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Development And Evaluation of Effective Microorganism Mud Balls as An Eco-Friendly Water Purification Strategy

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***Abstract*—Water pollution is a major environmental issue affecting public health, aquatic life, and sustainable development. This study examined the effectiveness of Effective Microorganism (EM) Mud Balls, made from red soil, rice bran, jaggery, EM solution, and alum, for treating polluted water at two sites in Ghaziabad, India: The Hindon River and the Indra Priyadarshini Park Pond. The addition of alum, a natural coagulant, was a key modification to improve treatment efficiency. Water quality was analysed before and after 21 days using parameters such as BOD, COD, TDS, TSS, pH, and the presence of algae and zooplankton. Laboratory results showed significant improvement in both samples. In the Hindon River sample, BOD decreased by 84.7% and COD by 82.5%. In the pond sample, TDS declined by 78.0%. Algae and zooplankton were completely removed in both samples. The findings suggest that alum-enhanced EM Mud Balls are a low-cost, eco-friendly, and scalable alternative for water purification. This method also supports initiatives such as Namami Gange, Swachh Bharat Abhiyan, and Jal Shakti Abhiyan, as well as the UN Sustainable Development Goals 3, 6, 13, 14, and 15.**

***Index Terms*—Effective Microorganisms; EM Mud Balls; water purification; bio-remediation; alum coagulation; Hindon River; water pollution; SDGs**

I. INTRODUCTION

Safe and clean water is recognised as a basic human necessity, yet a large share of the global population still lacks reliable drinking water services. In India, the quality of rivers, ponds, and other freshwater resources has declined due to rapid urbanisation, industrial discharge, untreated sewage, and agricultural runoff (Ejiohuo et al., 2025). These pressures are especially visible in densely populated states such as Uttar Pradesh, where increasing demand and inadequate wastewater management have intensified water contamination problems. Reports from parts of Ghaziabad, including Vaishali, Brij Vihar, and nearby residential areas, have highlighted concerns regarding foul odour, turbidity, irregular supply, and dependence on packaged drinking water, placing additional financial and health burdens on households(The Energy and Resources Institute, 2010).

The Hindon River, a tributary of the Yamuna, is widely regarded as one of the most stressed river systems in the National Capital Region because of continuous inflow of domestic sewage and industrial waste. Urban ponds and artificial lakes face similar degradation (Kumar et al., 2018). Nutrient enrichment, algal blooms, sediment accumulation, and microbial growth frequently reduce water quality and ecological value in such water bodies, including ponds located within public parks. Conventional treatment methods such as chlorination, chemical coagulation, and centralised filtration systems can be effective, but they often require substantial infrastructure, technical oversight, and recurring operational costs, which may limit their use in decentralised settings (Emer, 2024).

Bioremediation has emerged as a sustainable alternative for restoring polluted aquatic environments. One such approach is Effective Microorganism (EM) technology, developed by Professor Teruo Higa at the University of the Ryukyus, Japan (Saleh et al., 2024). EM consists of selected beneficial microbes, mainly lactic acid bacteria, yeasts, and photosynthetic bacteria, which work synergistically to degrade organic matter, reduce odour, suppress harmful microorganisms, and improve ecological balance. When incorporated into soil-based spheres known as EM Mud Balls or Bokashi Balls, these microbial communities can be introduced directly into water bodies and bottom sediments, where they gradually activate remediation processes (Zakarya et al., 2025).

The use of EM Mud Balls has been reported in several international restoration efforts, including lakes, reservoirs, and coastal environments in countries such as Malaysia, Poland, Singapore, and Russia (Abd Wahab & Ahmad, 2025). However, scientific evaluation of this method under Indian urban conditions remains limited. Therefore, the present study was undertaken to assess the effectiveness of EM Mud Balls for polluted water bodies in Ghaziabad, Uttar Pradesh. In addition, a modified formulation containing alum (potassium aluminium sulphate) was investigated. Alum is widely used as a coagulant in water treatment and was included to enhance suspended particle removal, improve clarity, and strengthen the overall remediation process(Wahab et al., 2025a).

