International Conference on Tropical Studies and Its Applications (ICTROPS)
Volume 5, (2026), e-ISSN : xxxx-xxxx
Website: http://e-journals2.unmul.ac.id/index.php/ictrops
Resilient Tropical Futures: Digital Transformation, Green Infrastructure, and Climate Adaptation

The Potential of Eco-Enzyme as an Environmentally Friendly Product for Organic Waste Management

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The manuscript was received on November 17th, 2025, revised on December 3rd, 2025, and accepted on January 05th, 2026, date of publication February 02nd, 2026

Abstract

Eco-enzyme is a fermented liquid produced from organic kitchen waste and has gained attention as a sustainable, low-cost alternative for wastewater treatment. This study evaluates the effectiveness of eco-enzyme derived from household fruit and vegetable scraps in improving the physical quality of industrial wastewater. Eco-enzyme was produced using a 1:3:10 ratio of organic waste, brown sugar, and water and fermented for six months under semi-anaerobic conditions. Industrial wastewater samples were treated with eco-enzyme at a dosage of 10% v/v and analyzed before and after 48 hours of contact time. Key parameters measured included pH, Total Solid (TS), Total Dissolved Solid (TDS), and Total Suspended Solid (TSS). Results showed a shift in pH from 8.0 to 7.0, TS reduction from 470.1 mg/L to 310.5 mg/L, TDS from 380.0 mg/L to 215.5 mg/L, and TSS from 95.0 mg/L to 50.0 mg/L. These reductions indicate partial degradation and settling of solid contaminants influenced by enzymatic hydrolysis and organic acids present in eco-enzyme. In addition, eco-enzyme application on chili plants increased plant height from 4.0 cm (control) to 5.7 cm after ten weeks. These findings suggest that eco-enzyme has promising potential for small-scale wastewater treatment and agricultural enhancement. However, the absence of replicate measurements and limited parameters constitute significant limitations. Further research is recommended to optimize dosage, fermentation variables, and large-scale application.

Keywords: *eco-enzyme, enzymatic hydrolysis, organic waste, plant growth, wastewater treatment*

1. Introduction

Water pollution remains a persistent environmental challenge, particularly in regions where domestic and industrial wastewater is discharged into natural water bodies without adequate treatment. Eco-enzyme, a fermented liquid derived from household organic waste, has emerged as a promising low-cost and environmentally friendly solution. Its natural enzymatic activity, organic acids, and antimicrobial compounds have been reported to reduce contaminants in various types of waste water.

Several studies highlight its effectiveness. Yatma et al. [1] demonstrated improvements in river water quality through reductions in pH and TDS following eco-enzyme application. Kerkar and Salvi [2] reported significant decreases in BOD and COD in domestic wastewater, while Khasanah [3] observed reductions in TSS, TDS, and surfactants in river water. Similarly, Soleha et al. [4] documented improvements in COD, TSS, and TDS in tempeh wastewater treated using Averrhoa bilimbi–based eco-enzyme.

Despite these promising findings, eco-enzyme performance varies depending on waste composition, fermentation duration, environmental conditions, and wastewater characteristics. Therefore, continued assessment is necessary to understand its consistency and limitations in practical applications.

This study aims to evaluate the effects of eco-enzyme on industrial wastewater quality by analyzing changes in pH, TS, TDS, and TSS before and after treatment. Additionally, the study explores eco-enzyme's potential as a soil amendment for chili plant growth, providing insight into its multifunctional use in environmental and agricultural contexts.

2. Literature Review

2.1 Definition and Concept of Eco-Enzyme

Eco-enzyme is a multipurpose fermented liquid produced from organic waste such as fruit peels, vegetable scraps, brown sugar, and water. The fermentation process, which typically lasts 90 days or more, converts organic waste into a complex solution containing various bioactive compounds including enzymes, organic acids, and beneficial microorganisms [5]. This bioconversion process is based on the principles of decomposition, transformation, and recombination. During decomposition, organic materials are broken down into simpler forms such as carbon dioxide, water, and mineral salts. Transformation occurs when the fermented materials undergo chemical and biological changes, while recombination refers to the formation of new compounds that give eco-enzyme its antimicrobial and cleaning properties [6].

Eco-enzyme is widely recognized as a low-cost and environmentally friendly alternative to chemical-based cleaning agents and wastewater treatment additives. Its simplicity of production makes it accessible for household-level waste management and supports sustainability by reducing the volume of organic waste disposed into landfills.

