Research Article

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Innovative Use of Eco-Enzymes for Domestic Wastewater Purification

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ABSTRACT

The rapid pace of urbanization and the resultant increase in waste generation have significantly escalated the challenges associated with managing organic waste. In line with contemporary sustainable practices, it is imperative to recycle and repurpose waste effectively. This study investigates the use of eco-enzyme, an environmentally friendly product derived from fruit and vegetable scraps, along with natural sweeteners, in the treatment of domestic wastewater. The study assessed the impact of eco-enzyme concentrations at 15% and 20% over a five-day period. Results demonstrated that treated wastewater met irrigation standards after the treatment period. Parameters such as acidity, dissolved solids, biochemical oxygen demand, chemical oxygen demand, and microbial counts were analyzed. The 15% eco-enzyme solution reduced biochemical oxygen demand by 90.54% and chemical oxygen demand by 83.33%, while the 20% solution achieved reductions of 94.20% and 86.34%, respectively. Dissolved solids levels were reduced to 412 ppm and 422 ppm for the 15% and 20% solutions, respectively, and microbial counts decreased significantly. However, the study is limited by the short duration of the treatment period and the scope of the parameters analyzed, which may not fully capture the long-term effectiveness and broader environmental impacts of eco-enzyme use. This research underscores the potential of eco-enzyme technology in enhancing wastewater treatment processes, promoting environmental sustainability, and alleviating the burden on waste management systems. The eco-enzyme production process is straightforward and accessible, involving the fermentation of kitchen waste, and can be readily adopted in both urban and rural settings. Further research is recommended to optimize the fermentation process, reduce digestion time, and explore the broader applications of eco-enzymes in fields such as agriculture and domestic cleaning.

Keywords: Domestic wastewater; Eco-enzyme; Vegetable waste; Fruit peel.

1. INTRODUCTION

Environmental protection is one of the most important challenges for the people (Bilal et al., 2018). The management of sewage and solid waste in urban India is a significant environmental challenge (Sharma and Juneja, 2022). Various industrial processing are the main sources of water pollution, and it may vary extensively with the nature of industry (Nur-E-Alam *et al.* 2020; Wu *et al.* 2021). Despite the government's efforts to ensure universal toilet usage, only 30% of the sewage generated in urban areas is treated. Approximately 62,000 million liters per day (MLD) of untreated sewage is often released into streams, sea, lakes, and wells, polluting about 75% of the country's water bodies. As reported by the Central Pollution Control Board in 2015, India has an effluent treatment capacity of just over 23,000 MLD, which accounts for 37% of the total sewage produced. Out of more than 800 sewage treatment plants nationwide, only around 500 are functional, processing approximately 18,883 MLD of sewage. (Salvi and Patil, 2021; Salvi, 2021; Tao *et al.* 2012). This starkly highlights that 70% of urban sewage in India is not adequately treated, exacerbating the country's water pollution crisis.

Rapid urbanization combined with insufficient waste management infrastructure has led to severe environmental pollution caused by the improper treatment and disposal of sewage and organic waste (Natarajan *et al.* 2022). The primary issue addressed in this study is the ineffective management and treatment of escalating sewage and organic waste in urban India, which leads to significant environmental pollution of water, soil, and air. India's large population contributes to substantial waste generation, particularly organic waste from household activities such as the peeling and cutting of fruits and vegetables (Ketnawa *et al.* 2011; Okoduwa et al. 2017). Restaurants, vegetable markets, fruit markets and food processing industries produce decomposable waste such as fruits, vegetables and its peels, etc. in huge quantities (Arun and Sivashanmugam, 2015). Management of these organic wastes is currently a major issue all over the world. Improper disposal of this organic waste, often dumped openly without prior treatment, leads to soil, water, and air pollution (Zdarta *et al.* 2021). Open dumping of solid waste contaminates groundwater through leachate and increases air pollution due to the emission of harmful gases. Research indicates that 80% of solid waste can be recycled or reused. However, in many Indian urban areas, formal waste

processing and recovery units are not well established, and the financial implications of waste recovery and recycling have not been fully explored. Given this background, the motivation for this study arises from the pressing need to address the challenges associated with managing organic waste and untreated sewage in urban India.

Enzymes have played a crucial role in various aspects of human life, from food production to textile manufacturing and biofuel production. Eco-enzyme, a type of enzyme derived from fermenting organic kitchen waste such as fruit and vegetable peels, jaggery, and water, offers a sustainable solution for waste management (Samiksha and Kerkar, 2020). The fermentation process, which takes approximately three months, converts these materials into a vinegar-like substance with cleaning and non-toxic properties. The key ingredient in this process is molasses, which microorganisms convert into alcohol and subsequently into acetic acid (vinegar) (Varshini and Gayathri, 2023).