This study was undertaken to formulate alum-enriched EM Mud Balls, evaluate their effect on major physicochemical and biological water-quality parameters over a 21-day treatment period, compare the results with CPCB standards for inland surface water, and determine their suitability as an economical and environmentally sustainable water purification approach for Indian water bodies.

II. MATERIALS AND METHODS

2.1. Study Sites and Sample Collection

Water samples were collected on 1 June 2025 from two locations in Ghaziabad, Uttar Pradesh:

- Sample A: Hindon River, Hindon Vihar, Ghaziabad (Lat: 28.671885, Long: 77.401082)
- Sample B: Indra Priyadarshini Park Pond, Indira Kunj, Ghaziabad (Lat: 28.674392, Long: 77.400263)

Samples were collected in sterile, labelled containers and transported under controlled conditions to AES Laboratories Pvt. Ltd. (ISO/IEC 17025:2017 accredited by NABL) for baseline analysis. GPS-tagged photographs were taken at both sites to document collection conditions.

2.2. EM Mud Ball Formulation

The experimental work was completed through a systematic nine-step methodology. Initially, polluted water samples were collected from both selected locations in sterile containers to avoid external contamination. Before treatment, baseline physicochemical and biological analyses were performed at AES Laboratory. Simultaneously, preliminary observations were recorded for colour, odour, turbidity, pH using pH strips, and Total Dissolved Solids (TDS) using a digital TDS meter. After initial testing, all raw materials required for EM Mud Ball preparation, namely red soil, rice bran, jaggery, alum, and EM-1 solution, were procured and measured in predetermined quantities. The dry ingredients were thoroughly blended, after which the EM solution was added gradually while kneading until a uniform dough-like consistency was achieved. This mixture was then hand-rolled into lemon-sized spheres of approximately 4–5 cm diameter using gloves. The prepared balls were kept under shaded conditions for 48–72 hours to permit controlled fermentation and activation of beneficial microorganisms. Once dried, the EM Mud Balls were added to the collected water samples at a dosage of two balls per litre. Changes in water quality were monitored at regular intervals on Days 7, 14, and 21, with observations recorded for colour, clarity, odour, pH, TDS, and turbidity. At the end of the treatment period, the water samples were again submitted to AES Laboratory for final analysis and comparison with baseline values (Park et al., 2016).

Table 1: EM Mud Ball Formulation

Ingredient	Quantity	Function
Red Soil	2 kg	Provides structure and binds the ball; serves as a carrier matrix
Rice Bran	500 g	Boosts microbial activity and supports fermentation substrate
Jaggery	100 g	Acts as a carbon-rich food source for microbial proliferation
Alum (Novel Addition)	50 g	Natural coagulant; accelerates sedimentation and improves clarity
EM-1 Solution	100 ml	Contains beneficial microorganisms that decompose organic pollutants
Water	As required	Activates fermentation and binds the mixture

Measurement Instruments and Standards

Water-quality assessment was carried out using standard analytical tools and recognised regulatory benchmarks. A digital TDS meter was used to determine Total Dissolved Solids (mg/L), while pH strips were employed for routine estimation of pH values during the observation period. Detailed physicochemical and biological analyses, including BOD, COD, TDS, TSS, pH, and microbial or biological parameters, were conducted by AES Laboratory, a NABL-accredited testing facility. The analytical results were interpreted with reference to the Central Pollution Control Board (CPCB) General Standards for Discharge of Environmental Pollutants [Schedule VI], which served as the compliance framework for evaluating treatment performance (Wahab et al., 2025).

III. RESULTS

Visual and Field Observations

Field observations were taken every seven days during the 21-day treatment period. On Day 0, both samples showed heavy pollution. Sample A (Hindon River) was muddy brown with a foul smell, suspended particles, and insects. Sample B (Indra Priyadarshini Park Pond) was greenish, cloudy, and had an unpleasant odour with visible algal growth.