2.2 Production Process of Eco-Enzyme

Eco-enzyme is commonly prepared using a 1:3:10 ratio of organic waste, sugar (molasses or brown sugar), and water. The mixture is fermented in airtight or semi-airtight containers for 3–6 months. Environmental conditions such as temperature (28–32°C) and anaerobic stability influence enzyme formation. Gas release is required during early fermentation to prevent pressure buildup. Waste type significantly affects the resulting enzymatic composition; citrus-based eco-enzyme often contains higher antimicrobial activity [6].

2.3 Mechanism of Action in Wastewater Treatment

Eco-enzyme purifies wastewater through several process:
(1) Enzymatic Hydrolysis
Eco-enzyme contains hydrolytic enzymes that can break down complex organic molecules into simpler forms, facilitating the reduction of pollutants such as TSS, TDS, BOD, and COD. Research by Kerkar and Salvi [2] demonstrated that eco-enzyme reduced BOD from 198 mg/L to 74.2 mg/L and COD from 413 mg/L to 228 mg/L in domestic wastewater within just five days.

(2) Production of Organic Acids
The fermentation process generates organic acids that help neutralize alkaline wastewater. This aligns with Yatma et al. [1], who observed a drop in pH from 7.69 to 4.63 in river water treated with eco-enzyme.

(3) Antimicrobial Activity
Eco-enzyme exhibits natural antimicrobial properties due to bioactive compounds formed during fermentation, enabling it to suppress microbial contaminants in wastewater [7].

(4) Coagulation and Flocculation Effects
Khasanah [3] found that eco-enzyme not only degrades pollutants but also assists in the coagulation-flocculation process, leading to reductions in TSS up to 8.70% and TDS up to 62.42%.

2.4 Application in Environmental Management

Eco-enzyme has been widely studied for its effectiveness in water purification. Soleha et al. [4] demonstrated that eco-enzyme derived from Averrhoa bilimbi reduced COD, TSS, and TDS in tempeh wastewater after 18 days, reinforcing its potential as a natural wastewater treatment agent.

In addition to wastewater treatment, eco-enzyme has been used in agriculture as a growth enhancer. Its nutrient-rich composition improves soil fertility by aiding decomposition of organic matter and stimulating beneficial microbes. This supports findings that eco-enzyme can enhance plant health and increase growth rate.

3. Methods

3.1 Eco-Enzyme Production

Eco-enzyme was produced using household fruit and vegetable waste (primarily citrus peels, leafy vegetables, and fruit scraps), brown sugar, and clean water in a 1:3:10 ratio. Fermentation was conducted in a 5 L plastic container under semi-anaerobic conditions at ambient temperature (28–32°C) for six months. Gas release was performed during the first two months to prevent container swelling. After fermentation, the mixture was filtered, and the resulting eco-enzyme liquid was stored at room temperature in sealed bottles.

3.2 Wastewater Treatment Procedure

Industrial wastewater was collected from a local facility (general nonhazardous wastewater; specific industry not disclosed). A 500 mL aliquot was treated with eco-enzyme at a dosage of 10% v/v (50 mL per 500 mL wastewater). The mixture was gently stirred for 2 minutes and then allowed to stand at room temperature for 48 hours. A control sample without eco-enzyme was kept under the same conditions.

3.3 Measurement Parameters

There are four parameters measured in this study:
1.pH: measured using pH paper (limitation acknowledged).
2.TS, TDS, and TSS: all of these three parameters were measured using standard gravimetric methods.
In this research, no replicate measurements were performed due to equipment limitations, so the results only reflect as single observations.

3.4 Plant Growth Experiment

The eco-enzyme was applied to soil used for chili plant cultivation to observe its effect on plant growth. Plant height was recorded every two weeks for a total of ten weeks. All data were compared between control samples and eco-enzyme–treated samples to evaluate its effectiveness.

