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Research Paper

Use of Eco Enzyme to Reduce the Chemical Oxygen Demand of Synthetic River Water

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Abstract

Eco enzyme is claimed to improve the quality of polluted water. However, the low pH of eco enzyme solutions can acidify water. The objective of this study was to investigate the effectiveness of eco enzyme in reducing the COD of river water and its effect on the pH of sterilized synthetic river water. The effect of 0.01%, 0.5%, and 1% enzyme concentrations on the COD and pH of synthetic river water with an initial COD of 240 mg/l was investigated. The results showed that eco enzyme itself has high concentration of COD and low pH. The undiluted eco enzyme increased the COD and decreased the pH of both neutralized and non-neutralized synthetic river water. At a 1% eco enzyme concentration and neutral pH, the COD increased in the beginning of experiment and had decreased only by 31.7% after 6-8 days. The COD concentration in this steady state condition had a higher value than that of the initial COD concentration in the river water. This study showed that adding only eco enzyme to synthetic river water is not effective in reducing its COD content.

Keywords: *COD removal; eco enzyme concentration; pH; river pollution; synthetic river water.*

Introduction

Many urban areas face the problem of river pollution. In Indonesia, surface water is often polluted by both domestic and industrial waste [1]. This is because all human activities produce liquid, solid, and gas wastes that can potentially significantly pollute the environment [2]. Wastewater is discharged from households, industries, and other public places as residual water, and it generally contains materials and substances that can be harmful to human health and disrupt the environment [3],[4]. As determined by multiple studies, the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of rivers in large Indonesian cities exceed Indonesian statutory surface water quality standards; hence, they are classified as being lightly to heavily polluted [5-7].

Eco enzyme, also known as garbage enzyme, is made from organic solid waste. It is produced by fermenting a mixture of sugar, water, and kitchen waste or vegetables and fruit for 3 months [8]. The benefits of eco enzyme include its use as garden fertilizer and insect repellent, household cleaner, and even as shampoo and detergent [9,10]. However, applying an undiluted eco enzyme solution to plants or soil can make the soil acidic, which can be detrimental to plants [11]. Therefore, the eco enzyme solution needs to be diluted with water. Many communities in Indonesia have produced their own eco enzyme and discharged it into polluted rivers, claiming that it can remove pollutants in rivers and improve water quality. Several previous studies have been performed to investigate the effectiveness of eco enzyme in improving greywater and domestic wastewater [8,9,12]. Another experiment showed that eco enzyme removed COD, TSS and VSS up to 78%, 45% and 46%, respectively, from industrial waste activated sludge [13]. However, to date, no valid research has shown that eco enzyme can improve the water quality of polluted rivers.

Several communities in Indonesia have applied eco enzyme to rivers without accounting for the amount of eco enzyme that is safe for the rivers' ecosystems and biota. Given that the pH of eco enzyme is very low, the

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direct application of eco enzyme without knowing the right concentration could lower the pH of the river water, infringe water quality standards, and detrimentally affect river organisms. Previous research found that using 10% of eco enzyme in domestic wastewater could decrease COD in a duration period of 50 days but gave a pH as low as 4.7 [14]. The purpose of this study was to determine the effect of eco enzyme on the COD, a pollution indicator, of synthetic river water.

Materials and Methods

Synthetic River Water Preparation

This study used synthetic river water with a COD that corresponded to the highest COD of Cikendal River, which flows through Bandung City, West Java, Indonesia. According to data obtained from the Bandung City Environmental Service, the highest Cikendal River COD in 2020 was 239.55 mg/l; therefore, for this study, the COD level of the synthetic river water was set at 240 mg/l using glucose. The glucose used was D(+)-Glucose anhydrous for biochemistry from Merck. Synthetic river water was used because the COD of natural river water fluctuates over time, and there was no facility available to store and preserve the large quantities of natural river water required for the room-temperature experiments. Prior to being used in the experiments, the synthetic river water was sterilized in an autoclave (Medical YX-24LM; GEA) at 121 °C for 15 minutes.

The water used to make this synthetic river water was distilled water. The glucose used to regulate the COD levels in the water was glucose solution. The eco enzyme used for this research was acquired from the Eco Enzyme Community Bandung (https://www.instagram.com/ecoenzymebandung/?hl=en). The ingredients of this eco enzyme were fruit waste and molasses. The eco enzyme product of this community is regularly used for river water application. To regulate the synthetic water pH, an NaOH solution was used to neutralize the water.

Determination of Eco Enzyme Concentration based on pH and COD

A preliminary study was undertaken to determine the eco enzyme concentration based on the pH and COD of the eco enzyme solution. The pH and COD of the eco enzyme were determined after diluting it with distilled water to 10, 100, 200, 1,000, 10,000, 50,000, and 100,000 dilutions. These dilutions were equivalent to eco enzyme concentrations of 100% (without dilution), 10%, 1%, 0.5%, 0.1%, 0.01%, 0.002%, and 0.001%, respectively. Among those variations, the chosen concentration was that with a pH of 6 to 8 and a COD of >1 mg/l.

