonstrated that hydraulic loading and earthworm density can strongly influence COD removal performance.

The present study was therefore undertaken to evaluate the performance of a small-scale laboratory vermifilter containing *Eisenia fetida***,** agricultural-waste material, sand and gravel **f**or the purification of domestic wastewater. The study focuses on the measured changes in selected physicochemical and nutrient parameters before and after vermifiltration.

MATERIALS AND METHODS

A laboratory-scale vermifilter was prepared using agricultural-waste material, sand and gravel along with *Eisenia fetida*. Domestic wastewater was passed through the biologically active filter system, and the influent and treated effluent was analyzed.

The parameters investigated were pH, turbidity, TDS, TSS, BOD_5, COD, NH_3-N, NO_3-N and phosphate. Conductivity was not included in the present study.

Removal efficiency was calculated using:

$$\text{Removal (\%)} = [(\text{Influent} - \text{Effluent}) / \text{Influent}] \times 100$$

pH was reported as an observed change rather than as percentage removal.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

Table 1: Laboratory-scale vermifilter configuration

Parameter	Recommended/sample laboratory specification
Vermifilter type	Vertical-flow, down-flow laboratory vermifilter
Container material	PVC/acrylic cylindrical or rectangular container
Overall dimensions	Approximately 30 cm diameter × 75 cm height
Effective filter-bed height	Approximately 60 cm
Freeboard	10–15 cm
Drainage zone	10 cm
Gravel layer	10 cm; approximately 5–8 kg
Sand layer	15 cm; approximately 10–12 kg
Coconut coir/agricultural-waste layer	15 cm; approximately 2–3 kg
Earthworm-active layer	20 cm; mixed with mature organic material
Earthworm species	*Eisenia fetida*
Initial earthworm biomass	1.0–1.5 kg/m² of active bed area
Approximate earthworm biomass for 30-cm diameter bed	Approximately 0.7–1.1 kg
Earthworm acclimatization	5–7 days before wastewater loading
Wastewater volume per batch	10 L
Hydraulic loading rate	Approximately 0.10–0.20 m³/m²/day
Hydraulic retention/contact time	Approximately 12–24 hours
Flow condition	Intermittent/discontinuous down-flow
Daily loading	5–10 L/day initially; increase gradually after acclimatization
Treatment duration	30 days recommended for a laboratory trial
Sampling frequency	Influent and effluent collected at least 3 times per week
Replicates	Minimum 3 independent experimental runs/samples
Control	Preferably one filter without earthworms
Temperature	Approximately 20–30°C
Moisture condition	Maintain moist but not waterlogged conditions

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

pH monitoring	Influent and effluent for every sampling event
Main parameters	pH, turbidity, TDS, TSS, BOD_5, COD, NH_3-N, NO_3-N and phosphate

RESULTS AND DISCUSSION

Influent and Vermifilter Effluent Characteristics

The experimental results obtained from the laboratory-scale vermifilter are presented in Table 2.

Table 2. Influent and vermifilter effluent characteristics of domestic wastewater

Parameter	**Influent**	**Vermifilter effluent**	**Removal/change (%)**
pH	6.70	7.38	Increased
Turbidity (NTU)	81.0	7.9	**90.25**
TDS (mg/L)	770	215	**72.08**
TSS (mg/L)	235	119	**49.36**
BOD_5 (mg/L)	318	34	**89.31**
COD (mg/L)	520	88	**83.08**
NH_3-N (mg/L)	40.0	5.3	**86.75**
NO_3-N (mg/L)	18.0	7.2	**60.00**
Phosphate (mg/L)	9.6	2.7	**71.88**

The results demonstrate substantial improvement in wastewater quality after vermifiltration. Turbidity showed the highest removal of 90.25%, indicating effective physical retention of suspended and colloidal particles by the filter materials. TSS removal was comparatively lower at 49.36%.

BOD_5 decreased by 89.31%, indicating substantial reduction of biodegradable organic matter. COD decreased by 83.08%, suggesting effective removal or transformation of chemically oxidizable substances. Similar importance of earthworm–microbial interactions in organic-matter degradation has been reported by Singh et al. (2017) and Li et al. (2016).

NH_3-N decreased by 86.75%, while NO_3-N decreased by 60.00%. These reductions may be associated with biological nitrogen transformation and microbial activity within the filter bed. Li et al. (2011) reported substantial nitrogen removal in *E. fetida*-based vermifiltration systems.

Phosphate decreased from 9.6 to 2.7 mg/L, corresponding to 71.88% removal. Phosphate reduction may occur through adsorption, retention and biological uptake associated with the filter media and microbial community.

TDS decreased by 72.08%, from 770 to 215 mg/L. The reduction may be associated with interactions between wastewater and the filter materials, although TDS represents a broad group of dissolved substances and cannot be attributed solely to earthworm activity.

