International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 2s, 2025
https://www.theaspd.com/ijes.php

SUSTAINABLE SULLAGE WATER TREATMENT USING BIOENZYMES: AN EXPERIMENTAL PERSPECTIVE

N.B. Geetha[1], M. Rajagopal[2], S.Priya[3], G.Gokul Surendra kumar[4], K.Rajmohan[5]

[1,2]*Mechanical Engineering, PERI Institute of Technology, Chennai-48*
[3,4,5]*Electronics and Communication Engineering, PERI Institute of Technology, Chennai-48.*
Corresponding mail id: publications@peri.ac.in

ABSTRACT *With the rapid growth of the global population, the challenge of managing sewage and industrial waste has become increasingly urgent. Currently, nearly 70–80% of rivers and streams are contaminated with pollutants, posing severe risks to human health and the environment. If left unchecked, continued degradation of water bodies could have catastrophic consequences. To ensure sustainable water quality for future generations, innovative and eco-friendly treatment methods are essential. Advancements in wastewater treatment technologies now enable efficient and cost-effective purification of used water. Among the various types of waste water, sullage—also known as greywater—originates from domestic activities such as bathing, washing, and kitchen use. It typically contains food residues, oils, detergents, soaps, and organic matter. This study focuses on the experimental treatment of sullage water using bioenzymes, which are biologically derived catalysts that enhance the breakdown of organic pollutants through microbial action. The aim is to evaluate the effectiveness of bioenzymes as a sustainable and environmentally friendly solution for greywater treatment.*

Keywords: *Sullage water, Bioenzyme, Greywater treatment, Microbial action, Wastewater management*

INTRODUCTION

Water scarcity and pollution have become major global concerns due to rapid urbanization, population growth, and industrialization. In developing countries like India, a significant portion of wastewater generated from households is discharged untreated into surface water bodies, contributing to environmental degradation and posing threats to public health. Among various types of domestic wastewater, sullage water, also known as greywater, originates from non-toilet sources such as kitchens, showers, and laundry. Although less contaminated than blackwater, sullage still contains considerable amounts of organic matter, detergents, oils, and suspended solids, making it unsuitable for direct reuse or discharge without treatment.

Conventional wastewater treatment methods, while effective, often involve high capital investment, energy consumption, and complex operational procedures, making them less feasible for decentralized or small-scale applications. This calls for the adoption of low-cost, eco-friendly, and sustainable alternatives that can address the rising demand for water recycling and reuse.

Bioenzymes, produced through the fermentation of organic materials using beneficial microorganisms, have emerged as a promising green technology for wastewater treatment. These natural catalysts accelerate the decomposition of organic pollutants, reduce biochemical oxygen demand (BOD) and chemical oxygen demand (COD), and improve overall water quality without the use of harmful chemicals. Additionally, bioenzymes are biodegradable, non-toxic, and can be prepared using locally available materials, enhancing their applicability in rural and urban settings alike.

The present study aims to explore the potential of bioenzymes in the treatment of sullage water through an experimental approach. The objectives include preparation of bioenzyme formulations, analysis of key physico-chemical parameters before and after treatment, and evaluation of treatment efficiency with respect to established water quality standards. By focusing on a sustainable, nature-based solution, this research contributes to the broader goal of integrated water resource management and circular economy practices.

A major contributor to freshwater contamination is untreated domestic wastewater, which includes both blackwater (from toilets) and greywater (from baths, kitchens, and laundry). Greywater, although not containing fecal matter, carries organic pollutants such as soap, detergents, oils, and food residues. In many areas, greywater is discharged into rivers and water bodies without adequate treatment, leading to significant environmental degradation.

Since much of the water used domestically does not require potable quality—such as water for flushing toilets, gardening, or cleaning—there is a strong case for treating and reusing greywater to alleviate pressure on freshwater sources. Recycling treated sullage can reduce freshwater demand by up to 50–60%.

