Review: The Use of Eco-Enzymes in Greywater Treatment

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Abstract

Water pollution in rivers is a growing health concern and threatens clean water availability. While industrial pollution is often blamed, domestic wastewater is a major contributor, especially in developing countries. There is a common assumption that industrial pollution is the main cause of water pollution. However, an interesting fact is that river pollution is largely dominated by contamination from household wastewater (domestic waste) discharged directly into drainage systems and ending up in rivers without prior treatment. Such cases are particularly prevalent in developing countries. Therefore, the challenge is to find solutions to treat domestic wastewater using simpler and cheaper technologies. This review focuses on eco-enzymes as a potential treatment for greywater. Eco-enzymes are produced by fermenting organic waste materials for at least three months. This paper will review the treatment of greywater using eco-enzymes, including the eco-enzyme production process, its characteristics, greywater characteristics, the methods employed, and the research findings. Finally, the paper will recommend possible avenues for further research related to the treatment of greywater using eco-enzymes

Keywords: *Greywater treatment, Eco Enzyme.*

I. Introduction

Interesting fact, water pollution in water bodies (such as rivers) is predominantly caused by discharges from residential activities or domestic wastewater [1] primarily due to greywater (wastewater from activities such as washing, bathing, and kitchen use). Greywater, in terms of quality, has much lower pollutant levels compared to blackwater (wastewater from toilets), but the volume of greywater produced is much larger than that of blackwater [2][3][4]. Therefore, if large quantities of greywater are produced without proper treatment and directly discharged into bodies of water (a common occurrence in many developing countries), water pollution occurs. The consequences of this pollution can lead to reduced availability of clean water sources and can also pose health risks. Thus, finding solutions to address this water pollution challenge becomes crucial.

The mechanisms for handling domestic greywater treatment vary from simple to complex technologies [5], requiring significant energy and investment funds. Interestingly, a simple technology currently in development is the treatment of greywater using what is known as eco-enzyme. Some refer to this eco-enzyme as garbage enzyme [5][6]. Eco-enzyme is an enzyme produced from anaerobic fermentation of organic waste such as vegetable scraps or fruit peels mixed with sugar and water in a ratio of 1:3:10, where 1 part sugar or molasses: 3 parts organic waste material: 10 parts of water.

The utilization of eco-enzymes in greywater treatment is quite intriguing. The production of eco-enzymes helps in reducing organic waste at landfills. Organic waste buried in landfills, if mixed with other solid waste, it will reduce the quality of recyclable waste. Moreover, organic waste can generate biogas in the form of methane gas, which is a greenhouse gas contributor making global warming worsen. In the case of Indonesia, it was discovered that the production of municipal solid waste can reach 20.23 × 10^6 tons/year which can produce about 875,130 tons/year of methane as the most component of landfill gas [7]. This is typically huge number of biogas production. So, if the organic waste can be transformed into eco-enzyme which has ability to treat the greywater, it will be a good practice to reduce greenhouse gas and water pollution simultaneously.

This paper will review what eco-enzymes are, how to produce eco-enzymes, the methods used in treating greywater wastewater using eco-enzymes, the efficiency of eco-enzymes in treating greywater, the potential of eco-enzyme in treating greywater, and potential future research opportunities.

II. ECO ENZYME PREPARATION

From previous studies on eco-enzyme production, it is shown that eco-enzymes are made using the formula 1 : 3 : 10, which consists of 1 part sugar or molasses : 3 parts organic material : 10 parts water [6] [8]. Various organic materials are used, either single types or combinations. Commonly used organic materials include fruit peels such as pineapple peels [9] orange peels [10], or other types of organic matter [11][12]. The schematic of eco-enzyme preparation can be seen in Figure 1.

Once the maturation period is reached (minimum of three months), the mixture can be filtered to separate the organic material from the water containing the eco-enzyme. Typically, the filtered water appears light brown with a distinct aroma, often reminiscent of alcohol. The filtered water can be used in treating greywater. The condition of eco-enzyme in every month progression is observable in Figure 2 until Figure 4.