The primary objective of this study is to explore the application of eco-enzyme in treating domestic wastewater and to evaluate its effectiveness in improving the quality of household wastewater. Specifically, the study assesses the impact of two eco-enzyme dilutions (15% and 20%) on wastewater quality over a five-day treatment period. The study demonstrates that Eco-enzyme can significantly reduce pollutants in wastewater, making it suitable for agricultural use (Kallel *et al*. 2020).

The contribution of this study lies in its novel application of eco-enzyme technology as a cost-effective, sustainable solution for wastewater treatment. The outcomes suggest that eco-enzyme can not only enhance wastewater quality but also offer a scalable solution to alleviate the burden on existing waste management systems. However, the study highlights the necessity for additional research to optimize the fermentation process, shorten treatment duration, and thoroughly assess the environmental impact and potential broader applications of eco-enzyme technology.

2. EXPERIMENTAL SECTION

2.1 Materials and Methods

For the preparation of Eco-enzyme, fruit wastes such as watermelon, orange, noseberry, and pomegranate, along with vegetable wastes, were collected from individual households (Das *et al*. 2024; Saleem and Saeed, 2020). These organic wastes served as raw materials for producing Eco-enzyme (Fig. 1). Domestic wastewater samples were also collected to test the efficiency of the Eco-enzyme in treating wastewater. The filtered Eco enzyme samples were analyzed after fifteen days of filtration. Various parameters, including pH, protein, carbohydrates, Total Dissolved Solids, Biochemical Oxygen Demand, Chemical Oxygen Demand, and Most Probable Number were measured according to standard procedures. In this study, two concentrations of Eco-enzyme, 15% and 20%, were prepared using domestic wastewater. 4 beakers were filled with these specific dilutions of the Eco-enzyme solution. The beakers were covered with aluminum foil and allowed to undergo the digestion process. Parameters such as pH, TDS, BOD_5, COD, and MPN were analyzed for all samples following standard methodologies. Analyzing these results offers valuable insights into the impact of varying Eco-enzyme concentrations on the purification process, helping to determine the optimal concentration and conditions for achieving maximum pollutant reduction.

Fig. 1: Containers with organic wastes for Eco-enzyme preparation

2.2 Experimental Setup

The preparation of Eco-enzyme involves three primary materials: food waste (fruit peels and vegetable waste), water, and jaggery. Research indicates that approximately 45% of household waste is organic, making it a readily available material for Eco-enzyme production. The organic waste is fermented in a 5 – litre capacity bottle for three months, mixed with jaggery and water in a ratio of 3 : 1 : 10 (Hemalatha and Visantini, 2020; Samiksha and Kerkar, 2020). For instance, to prepare 1 liter of Eco-enzyme, 300 grams of food waste, 100 grams of brown sugar, and 1 liter of water are required (Janarthanan *et al*. 2020). The container used for fermentation must be airtight, with the cap released daily during the first few weeks to vent gases produced during fermentation and prevent pressure buildup that could cause an explosion. After the three-month fermentation period, the mixture is filtered to separate the liquid Eco-enzyme from the residual solid waste. The resulting Eco-enzyme is then ready for use in treating domestic wastewater.

3. RESULT ANALYSIS

The distinctiveness of the filtered Eco enzyme samples was analyzed after fifteen days of filtration, with parameters such as pH, TDS, BOD, COD, and MPN measured according to standard procedures. The study involved testing two concentrations of Eco-enzyme, 15% and 20%, with domestic wastewater. For each concentration, two beakers were prepared, covered with aluminum foil, and subjected to a controlled digestion process over five days. Throughout the experiment, the same parameters were measured to evaluate the effectiveness of each concentration.

The samples were analyzed using standard analytical methods: pH was measured using a pH meter, TDS with a conductivity meter, BOD was determined through the five-day incubation method, COD was measured using the COD flask titrimetric method, and MPN was assessed using the multiple-tube fermentation technique. The experimental setup allowed for a comparative analysis of the two concentrations of Eco-enzyme in improving wastewater quality.

Table 1. Characteristics of eco-enzyme

Parameters	Unit	Reading Value
pH	-	3.63
TDS	ppm	1092.00
BOD	ppm	87.29
COD	ppm	171.00
MPN	CFU/100 ml	< 3.00

The Eco-enzyme solution exhibited an acidic pH of 3.63, TDS of 1092.00 ppm, BOD of 87.29 ppm, COD of 171.00 ppm, and MPN of less than 3 CFU/100 mL (Table 1). Before treatment, the domestic wastewater sample had a pH of 6.13, TDS of 517.00 ppm, BOD of 203.00 ppm, COD of 421.00 ppm, and MPN of 11 x 10^4 CFU/100 mL (Table 2).