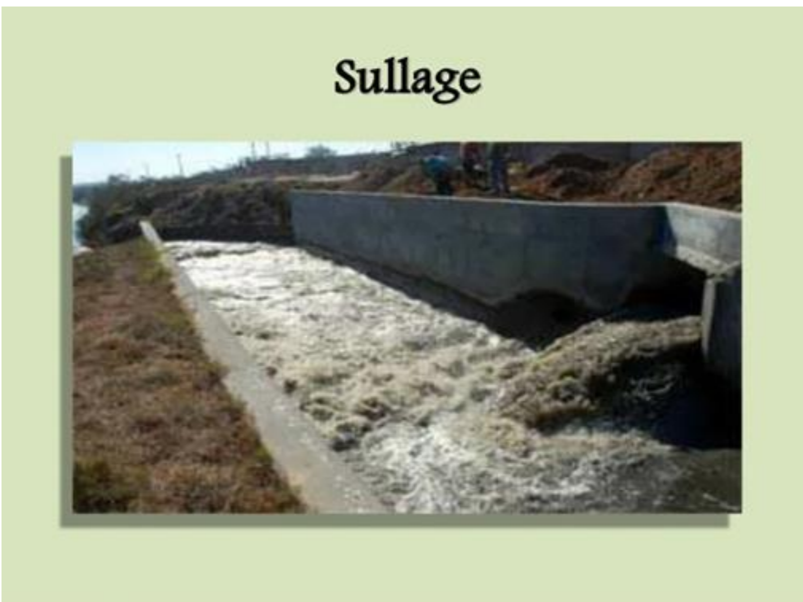

Fig no: 1 .Sullage water flow

Effective greywater treatment solutions must be affordable, environmentally friendly, and safe for human health. Among the various emerging technologies, bioenzymes—organic catalysts produced by microorganisms—offer a sustainable option. These enzymes accelerate the breakdown of organic pollutants and are biodegradable, non-toxic, and cost-effective. By enabling decentralized water treatment, bioenzymes represent a promising approach for greywater reuse, particularly in peri-urban and rural contexts.

LITERATURE REVIEW

Singh et al highlights the effectiveness of bio-enzymes derived from microbial and plant sources in breaking down organic pollutants in domestic wastewater. The paper outlines enzyme types, mechanisms, and applications, emphasizing eco-enzymes' role in enhancing treatment efficiency without harmful chemical residues[1].Gowri et al explores a low-cost, sustainable greywater treatment system using a biofilter made of coconut shell, pebbles, and sand. The system showed significant reductions in BOD, COD, and TDS, promoting the reuse of greywater for gardening and flushing[2].Hartl et al investigates microbial fuel cells integrated with constructed wetlands. Results showed enhanced contaminant removal and increased bacterial activity along the flow path, making the setup promising for decentralized wastewater treatment and energy recovery[3].Leal L H et al compares aerobic, anaerobic, and combined treatment systems for greywater. Aerobic treatment achieved the highest COD removal (90%), while the combined system offered good performance with lower operational complexity, supporting the use of biologically based solutions for greywater reuse[4].

Rajakaruna, R.M.A.S.D., et al.reviews the use of sludge-derived adsorbents for heavy metal removal in wastewater. The study emphasizes their cost-effectiveness and eco-friendliness, showing that treated sludge can serve as a sustainable adsorbent in bio-based greywater treatment systems[5].Garcia-Herrero, L., et al.compares the environmental and economic performance of full-scale constructed wetlands in northern and southern Italy. The research finds that constructed wetlands offer high environmental benefits, particularly for decentralized wastewater treatment[6].Yapıcıoğlu, P.S., & Yeşilnacar, M.İ. both present a novel approach using agro-industrial waste-derived biochar as a filter medium for greywater treatment. The system proved effective in removing organic matter and nutrients, suggesting biochar's promise in sustainable, low-cost water reuse technologies[7].