III. ECO-ENZYME CHARACTERISTICS

In the fermentation mixture of organic material and sugar or molasses, molasses serves as a carbon source for microorganisms. This fermentation process produces acetic acid.

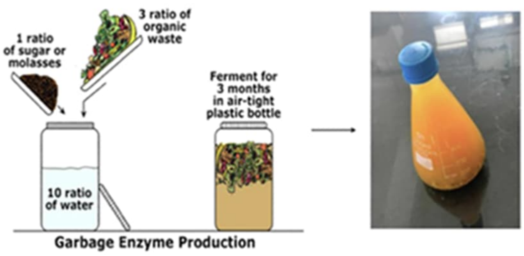

Figure 1. Scheme of Eco-Enzyme Production [13]

Figure 2. Eco-enzyme Progress in one month [14]

Figure 3. Eco-enzyme Progress in two months [14]

Figure 4. Eco-enzyme Progress in three months [14]

The higher the amount of acetic acid produced, the higher the hydrolytic enzymes generated, and the lower acidity levels make the eco-enzyme more effective. The characteristics of eco-enzymes from various studies can be seen in Table 1[15].

According to Table 1, eco-enzymes fermented for three months exhibit acidic properties, indicated by pH values ranging from 2.1 to 3.85. At the beginning of the fermentation process, pH values show 6.2 after 40 hours of fermentation and approximately 6.5 after three days. Characterization of BOD, COD, and TDS shows varying values with BOD significantly lower than COD. Several studies indicate that eco-enzymes contain protease, amylase, and lipase enzymes (Arun and [16][17]. Protease enzymes function to break down proteins, amylase enzymes digest starch into smaller molecules, ultimately producing maltose, which is further broken down into glucose molecules by maltase. Lipase enzymes are responsible for breaking down fats.

Table 1. Components and Chemical Characteristics Eco-Enzyme[15].

Garbage Enzyme Components			Fermentation Conditions		pH	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	TOC (mg/L)	Protein Content (mg/L)	Protease (Units/mL)	Amylase (Units/mL)	Lipase (Units/mL)	Ref.
Carbon Source	Organic Waste	Solution	Temperature	Fermentation Time										
Jaggery	Fruit-Waste	Water	25 C	3 Months	3.35	83.7	1640	1056	-	39.89	-	-	-	(Mandpe et al., 2021)
Jaggery	Waste Fruits	Water	25 C	3 Months	-	-	-	-	-	-	-	-	-	(Jiang et al., 2021a)
Brown Sugar	Waste Fruits	Water	25 C	3 Months	3.1	-	-	-	4130		-	-	-	(Jiang et al., 2021b)
Jaggery	Fruit Peels	Water	25 C	3 Months	3.30	123	18784.5	991.6	-	-	-	-	-	(Negi et al., 2020a)
Molasses	Different Fruits	Water	25 C	3 Months	3.4 – 3.7	65–81	150–160	995–1027	-	-	-	-	-	(C. Arun and Sivashanmugam, 2015a)
Molasses	Fruit Peels	Water	-	3 Days	6.5 ± 1	-	-	-	-	-	78 ± 3	57 ± 7	43 ± 2	(Arun and Sivashanmugam, 2018)
Molasses	Vegetables And Fruits	Water	25 C	3 Months	3.6	79	158	1040	-	42	0.08	3	2500	(Arun and Sivashanmugam, 2014)
Molasses	Waste Fruits	Water	37 C	40 Hours	6.2	-	-	-	-	-	75.57 ± 1.82	64.20 ± 1.04	52.05 ± 2.40	(Selvakumar et al., 2019)
Jaggery	Waste Fruits	Water	28 C	-	3	134	17320	3910-	-	-	-	-	-	(Rani et al., 2020)
Brown Sugar	Waste Fruits	Water	25 C	3 Months	3.1 – 3.3	70–82	140–162	1035–1092	-	-	+	+	+	(Bulai et al., 2021)
Jaggery	Fruit Peels	Water	-	4 Weeks	3.5	75	148	1053	-	38	-	-	-	(Sambaraju and Sree Lakshmi, 2020)
Jaggery	Fruit/Vegetable Peels	Water	25 C	3 Months	2.91	1300	48200	2210	-	-	-	-	-	(Nazim, 2013)
Brown Sugar	Vegetable and Fruit Biomass	Water	25 C	3 Months	3.5	150	-	-	-	-	-	-	-	(Tang and Tong, 2011a)
Molasses	Fruit Peels	Water	25 C	3 Months	-	-	-	-	-	-	74.990	56.409	44.039	(Arun and Sivashanmugam, 2017)
Molasses	Fruit Peels	Water	25 C	4 Days	-	-	-	-	-	-	-	-	56.51 ± 1.2	(Selvakumar and Sivashanmugam, 2019b)
Molasses	Fruit and Vegetable Peels	Water	37 C	26 Days	3.85	-	-	-	-	87365	0.050 Units/mg	1.782 Units/Mg	0.355 Units/Mg	(Rahman et al., 2021)