Figure: Polluted water samples collected from the selected study sites, namely the Hindon River and Indra Priyadarshini Park, located in Ghaziabad, Uttar Pradesh.

By Day 7, a slight improvement was noticed in both samples, mainly an odour reduction, although turbidity was still high. On Day 14, Sample A became lighter brown with less smell, while Sample B looked less green and cleaner.

Figure: Visual improvement in water samples during EM Mud Ball treatment. Day 7 showed reduced odour, Day 14 showed a cleaner appearance with less greenness, and by Day 21, both samples were markedly clearer with improved odour.

By Day 21, both samples showed clear improvement. Sample A was nearly clear, had a pleasant odour, and TDS reduced from 489 ppm to 218 ppm. Sample B also became much clearer with a pleasant smell, and TDS dropped from 1952 ppm to 425 ppm. Turbidity in both samples was greatly reduced and close to clear water.

Laboratory Results Sample A (Hindon River)

Table 2: Sample A (Hindon River) Before and After Treatment (NABL-accredited laboratory results)

Parameter	Before Treatment	After Treatment	CPCB Limit	Status
BOD (3 days @ 27°C)	150 mg/L	23 mg/L	30 mg/L	✓ Compliant
COD	670 mg/L	117 mg/L	250 mg/L	✓ Compliant
TDS	356 mg/L	202 mg/L	450 mg/L	✓ Safe
TSS	118 mg/L	84 mg/L	100 mg/L	✓ Compliant
pH (at 25°C)	6.26	6.30	5.5 – 9.0	✓ Normal
Zooplanktons	Present	Absent	Absent	✓ Removed
Algae	Present	Absent	Absent	✓ Removed

Sample A exhibited the most dramatic improvements. BOD fell from 150 mg/L to 23 mg/L, an 84.7% reduction, bringing it well within the CPCB inland surface water standard of 30 mg/L. COD decreased from 670 mg/L to 117 mg/L (82.5% reduction), dropping below the 250 mg/L standard. TDS reduced from 356 mg/L to 202 mg/L, and TSS from 118 mg/L to 84 mg/L. Both algae and zooplankton were absent post-treatment.

Laboratory Results Sample B (Indra Priyadarshini Park Pond)

Table 3: Sample B (Indra Priyadarshini Park Pond) Before and After Treatment (NABL-accredited laboratory results)

Parameter	Before Treatment	After Treatment	CPCB Limit	Status
BOD (3 days @ 27°C)	32 mg/L	5.0 mg/L	30 mg/L	✓ Compliant
COD	140 mg/L	28 mg/L	250 mg/L	✓ Compliant
TDS	1765 mg/L	389 mg/L	450 mg/L	✓ Safe
TSS	22 mg/L	7.0 mg/L	100 mg/L	✓ Compliant
pH (at 25°C)	8.48	5.90	5.5 – 9.0	✓ Normal
Zooplanktons	Present	Absent	Absent	✓ Removed
Algae	Present	Absent	Absent	✓ Removed

Sample B showed equally compelling results. TDS declined from a very high baseline of 1765 mg/L to 389 mg/L, a 78.0% reduction. BOD fell from 32 mg/L to 5 mg/L (84.4%), and COD from 140 mg/L to 28 mg/L (80.0%). pH shifted from a slightly alkaline 8.48 to a well-balanced 5.90, within the optimal CPCB range. Algae and zooplankton were eliminated.

IV. DISCUSSION

The present study demonstrates that EM Mud Balls can substantially improve the quality of polluted water through an integrated biological remediation process. The observed reductions in BOD, COD, TDS, TSS, turbidity, odour, and biological contaminants indicate that the treatment acted on multiple sources of pollution simultaneously. These findings support the concept that microbial consortia can restore degraded water bodies by accelerating natural self-purification mechanisms (Zakarya et al., 2025).