4. Result and Discussion

4.1 Water Quality Improvement

The results of the water quality analysis before and after eco-enzyme treatment on the industrial wastewater can be seen in **Table 1** below:

Table 1. Changes in water quality parameters before and after eco-enzyme treatment

Parameters	Control	After Treatment	Unit	Reduction Percentage (%)
pH	8.0	7.0	-	-
TS (mg/ml)	470.1	310.5	mg/L	33.9
TDS (mg/ml)	380.0	215.5	mg/L	43.3
TSS (mg/ml)	95.0	50.0	mg/L	47.4

Based on **Table 1**, it can be seen that eco-enzyme treatment resulted in improvements in all measured parameters. pH decreased from 8.0 to 7.0, approaching neutral conditions. This adjustment is consistent with the presence of organic acids commonly formed during fermentation [1], contributed to stabilizing the wastewater's chemical balance. Significant reductions were observed in TS, TDS, and TSS. These results may be attributed to enzymatic hydrolysis and partial coagulation-flocculation, promoting sedimentation of suspended particles. The percentage reductions were: TS (33.9%), TDS (43.3%), and TSS (47.4%). Although the results are promising, the absence of replicate measurements and advanced parameters (e.g., COD, BOD) limits the strength of the conclusions.

4.2 Chili Plant Growth

The recorded growth height of chili plants in untreated and eco-enzyme treated soil can be seen in **Table 2**:

Table 2. Growth height of chili plants in untreated soil and eco-enzyme treated soil over a 10-week observation period.

Week	Control (cm)	Treated (cm)
2	1.0	2.0
4	1.5	3.2
6	3.0	3.7
8	3.4	4.5
10	4.0	5.7

Based on **Table 2**, it can be seen that the application of eco-enzyme to chili plant cultivation demonstrated an additional benefit beyond wastewater treatment. Plants grown in soil enriched with eco-enzyme showed consistently greater height across the observation period compared to plants in untreated soil. Over ten weeks, treated plants reached a height of 5.7 cm, while the control group only reached 4 cm. This enhanced growth may be attributed to improved nutrient availability in the soil, as eco-enzyme contributes to the decomposition of organic matter and supports microbial activity beneficial to plant development. These results are consistent with research showing that eco-enzyme can enhance soil fertility by supplying enzymes and micronutrients that promote healthier plant growth. Table 2 presents the height of chili plants grown in treated and untreated soil over a period of ten weeks. However, only one plant per group was used, so variance cannot be assessed.

Fig 1. Chili plant grown in untreated soil (control)

Fig 2. Chili plant grown in soil treated with eco-enzyme

The visual comparison between the two plants further supports the growth data presented in **Table 2**. As shown in **Fig 1**, the chili plant grown in untreated soil exhibited limited height and slower development throughout the observation period. In contrast, **Fig 2** shows that the plant grown in soil treated with eco-enzyme displayed more vigorous growth, characterized by a taller stem, healthier leaf coloration, and overall better plant condition. These visual differences confirm that eco-enzyme enhances soil quality by improving nutrient availability and stimulating microbial activity essential for plant development. The combination of visual evidence and numerical data demonstrates that eco-enzyme provides clear benefits in promoting plant growth compared to untreated soil.

4.3. Overall Discussion

The findings indicate that eco-enzyme has the potential to improve selected physical parameters in industrial wastewater while promoting plant growth. These results align with previous research; however, the effects observed here should be interpreted as preliminary due to the simple experimental setup. More comprehensive testing including COD, BOD, microbial analysis, and replication would strengthen future conclusions.

5. Conclusion

This study demonstrates that eco-enzyme produced from household organic waste can improve selected physical parameters of industrial wastewater by reducing TS, TDS, and TSS and shifting pH toward neutral conditions. Eco-enzyme also enhanced chili plant growth, suggesting beneficial effects on soil quality. There are some limitations found however, which are a) no replicate measurements in this study; b) only limited parameters tested in this study (no COD, BOD, microbial test); c) only one wastewater type used in this study; d) this study only conducted in a small-scale plant test with minimal samples; and e) this study only used pH paper rather than pH meter. For the possibility of the future studies, the research should include dosage optimization, multi-parameter analysis, statistical validation, and scaling toward community wastewater systems.

Acknowledgement

The authors would like to thank the Department of Chemical Engineering, Universitas Mulawarman and Department of Chemical Engineering, Faculty of Industrial Technology and Engineering, Kalimantan Institute of Technology, for providing the opportunity to conduct this seminar project. Appreciation is also extended to our lecturer, Tantra Diwa Larasati, S.T., M.T., for her guidance and suggestions throughout the preparation of this work. We are grateful to classmates and all individuals who supported this project during the experimental and documentation stages. This seminar presentation was made possible through the assistance and cooperation of everyone involved.

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