+: Present

IV. GREYWATER CHARACTERISTICS

Understanding the characteristics of greywater is very important because it helps the researcher to figure out what treatment expected to be implemented. Studies showed that greywater characteristics may vary depend on the quality of fresh water, location, lifestyle [18]. The characteristics is classified as physical and chemical characteristics shown in Table 2. and Table 3. [19]. The two groups of characteristics were summarized from some studies. From the tables, it is clearly seen that each of the greywater parameters may have a wide range of data for each greywater sources. It will depend on many factors.

Table 2. Physical Characteristic on Greywater Summary [19]

Parameter	Bathroom	Hand basin	Kitchen	Laundry	Light greywater	Dark Greywater
Temperature (0C)	25.8 - 29	-	24.4 - 30.9	22.4 - 35	13.4 - 29	22.4 - 35
Turbidity (NTU)	19 - 375	35 - 164	210 - 357	34 - 510	13 - 375	34 - 510
Total suspended solids (mg/L)	19 -793	25 - 181	11 - 3934	33 - 4564	7 - 793	11 - 4564

Table 3. Chemical Characteristics on Greywater Summary[19]

Parameter	Bathroom	Hand basin	Kitchen	Laundry	Light greywater	Dark Greywater
pH	5.9 - 8.40	6.72 - 9.82	5.58 - 10.00	5.00 - 10.33	4.9 - 8.53	5 - 10.33
BOD	20 - 673	33 - 305	185 - 2460	44 - 3330	20 - 673	44 - 3330
COD	60 - 903	47 - 587	411 - 8071	58 - 4155	23 - 1489	58 - 8071
Total Nitrogen	2.7 - 148	2.5 - 10.4	0.5 - 65	2.8 - 31	1.3 - 60	0.5 - 65
Total Phosphorus	0.1 - 60	0.3 - 2.6	2.7 - 187	0.2 - 51.6	0.1 - 60	0.2 - 187

In physical parameter, the temperatures were varied around 22^0C until 35^0C of each greywater sources. The highest temperature found was in laundry 35^0C. It may be caused by the use of warm water in laundry.Greywater from kitchen and laundry showed bigger number on turbidity and TSS compared to other greywater sources.

While concerning in chemical characteristics, the highest value is in COD which reach about 8071 mg/L. For BOD the highest values is about 3330 mg/L. The characteristics of kitchen wastewater and dark greywater have quiet similar number in BOD and COD

V. GREYWATER TREATMENT USING ECO-ENZYME

Various methods have been explored in studies on using eco-enzymes to reduce pollutants caused by greywater. A research conducted on greywater treatment using eco-enzymes with an anaerobic method which involved tightly sealed chemical glasses was conducted for five days using eco-enzyme doses of 10%, 20%, and 30% of one liter of greywater were applied [20]. Parameters observed included pH, BOD, COD, TDS, and MPN. Results showed that after five days, the 10% eco-enzyme concentration was more effective than higher concentrations in reducing BOD (approximately 65%), COD (50%), and MPN (100%). However, the eco-enzyme was not effective in reducing TDS, achieving less than a 20% reduction.