The treatment effect can be explained through a sequence of microbial interactions. Initially, beneficial microorganisms colonize the water and sediment interface, where they degrade accumulated organic matter and sludge. This process lowers the organic load, reflected by the marked reduction in BOD and COD values after treatment. As decomposition progresses, microbial competition suppresses undesirable and pathogenic organisms, improving the biological quality of water. At the same time, nutrient uptake by the microbial community reduces the availability of nitrogen and phosphorus, which are key drivers of eutrophication and algal blooms. The combined outcome of these processes is clearer water, reduced odour, and improved ecological balance.

An important feature of this study was the inclusion of alum in the EM Mud Ball formulation. Alum is a well-established coagulating agent that promotes aggregation and settling of suspended particles, colloids, and microbial debris. Its incorporation appears to have complemented microbial activity by providing rapid initial clarification, particularly during the early treatment period when reductions in turbidity and TDS were first observed. The dual action of immediate coagulation followed by sustained biodegradation may explain the broad improvement in all measured parameters within 21 days. This suggests that combining biological and physicochemical processes can enhance the efficiency of low-cost water remediation systems.

Comparison of pre-treatment and post-treatment data showed substantial movement of all parameters toward acceptable standards. Before treatment, the water samples exhibited severe contamination, with high organic load, excessive dissolved solids, unpleasant odour, and visible algal growth. After treatment, these indicators declined markedly, demonstrating the practical relevance of this approach for polluted urban water bodies. The results are particularly significant because they were achieved without reliance on intensive infrastructure or heavy chemical treatment.

The findings also have wider environmental relevance. Low-cost and decentralized remediation methods such as EM Mud Balls may support ongoing efforts aimed at river restoration, pond rejuvenation, and community-based water management(Maharjan & Ghimire, 2021). Their use can contribute to improved sanitation, healthier aquatic ecosystems, and reduced public exposure to contaminated water. In this way, the approach is consistent with national water conservation initiatives and broader sustainable development priorities related to clean water, ecosystem protection, and public health (Abd Wahab & Ahmad, 2025).

Despite these promising results, certain limitations must be considered. The study was performed under controlled sample conditions rather than in open natural water bodies, where flow rate, weather, seasonal variation, and pollutant load may influence treatment performance. The monitoring period was limited to 21 days and therefore does not provide information on long-term stability or the possibility of recontamination. In addition, the absence of multiple replicates reduces the statistical strength of the findings. Future research should focus on field-scale validation, extended monitoring, controlled comparative trials, and optimisation of dosage under different environmental conditions (Tomczyk et al., 2023).

V. CONCLUSION

This study demonstrates that Effective Microorganism (EM) Mud Balls, augmented with alum as a natural coagulant, are a highly effective, eco-friendly, and affordable method for purifying polluted water (Monica et al., 2011). Across both study sites, the Hindon River and the Indra Priyadarshini Park Pond in Ghaziabad, all key water quality parameters improved dramatically within 21 days of treatment, with every post-treatment value meeting or exceeding CPCB standards for inland surface water. Biological contaminants, including algae and zooplankton, were eliminated (Safwat & Matta, 2021).

The alum-enhanced EM Mud Ball formulation represents an original scientific contribution, combining centuries-old Indian water-purification knowledge with contemporary microbiological techniques. The method is low-cost, requires no electricity or complex infrastructure, and uses readily available, non-toxic ingredients, making it particularly suitable for rural communities, urban park water bodies, and small river segments (Nugroho et al., 2019).

Beyond the laboratory findings, this project exemplifies the capacity of youth-led scientific inquiry to engage with real environmental challenges. It demonstrates that when curiosity, scientific rigour, and social purpose converge, even primary school students can produce meaningful contributions to environmental science and sustainable development. The results presented here constitute a proof of concept and an invitation for larger-scale experimental validation, community engagement, and potential policy consideration.

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REFERENCES

[1] N. A. Abd Wahab and M. L. Ahmad, "A study on the effective use of microorganisms using different amounts of mudball and wastewater retention time," *ASEANA Science and Education Journal*, vol. 5, no. 1, pp. 1–8, 2025, doi: 10.53797/ASEANA.V5I1.1.2025.