Table 2. Properties of domestic wastewater sample

Parameters	Unit	Reading Value
pH	-	6.13
TDS	ppm	517.00
BOD	ppm	203.00
COD	ppm	421.00
MPN	CFU/100 ml	11 x 10^4

After treating domestic wastewater with a 15% Eco-enzyme solution, the following changes were observed over five days: pH increased from 4.82 to 7.96; TDS decreased from 603 ppm on day 1 to 412 ppm on day 5; BOD reduced from 141 ppm on day 1 to 74 ppm on day 5; COD dropped from 352 ppm on day 1 to 192 ppm on day 5; and MPN values were reduced 6.5 x 10^4 to 3.3 x 10^4 CFU/100 mL on day 5 (Table 3). The pH increased by 65.14 %, percentage reduction for TDS was 46.36%, BOD removal was 90.54%, COD reduction was 83.33%, and total coliform bacteria removal was approximately 96.96% from domestic waste water (Fig. 2).

Table 3. Outcome of domestic wastewater treatment using 15% eco-enzyme solution

Parameter	One Day	Three Days	Five Days	Agriculture Standards
pH	4.82	7.12	7.96	5.5 – 9.0
TDS	603	509	412	2100
BOD	141	102	74	100
COD	352	263	192	-
MPN	6.5 x 10^4	4.3 x 10^4	3.3 x 10^4	-

When treated with a 20% Eco-enzyme solution, the effluent properties showed: pH increased from 5.11 to 8.90; TDS decreased from 636 ppm on day 1 to 422 ppm on day 5; BOD reduced from 134 ppm on day 1 to 69 ppm on day 5; COD dropped from 341 ppm on day 1 to 183 ppm on day 5; and MPN values were reduced 6.1 x 10^4 to 3.1 x 10^4 CFU/100 mL on day 5 (Table 4). The pH increased by 74.17 %, percentage reduction for TDS was 50.71%, BOD removal was 94.20%, COD reduction was 86.34%, and total coliform bacteria removal was nearly 96.77% (Fig. 2).

Table 4. Outcome of domestic wastewater treatment using 20% eco-enzyme solution

Parameter	One Day	Three Days	Five Days	Agriculture Standards
pH	5.11	7.33	8.90	5.5 – 9.0
TDS	636	529	422	2100
BOD	134	91	69	100
COD	341	241	183	-
MPN	6.1 x 10^4	3.9 x 10^4	3.1 x 10^4	-

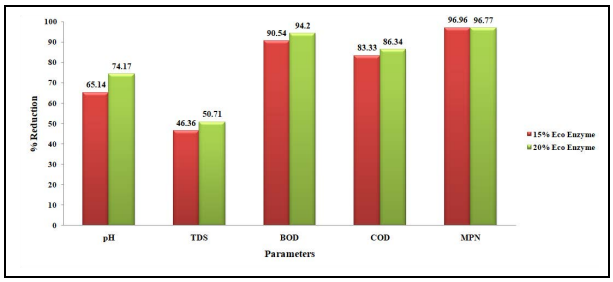

Fig. 2: Comparison of key parameter reductions in domestic wastewater treatment using 15% and 20% eco-enzyme solutions over a 5-day period

This research work demonstrates the potential of Eco-enzyme, derived from household fruit and vegetable wastes, as an effective treatment for domestic wastewater. Both 15% and 20% Eco-enzyme solutions significantly improved the quality of the treated wastewater, achieving substantial reductions in TDS, BOD, COD, and MPN. The results specify that Eco-

enzyme can be a sustainable and cost-effective solution for improving wastewater treatment processes, with the higher concentration yielding slightly better outcomes.

4. CONCLUSION

This study employed a methodical approach to evaluate the effectiveness of Eco-enzyme, derived from household fruit and vegetable wastes, in treating domestic wastewater. The methodology involved filtering Eco-enzyme samples for fifteen days and analyzing key parameters such as pH, TDS, BOD, COD, and MPN, according to standard procedures. Two concentrations of Eco-enzyme, 15% and 20%, were tested with domestic wastewater, and the same parameters were measured throughout the digestion process.

The results demonstrated significant improvements in the quality of the treated wastewater. For the 15% Eco-enzyme solution, pH increased by 65%, TDS decreased by 46.36%, BOD was reduced by 90.54%, COD dropped by 83.33%, and total coliform bacteria were reduced by approximately 96.96%. Similarly, the 20% Eco-enzyme solution resulted in a pH increase of 74.17%, a TDS reduction of 50.71%, a BOD reduction of 94.20%, a COD reduction of 86.34%, and a total coliform bacteria reduction of nearly 96.77%. The results indicate that Eco-enzyme, particularly at higher concentrations, can be an effective, sustainable, and cost-efficient solution for wastewater treatment. The results underscore the potential of Eco-enzyme in achieving substantial pollutant reductions, making it a promising alternative for enhancing wastewater treatment processes. To fully harness the potential of Eco-enzyme technology, additional research is necessary to optimize the digestion period, thoroughly characterize the enzyme, assess its environmental impact, and ensure the safe disposal of solid residues.

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DATA AVAILABILITY

All the data presented in this manuscript are derived from literature studies on the use of eco-enzymes for treating domestic wastewater and are available upon reasonable request.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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