Arden, S., & Ma, X. both discusses the use of constructed wetlands for greywater treatment and reuse. It covers different plant species, substrate types, and configurations, highlighting their effectiveness, low cost, and environmental compatibility for decentralized treatment[8].Bolton.C.R. et al presents an integrated greywater treatment system combining microbial fuel cells (MFCs) and sand filtration. The system demonstrated high removal rates of organic contaminants and nutrient pollutants while also generating electricity, offering a dual benefit of treatment and energy recovery[9]. Cecconet, D., et al. introduces an innovative reactor system that uses electrical enhancement to improve biomass concentration and contaminant removal in wastewater. Shows potential for small-scale greywater systems, offering improved treatment rates and sustainability[10].Meda, A., et al.compares multiple greywater treatment systems in terms of energy consumption and environmental footprint. Highlights the energy efficiency of biological processes like biofiltration and enzymatic systems for sustainable urban water reuse[12].Arashiro, L.T., et al conducts life cycle assessment (LCA) of high-rate algal ponds, showcasing them as eco-friendly systems for nutrient removal and biomass recovery from wastewater, relevant to integrating biological processes in sullage treatment[13].

Hartl, M., et al. discusses microbial fuel cell integration into constructed wetlands for enhancing bacterial activity and contaminant degradation. Demonstrates high potential in greywater treatment and sustainable energy recovery[14].Garcia-Galan, M.J., et al.explores photobioreactors that use algae to treat wastewater with a focus on nutrient uptake and reuse. While geared towards agriculture, the findings support bio-based solutions like algal and enzymatic systems in sullage treatment[15].Cheng, D.-L., et al. sullage treatment in Suzhou River using integrated biological and physical systems with added energy recovery. Highlights the value of utilizing waste streams for energy production in sustainable water management[16].

Tayde, P., et al. investigates the feasibility of using treated sullage for non-potable uses like toilet flushing and irrigation. Emphasizes the role of cost-effective, decentralized treatments using natural and bio-based approaches[17].Shanmugan, S., et al.explores a solar-powered sullage treatment system using nanoparticle-enhanced solar stills. Offers a hybrid solution combining renewable energy and advanced materials for efficient greywater reuse[18].Husain, M., & Husain, Q. et al reviews the use of redox mediators to enhance oxidoreductive enzyme activity in breaking down organic pollutants. Supports the application of enzyme-mediated systems in bio-based sullage treatment[19].

Tan, A.H. proposing an effective wastewater treatment setup using biological components suitable for commercial buildings. Lays groundwork for small-scale enzymatic or biofilter systems in sullage management[20].Lu, J., et al. Demonstrates how oxidative enzymes can remove pharmaceutical contaminants like acetaminophen through advanced enzymatic reactions. Highlights enzymatic treatment's efficiency in degrading persistent pollutants[21].Lee, S., et al. Focuses on the enzymatic removal of phenol using thermostable β-tyrosinase. Demonstrates bioconversion of toxic compounds into less harmful byproducts, supporting enzyme use in sullage treatment[22].

BIO ENZYMES

Bio enzyme cleaners are cleaning products that use non-pathogenic, "good" harmless bacteria to digest wastes, soils, stains and malodors. The bacteria do this by producing chemicals called Bio enzyme that break down certain molecules (wastes/soils) into tiny pieces. These smaller pieces of food feed bacteria. The bacteria consume these soils and break them down into two basic compounds: water and carbon dioxide. The bacteria grow in number and continue to consume the waste until their food supply diminishes (the food waste is gone).

Bioenzyme are the liquids made with citrus peel, jaggery pieces and water mix in a required proportion. And after fermentation of some days the Bioenzyme ready to use. They are organic in nature and you can easily made this useful liquid at your home by just following some steps.

Often confused as a plant fertilizer only bioenzymes helps in many ways with such a limited cost to pay. It is now gaining popularity because of its non toxic natural behavior which shows the concern about preventing the environment by using it.

When bioenzymes apply to the stain or greasy area ,the bacteria digest and breakdowns them and makes the area or floor clean. The bacteria of bioenzymes can reach in very small cracks and crevices and that how they can clean your required very properly. It eliminates the malodour and soiling. It can be easily used as multipurpose like as cleaner, pesticides, insect repellents, etc.