[2] O. Ejiohuo, H. Onyeaka, A. Akinsemolu, O. F. Nwabor, K. F. Siyanbola, P. Tamasiga, and Z. T. Al-Sharify, "Ensuring water purity: Mitigating environmental risks and safeguarding human health," Water Biology and Security, vol. 4, no. 2, Art. no. 100341, 2025, doi: 10.1016/J.WATBS.2024.100341.

[3] C. Emer, "Impact of nutrient enrichment on algal bloom dynamics in freshwater ecosystems," Journal of Biology and Today's World, vol. 13, no. 5, pp. 0–1, 2024, doi: 10.35248/2322-3308-13.5.008.

[4] D. Kumar, V. Kumar, and S. Kumari, "Study on water quality of Hindon River (tributary of Yamuna River)," Rasayan Journal of Chemistry, vol. 11, no. 4, pp. 1477–1484, 2018, doi: 10.31788/RJC.2018.1143075.

[5] A. Maharjan and A. Ghimire, "Application of activated effective microorganism, mudball and biosand filter for the treatment of dye wastewater," Nepal Journal of Environmental Science, vol. 9, no. 1, pp. 41–48, 2021, doi: 10.3126/NJES.V9I1.37376.

[6] S. Monica, L. Karthik, S. Mythili, and A. Sathiavelu, "Formulation of effective microbial consortia and its application for sewage treatment," Journal of Microbial and Biochemical Technology, vol. 3, no. 3, pp. 51–55, 2011, doi: 10.4172/1948-5948.1000051.

[7] F. L. Nugroho, D. Rusmaya, and M. Damayanti, "Comparison of COD and TSS removals from artificial river water by mudballs made with activated EM1 and EM4 solutions," International Journal of GEOMATE, vol. 16, no. 55, pp. 28–33, 2019, doi: 10.21660/2019.55.4539.

[8] G. S. Park, A. R. Khan, Y. Kwak, S. J. Hong, B. K. Jung, I. Ullah, J. G. Kim, and J. H. Shin, "An improved effective microorganism (EM) soil ball-making method for water quality restoration," Environmental Science and Pollution Research, vol. 23, no. 2, pp. 1100–1107, 2016, doi: 10.1007/S11356-015-5617-X.

[9] S. M. Safwat and M. E. Matta, "Environmental applications of effective microorganisms: A review of current knowledge and recommendations for future directions," Journal of Engineering and Applied Science, vol. 68, no. 1, 2021, doi: 10.1186/S44147-021-00049-1.

[10] A. A. Saleh, M. H. Elsheikh, F. A. El-Nakieb, S. E. Sobhy, S. S. Kabeil, and E. E. Hafez, "New perspectives into the application of effective microorganism (EM) on phytopathogenic fungi: In-vitro antioxidant capacity, bioactive substances and fungicidal efficacy," Biotechnology & Biotechnological Equipment, vol. 38, no. 1, 2024, doi: 10.1080/13102818.2024.2387190.

[11] The Energy and Resources Institute (TERI), Environmental and Social Management Framework. New Delhi, India: TERI, 2010. [Online]. Available: https://nmcg.nic.in/writereaddata/fileupload/25_ESMFVvolIrevised04.02.2020WoH.pdf

[12] P. Tomczyk, P. S. Wierzchowski, J. Dobrzyński, I. Kulkova, B. Wróbel, M. Wiatkowski, A. Kuriqi, W. Skorulski, T. Kabat, M. Prycik, Ł. Gruss, and J. Drobnik, "Effective microorganism water treatment method for rapid eutrophic reservoir restoration," Environmental Science and Pollution Research, vol. 31, no. 2, p. 2377, 2023, doi: 10.1007/S11356-023-31354-2.

[13] I. A. Zakarya, N. A. Mazwin, T. N. T. Izhar, N. A. M. Hilmi, and M. Mohamad, "Effective microorganism (EM) technology for lake conservation and water quality restoration," Environmental and Earth Sciences Proceedings, vol. 33, no. 1, Art. no. 1, 2025, doi: 10.3390/EESP2025033001.