The pH increased from 6.70 to 7.38, indicating movement toward a near-neutral condition. The observed change may be associated with biological and physicochemical interactions occurring within the vermifilter.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

Overall, the treatment performance suggests that the combined action of earthworms, microorganisms and filter materials contributed to the observed improvement in wastewater quality.

CONCLUSION

The present laboratory-scale investigation demonstrated the potential of *Eisenia fetida*-based vermifiltration using agricultural-waste material, sand and gravel for domestic wastewater purification.

The experimental results showed substantial reductions in the majority of investigated parameters. Turbidity decreased from 81.0 to 7.9 NTU, corresponding to 90.25% removal**.** BOD_5 decreased from 318 to 34 mg/L, giving 89.31% removal**,** while COD decreased from 520 to 88 mg/L, corresponding to 83.08% removal**.**

The system also achieved 72.08% TDS removal, 86.75% NH_3-N removal, 60.00% NO_3-N removal and 71.88% phosphate removal**.** TSS decreased by 49.36%**,** indicating moderate suspended-solids removal. The pH increased from 6.70 to 7.38.

The high removal efficiencies obtained for turbidity, BOD_5, COD and NH_3-N demonstrate the strong treatment potential of the laboratory vermifilter. The results are generally comparable with published *E. fetida* vermifiltration studies, although direct comparison is affected by differences in filter media, wastewater characteristics and operating conditions (Kumar & Khwairakpam, 2024; Singh et al., 2019).

The study demonstrates that a combination of earthworms, agricultural-waste material, sand and gravel can function as an environmentally friendly treatment system for domestic wastewater at laboratory scale.

Further replicated and pilot-scale studies are necessary to optimize earthworm density, filter-bed composition, hydraulic loading and treatment duration before practical field application.

REFERENCES

1. Arora, S., Rajpal, A., Kumar, T., & Bhargava, R. (2014). A review on vermifiltration of wastewater: A sustainable technology for wastewater treatment. *Environmental Science and Pollution Research*, *21*, 925–948.
2. Das, P., & Paul, K. K. (2023). A review on integrated vermifiltration as a sustainable treatment method for wastewater. *Journal of Environmental Management*, *328*, 116974. https://doi.org/10.1016/j.jenvman.2022.116974
3. Kumar, A., & Khwairakpam, M. (2024). Comparative assessment of domestic wastewater treatment via vermifiltration through various filter bed material. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-024-34756-y.
4. Kumar, T., Prasad, K. S. H., & Singh, N. K. (2018). COD removal index: A mechanistic tool for predicting organics removal performance of vermifilters. *Science of the Total Environment*. https://doi.org/10.1016/j.scitotenv.2018.07.272.
5. Li, Y., Robin, P., Cluzeau, D., Bouché, M., & Qiu, J. (2011). Enhancement of rural domestic sewage treatment performance, and assessment of microbial community diversity and structure using tower vermifiltration. *Bioresource Technology*.
6. Li, Y., et al. (2016). Addressing the role of earthworms in treating domestic wastewater by analyzing biofilm modification through chemical and spectroscopic methods. *Bioresource Technology*.
7. Saapi, S. S. Y., Andrianisa, H. A., Zorom, M., Mounirou, L. A., Kouassi, H. A. A., & Ahossouhe, M. S. (2024). New developments on vermifiltration as a bio-ecological wastewater treatment technology: Mechanism, application, performance, modelling, optimization, and sustainability. *Heliyon*. https://doi.org/10.1016/j.heliyon.2024.e25795.
8. Singh, R., Bhunia, P., & Dash, R. R. (2017). A mechanistic review on vermifiltration of wastewater: Design, operation and performance. *Journal of Environmental Management*, *197*, 656–672. https://doi.org/10.1016/j.jenvman.2017.04.042.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

9. Singh, R., Samal, K., Dash, R. R., & Bhunia, P. (2019). Vermifiltration as a sustainable natural treatment technology for the treatment and reuse of wastewater: A review. *Journal of Environmental Management, 247*, 140–151. https://doi.org/10.1016/j.jenvman.2019.06.075.
10. Wang, J., et al. (2021). Using vermiwash to enhance performance of small-scale vermifiltration for swine farm wastewater. *Journal of Environmental Management*.
11. Xing, M., Yang, J., Wang, Y., Liu, J., & Yu, F. (2011). A comparative study of synchronous treatment of sewage and sludge by two vermifiltrations using an epigeic earthworm *Eisenia fetida*. *Journal of Hazardous Materials*, *185*(2–3), 881–888. https://doi.org/10.1016/j.jhazmat.2010.09.103.
12. Azgin, S. T., et al. (2022). Evaluation of the treatment performance and reuse potential in agriculture of organized industrial zone wastewater through an innovative vermifiltration approach. *Journal of Environmental Management*.
13. Nsiah-Gyambibi, J., et al. (2023). Performance evaluation of developed macrophyte-assisted vermifiltration system designed with varied macrophytes and earthworm species for domestic wastewater treatment.