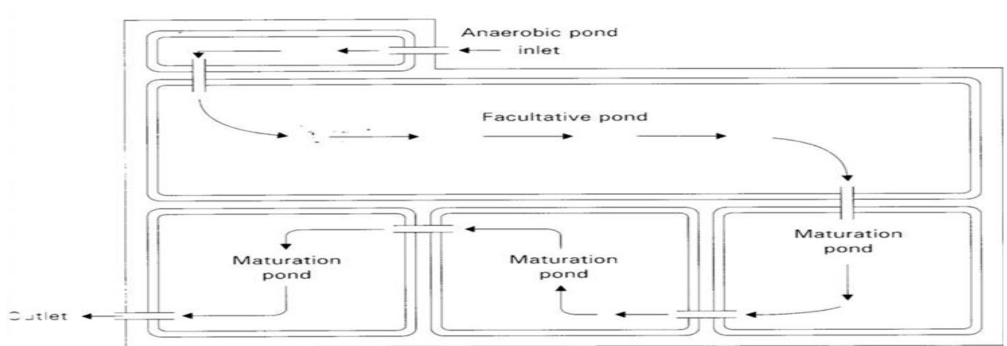

Fig no: 2 Flow diagram for sullage treatement.

Bioenzyme is totally natural fermented solution that can used a multipurpose cleaner. This will help in preventing the use of high toxic chemical based room cleaners that cost very high and also not save for human health. Synthetic cleaners also indirectly harms environment by polluting water with their toxic chemicals and continuous use of these synthetic cleaners also damage the floors and tiles. So instead of using these hazardous cleaners you can simply use homemade

TYPES- OF BIOENZYMES

Bioenzymes having different types of enzymes that are as-

1.Proteases-This enzymes helps in breakdowns of protein based materials.

2.Lipases-This enzymes helps in breakdown of fats and grease.

3.Amylases-this enzymes breakdown all types of starch molecules.

4.Cellulases-it helps in soften fabric and forever restore its colour as it is.

PREPARATION OF BIOENZYME-

1.First of all take jaggery, citrus peel and water in a proportion of 1:3:10 and add 1 tbsp of yeast in it. You can also use peels of carrot, cucumber, pineapple, sweet lime, and lettuce on the place of citrus.

2. Now mix all these ingredients in a plastic bottle with a screw bottle cap and keep it for 1 month for fermentation. And don't fill the solution to the brim.

3.The solution should stirred once in a day, as it produces the gases.

4. Now the fermentation will be done in anaerobic condition for 1 month.

5.After a month, strain the liquid and store it in a plastic bottle.

6.It is ready to use for different purpose.

Application of Bio enzyme Natural Cleaner

Use it as a cleaner and disinfectant various surfaces of the home like the glass windows, floor, countertops and so on. Bioenzymes is the best cleaner for your home as it will keep your pocket warm and also make you feel better by not polluting your nature by using the toxic cleaners.

These can repel small insects, cockroaches and ants at home. Bioenzyme also works very well for insects repellent, as in summer houseflies increases in home but if you apply this liquid and clean floor properly. It will prevent the houseflies to come in home.

Deodorise any space by spraying a solution of 25 percent bio enzyme with 75 percent of water.

It is perfect for cleaning the bathroom sink and Washing areas. Bioenzymes can remove the yellow stain of your washroom easily which is done by the toxic cleaners full of hazardous chemicals.

Bio enzymes are highly recommended for cleaning of tiles and grout because the bacteria can enter small cracks or crevices to remove soils and malodors.

This bio enzyme cleaner is effective in removing limescale deposits from the taps and steel appliances. The best example is your water heater rod after continuous heating the salt collects on it which decrease the heating efficiency of heating rod.

The organic solution can be used to clean pesticides and other chemicals from fruits and vegetables cleaning.

Bioenzyme as natural pesticide, many times people fond of growing plants have their terrace full of plants.

So, bioenzyme not only is a effective way to do a multipurpose work but also helps in use the waste of kitchen in a different way and can save so much money without doing anything. It also helps in managing the waste of kitchen. It's an easy making solution which can have several uses for a home. It preparation process is very easy and can ready within a month and can be used for many months.