Another similar research on greywater using eco-enzymes, employing an anaerobic method and monitoring parameters similar such as BOD, COD, TDS, MPN, and pH had been conducted [21]. The difference lies in using eco-enzyme concentrations of 5% and 10% with a longer digestion time of 15 days. The results indicated that a 10% concentration was still optimum for eco-enzymes in treating greywater. The efficiency in reducing MPN reached 90% to 100%. For BOD reduction, the 10% eco-enzyme concentration achieved 60% to 65%, and COD reduction was approximately 45%. These findings were comparable to previous research findings.

More varied research using eco-enzyme with concentrations of 5%, 10%, and 15% with digestion times of 5 days, 15 days, and 25 days was conducted [22]. Parameters studied included: pH, BOD, COD, Ammonia Nitrogen, and Phosphate, and it was also done under anaerobic conditions. The results indicated that BOD reduction up to 50% across concentrations. More longer digestion time, less effective of BOD reduction. COD reduction showed that the 5% concentration did not generate significant results, while the 10% concentration performed the best among all parameters.

More comprehensive research was conducted slightly difference in terms of eco-enzyme treatment duration and concentration [14]. Eco-enzymes were applied to wastewater at concentrations ranging from 5%, 10%, 15%, 20%, 25% and 30%. The mixture was placed in chemical glasses and shaken for 180 minutes. Parameters studied were pH, BOD, COD, TDS, Oil and Grease, and Chloride. Additionally, biological activity within the eco-enzyme was evaluated to determine which enzymes were obtained from the fermentation process. The finding showed that there were the presence of amylase, protease, and lipase enzymes in the eco-enzyme, indicating its ability to digest carbohydrates, proteins, and fats. This condition was proven by significant reductions in fat content by 99.3%, the highest among the parameters studied. Reductions for other parameters were 75%, 90.8%, 93.57%, 94.35%, and 90.81% for BOD, COD, TDS, TSS, and chloride, respectively.

VI. THE POTENTIAL OF ECO-ENZYME IN GREYWATER TREATMENT

Based on the review conducted, researches on eco-enzymes in treating greywater shows significant potential. The studies showed that eco-enzyme was potential in reducing BOD, COD and MPN.

The presence of the enzyme like amylase, protease and lipase may effectively function as biocatalyst in digesting the pollutant in greywater. The biological activity of the enzyme will be effectively optimum on pH 6 – 7. [23]. In acidic condition, the activity of enzyme was found lower.

VII. POTENTIAL CHALLANGES FOR FUTURE RESEARCHES

Based on the review conducted, research on eco-enzymes in treating greywater wastewater shows significant potential. However, further research is needed. Potential areas for future research include:

1. Research of eco-enzyme applied in greywater under aerobic conditions. As mentioned earlier that water bodies, dominantly polluted by domestic wastewater. If the eco-enzyme will effectively work under aerobic condition, it will open possibility to apply the eco-enzyme directly to the river or a lake.
2. Research of eco-enzyme applied in a dynamic flow of polluted water. Most researchers conducted their studies in a static condition. While in reality, most polluted water like river is dynamic.
3. Studies in wastewater treatment plants, where greywater undergoes pretreatment processes. Currently, most research focuses on wastewater samples without prior treatment.
4. Exploration of other parameters such as dissolved oxygen (DO), turbidity, etc.,
5. Biological and chemical activities within eco-enzymes in greywater treatment are also intriguing topics for further research.

VIII. Conclusions

Eco-enzymes have great potential for treating greywater wastewater, especially in developing regions/countries. Their use can significantly reduce energy consumption, which is a costly aspect of wastewater treatment systems. Additionally, eco-enzyme application can help reduce the accumulation of organic waste in landfills, which contributes to methane gas emissions, a greenhouse gas. Eco-enzymes are also cost-effective to produce. The challenges for further research are indeed compelling and warrant exploration especially on (1) aerobic condition, (2) dynamic flow, (3) eco enzyme applied in real wastewater treatment, (4) more comprehensive parameters to be studied and (5) the activity of the enzyme especially in their biological and chemical behavior.

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