Bioenzyme Used: Enviro Enzyme-G

Enviro Enzyme-G is a dry, free-flowing powder formulation composed of hydrolytic enzymes and a consortium of eight naturally occurring bacterial strains. These microorganisms are genetically capable of producing high concentrations of enzymes essential for the breakdown and treatment of complex organic waste. The product functions under both aerobic and anaerobic conditions and is widely applied across diverse industries, including breweries, distilleries, food processing, dairies, textiles, leather industries, and municipal waste treatment plants.

The primary function of the enzymes is to catalyze hydrolytic reactions, breaking down long-chain organic waste molecules into simpler compounds. These smaller fragments can then be readily consumed and metabolized by the bacterial strains, leading to effective waste degradation.

Applications and Benefits of Enviro Enzyme-G:

Odour elimination: Breaks down odorous compounds, enhancing air quality around treatment units.

Reduction in sludge volume: Efficient digestion of solids minimizes residual sludge.

Improved sludge handling: Easier pumping, processing, and dewatering with less associated odour.

Increased treatment capacity: Enables faster and more efficient processing of larger waste volumes.

Shock resistance: Enhances the system's resilience to toxic influents.

Stabilized operations: Supports smoother and more balanced system performance.

Accelerated bacterial oxidation: Ensures more rapid and complete treatment of liquid phases.

Uniform digester performance: Promotes consistency in digestion, aiding routine operations.

Consistent compliance with effluent standards: Facilitates achievement of environmental discharge norms and contributes to public health safety.

Operational Parameters:

To ensure optimal performance, Enviro Enzyme-G must be used within specific physicochemical limits:

- **pH Range:**
  - Optimum: 7.0
  - Acceptable Range: 5.0 – 9.0
  - (Highly acidic conditions should be avoided)
- **Dissolved Oxygen (DO):**
  - Optimum: 2 ppm
  - Minimum: 1 ppm
- **Carbon to Nitrogen (C:N) Ratio:**
  - Optimum: 10:1
  - Maximum: 20:1
- **Temperature:**
  - Optimum: 30°C

- Minimum: 10°C
- Maximum: 40°C

COD (Chemical Oxygen Demand)

- It is a key parameter used to assess the amount of organic pollutants in the water. COD measures the amount of oxygen required to chemically oxidize organic matter in water.
- A high COD value indicates high levels of organic pollution.
- Reducing COD is essential for meeting environmental discharge standards and improving water quality.

Effect of Enviro Enzyme-G on COD:

Enviro Enzyme-G is designed to significantly reduce COD levels through its action on organic pollutants:

- The hydrolytic enzymes in the product break down complex organic molecules (fats, oils, proteins, carbohydrates) into simpler compounds.
- The bacterial strains then consume these smaller molecules, further reducing the organic load.
- This two-stage process — enzymatic breakdown followed by microbial digestion — lowers COD effectively, usually within 24 to 72 hours, depending on system conditions.

RESULTS AND DISCUSSION

pH Stability:

- pH values across all samples remained within the optimal neutral range (6.5 to 7.5), suitable for most biological and reuse applications.

Moderate to High Alkalinity:

- Alkalinity ranged from 55 mg/L to 680 mg/L. Some samples exceed standard limits, indicating potential for scaling in pipes if reused directly.

Hardness Levels:

- Water hardness (55–600 mg/L) varied significantly. While some samples are within acceptable limits, others approached or exceeded the maximum threshold for domestic reuse.

Elevated TDS (Total Dissolved Solids):

- TDS values were high (841–1746 mg/L), indicating a high concentration of dissolved inorganic and organic substances post-treatment.

High Fluoride and Iron Content:

- Fluoride (up to 3 mg/L) and Iron (up to 10 mg/L) levels exceeded potable water standards, suggesting the need for further filtration if intended for reuse beyond flushing or gardening.

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 2s, 2025
https://www.theaspd.com/ijes.php

Ammonia Presence:

- Ammonia concentrations ranged from 1–5 mg/L, which is significantly above drinking water standards and could be a concern for aquatic environments.

Stable Nitrite and Acceptable Nitrate Levels:

- Nitrite was consistently low (0.2 mg/L), and Nitrate remained within safe limits (20–45 mg/L), showing minimal nitrogen-related toxicity post-treatment.

Effectiveness of Bioenzyme:

- The enzyme-based treatment shows promise in breaking down complex organic matter (indirectly indicated by controlled pH and nitrogen parameters) and improving the overall reuse potential of sullage water.

TABLE NO:1 CHARACTERISATION OF SULLAGE WATER SAMPLES

Sample no	Ph	Alkalinity	Hardnes	Chloride	TDS	Flouride	Iron	Ammonia	Nitrite	Nitrate
1	7	450	590	390	1508	2	10	2	0.2	20
2	7.5	510	390	270	1224	1.5	5	1	0.2	45
3	6.5	560	550	330	1506	2	3	1	0.2	20
4	7	680	530	350	1630	1.5	3	5	0.2	20
5	6.5	620	480	290	1448	1.5	10	3	0.2	45
6	7	550	550	410	1592	3	5	3	0.2	20
7	7	530	400	380	1386	3	3	2	0.2	20
8	7	630	600	430	1746	2	5	3	0.2	20
9	6.5	450	55	280	841	3	10	3	0.2	20
10	6.5	55	520	310	947	2	3	2	0.2	20

COD REMOVAL AFTER ADDING BIOENZYME

The graph illustrates the variation in Chemical Oxygen Demand (COD) values across ten different sullage water samples before the application of the bioenzyme *Enviro Enzyme*-G. COD is a critical indicator of organic pollutant load in wastewater and reflects the oxygen required to oxidize organic compounds.

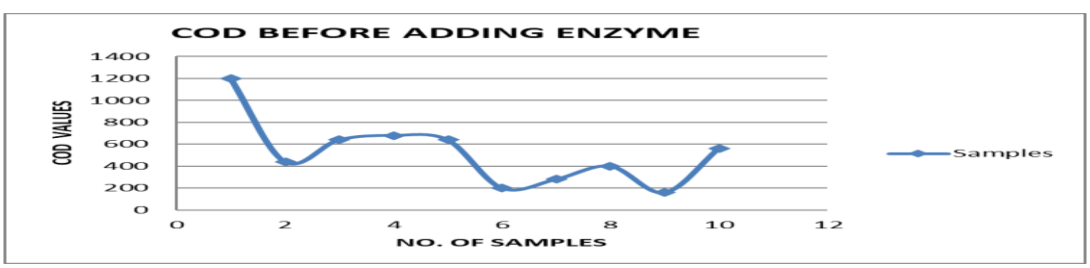

Fig No: 3 Adding Enzyme

COD READING AFTER ADDING 1MG OF ENZYME

The graph shows the **Chemical Oxygen Demand (COD)** values of sullage water samples **after treatment with 1 ml of Enviro Enzyme-G**. COD is a vital water quality parameter used to estimate the amount of organic pollutants present in wastewater. The reduction in COD values post-treatment signifies the effectiveness of the enzymatic action in breaking down organic matter.

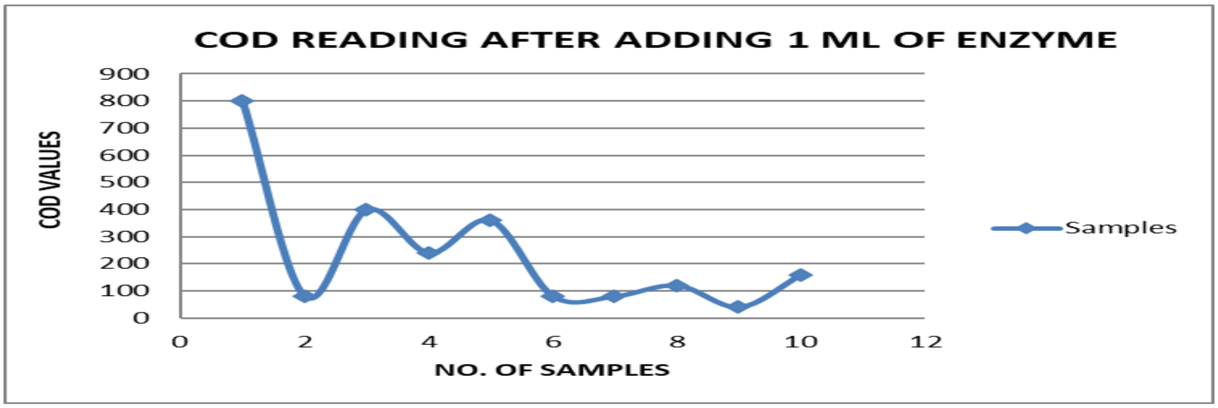

Fig No: 4 Adding 1 ML of Enzyme

CONCLUSION

The treatment of sullage water is essential to mitigate environmental degradation, operational challenges, aesthetic issues, and, most importantly, public health hazards. Reducing the organic load and eliminating pathogenic contaminants are key priorities in ensuring the safe reuse or discharge of greywater.This experimental study demonstrated the potential of Enviro Enzyme-G in effectively reducing the Chemical Oxygen Demand (COD) of sullage water under laboratory conditions. However, to validate the long-term efficacy and practical applicability of this bioenzyme, further research under real-world field conditions is necessary.The enzyme's performance showed temporal variations, indicating the need for a deeper investigation into factors influencing its stability and activity. Future studies should also focus on identifying suitable additives or activators that can enhance enzyme performance and accelerate degradation processes. Additionally, exploring appropriate pre-treatment methods to reduce the initial high COD levels could significantly improve the overall efficiency of enzymatic treatment.

REFERENCES:

[1] Singh, A., & Jain, R. (2024). Treatment of Domestic Wastewater Using Bio-Enzymes: A Review. Archives of Current Research International, 24(12), 147–154.

[2] Gowri, N.R., Muizz, M.A., Raqeeb, K.S.M., & Quisar, M. (2024). Biofiltration: A Sustainable Solution for Grey Water Treatment. International Journal of Engineering Research & Technology, 12(04).

[3] Hartl, M., Bedoya-Ríos, D.F., Fernández-Gatell, M., Rousseau, D.P.L., Du Laing, G., Garfí, M., & Puigagut, J. (2020). Contaminants Removal and Bacterial Activity Enhancement Along the Flow Path of Constructed Wetland Microbial Fuel Cells. arXiv preprint arXiv:2003.08896

[4] Leal, L.H., Temmink, H., Zeeman, G., & Buisman, C.J.N. (2010). Comparison of Three Systems for Biological Greywater Treatment. Water, 2(2), 155–169.

[5] Dhananjana Rajakaruna, R.M.A.S., Sewwandi, B.G.N., Najim, M.M.M., Baig, M.B., Alotaibi, B.A., & Traore, A. (2023). Sustainable Approaches for Wastewater Treatment: An Analysis of Sludge-Based Materials for Heavy Metal Removal from Wastewater by Adsorption. Sustainability, 15(20), 14937

[6] Garcia-Herrero, L., Lavrnic, S., Guerrieri, V., Toscano, A., Milani, M., Cirelli, G.L., & Vittuari, M. (2023). Cost-Benefit of Green Infrastructures for Water Management: A Sustainability Assessment of Full-Scale Constructed Wetlands in Northern and Southern Italy. arXiv preprint arXiv:2305.06284.

[7] Yapıcıoğlu, P.S., & Yeşilnacar, M.İ. (2025). Greywater Treatment Using Agro-Industrial Biochar: A Novel Water Reuse Approach. Biology and Life Sciences Forum, 41(1), 2.

[8] Arden, S., & Ma, X. (2018). Constructed Wetlands for Greywater Recycle and Reuse: A Review. Science of the Total Environment, 630, 587–599.

[9] Bolton, C.R., & Randall, D.G. (2019). Development of an Integrated Wetland Microbial Fuel Cell and Sand Filtration System for Greywater Treatment. Journal of Environmental Chemical Engineering, 7, 103249

[10] Cecconet, D., Salè, E.O., Callegari, A., & Capodaglio, A.G. (2019). Wastewater Treatment with a New Electrically Enhanced Biomass Concentrator Reactor: Trial Application and Technological Perspectives. Environmental Technology, 40, 896–902.

[11] Vuppaladadiyam, A.K., Merayo, N., Prinsen, P., Luque, R., Blanco, A., & Zhao, M. (2019). A Review on Greywater Reuse: Quality, Risks, Barriers and Global Scenarios. Reviews in Environmental Science and Bio/Technology, 18, 77–99.

[12] Meda, A., Henkel, J., Chang, Y., & Cornel, P. (2012). Comparison of Processes for Greywater Treatment for Urban Water Reuse: Energy Consumption and Footprint. In Water-Energy Interactions in Water Reuse (pp. 203–211). IWA Publishing.

[13] Arashiro, L.T., Montero, N., Ferrer, I., Acien, F.G., Gomez, C., & Garfi, M. (2020). Life Cycle Assessment of High Rate Algal Ponds for Wastewater Treatment and Resource Recovery. arXiv preprint arXiv:2003.06194.

[14] Hartl, M., Bedoya-Ríos, D.F., Fernández-Gatell, M., Rousseau, D.P.L., Du Laing, G., Garfí, M., & Puigagut, J. (2020). Contaminants Removal and Bacterial Activity Enhancement Along the Flow Path of Constructed Wetland Microbial Fuel Cells. arXiv preprint arXiv:2003.08896.

[15] Garcia-Galan, M.J., Gutierrez, R., Uggetti, E., Matamoros, V., Garcia, J., & Ferrer, I. (2018). Use of Full-Scale Hybrid Horizontal Tubular Photobioreactors to Process Agricultural Runoff. arXiv preprint arXiv:1806.09867. arXiv

[16] D. -L. Cheng, S. -J. Zhou and Q. -C. Wang, "Research on Suzhou river sullage treatment and energy resource utility," 2011 International Conference on Materials for Renewable Energy & Environment, Shanghai, China, 2011, pp. 1018-1021, doi: 10.1109/ICMREE.2011.5930974.

[17] P. Tayde, C. Shastri, B. Shah, N. Sankpal, N. Asabe and H. Jeswani, "Use of sullage for non-potable purpose," 2015 International Conference on Technologies for Sustainable Development (ICTSD), Mumbai, India, 2015, pp. 1-5, doi: 10.1109/ICTSD.2015.7095868.

[18] S. Shanmugan et al., "Sullage treatment of full solar energy process high way service of H2O in nano particles — Solar still waste water," 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI), Chennai, India, 2017, pp. 1914-1919, doi: 10.1109/ICPCSI.2017.8392049.

[19] Husain, M., and Husain, Q. "Applications of Redox Mediators in the Treatment of Organic Pollutants by Using Oxidoreductive Enzymes: A Review". Critical Reviews in Environmental Science and Technology; vol. 38, No. 1., 2008

[20] Tan, A. H. 2006. A study into a viable wastewater treatment system for a commercial site in Sarawak. BEng, Curtin University Sarawak Campus.

[21] Lu, J., Huang, Q., and Mao, L. "Removal of Acetaminophen Using Enzyme-Mediated Oxidative Coupling Processes: I. Reaction Rates and Pathways". Environ. Sci. Technol. 2009, vol. 43, pp.7062-7067. 2009

[22] Anonymous. 2002. At work on additives: Bio-additive aids nitrification, treatment plant study... Water Engineering & Management; Oct 2002; vol. 149, no. 10; ABI/INFORM Global pg. 41

[23] Lee, S., Hong, S., Sung, M. "Removal and bioconversion of phenol in wastewater by a thermostable β-tyrosinase". Enzyme and Microbial Technology, Vol., 19, pp 374 – 377, 1996