The value of pH was measured by a Lutron WA-2017SD pH-meter. The determination principle of a pH-meter works based on potentiometry, where the voltage of the solution is measured. The concentration of COD was analyzed using closed the reflux titrimetric method, where ampules and culture tubes with premeasured reagents are used, followed by determination of COD of samples inside tubes. Both parameters were determined according to standard methods for the examination of water and wastewater by APHA (American Public Health Association) [15].

Application of Various Concentrations of Eco Enzyme to Synthetic River Water

Determination of the effect of the eco enzyme on the COD, total suspended solids, and pH of the synthetic river water was conducted at 26 °C with an initial COD of 240 mg/l. Experiments were carried out by incubating bottles containing synthetic river water and varying the concentration of the eco-enzyme solution at 26 °C, corresponding to the average river water temperature in Bandung City, in a water bath shaker (Patra Produk). The pH and COD of the water samples were analyzed every 24 hours until the COD equilibrated. Three duplications were performed for each variation.

In addition to variation in eco enzyme concentration, the effect of adjusting the pH of the synthetic river water to neutral after the pH had decreased due to the addition of the eco enzyme solution was investigated. Previous research has shown that alkaline wastewater with a pH of 11.2 had its pH dropped to 4.79 in the first 30 minutes after being added with eco enzyme. The pH then increased above 6 after 10 minutes [16].

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Experimental Reactor

Glass bottles with a 150 ml working volume were used as experimental reactors (Figure 1). To maintain a constant and uniform temperature, the bottles were incubated at 26 °C in the water bath shaker (Figure 2).

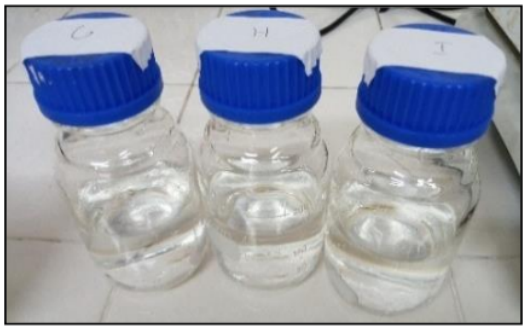

Figure 1 Experimental reactor bottles.

Figure 2 Water bath shaker.

Results and Discussion

The pH of Various Eco Enzyme Concentrations

Eco enzyme solutions made of fermented fruit are acidic. They contain alcohol and acetic acid. Therefore, the eco enzyme will decrease the pH of river water if applied directly. According to Tang and Tong [9], high concentrations of eco enzyme will acidify wastewater. The pH of the various concentrations of eco enzyme solution used in this study are shown in Table 1. The 0.001% concentration resulted in a near-neutral pH of 7.1.

Table 1 The pH of the eco enzyme at the various concentrations used in this study.

Concentration	pH Value
100%	3.5
10%	3.6
1%	3.8
0.5%	4.1
0.1%	4.1
0.01%	4.8
0.002%	5.9
0.001%	7.1

COD at Various Eco Enzyme Concentrations

Eco enzyme has a high COD because it contains organic matter [17]; hence, its addition to river water has the potential to increase the COD [18]. However, the addition of low concentrations of eco enzyme can result in the enzyme content being too low to reduce the COD of polluted river water. The COD of the various eco enzyme concentrations used in this study is presented in Table 2. The COD concentrations shown in Table 2 were analyzed from the mixture of eco enzyme at certain percentages in distilled water.

Table 2 COD concentration of various eco enzyme concentrations used in this study.

Concentration	COD (mg/l)
1%	172.41
0.1%	92.69
0.05%	58.99
0.025%	32.02
0.02%	30.34
0.0125%	13.48
0.01%	8.43

The highest COD was 172.41 mg/l for a concentration of 1% eco enzyme, and the lowest COD was 8.43 mg/l for a concentration of 0.01%. The composition of organic materials in eco-enzyme are organic acids, enzymes, and mineral salts [19].

Eco Enzyme Concentration and Additional Treatment

Dilution reduces the concentration of organic compounds and raises the pH of eco enzyme, improving its low pH [20]. In Nazim and Meera [8], a 10% concentration (pH 4.12; COD 410 mg/l) was more effective in greywater treatment than a 5% concentration (pH 4.26; COD 386 mg/l). Arun and Sivashanmugam [21] found that the activities of organic-compound-degrading enzymes, such as protease, amylase, and lipase, are affected by pH; hence, to obtain higher or optimal enzyme activity, the pH should be adjusted to between 6 and 8.

Based on this, the eco enzyme concentration selected for this study was 0.01% (pH 4.8; COD 8.43 mg/l). Concentrations of 1% eco enzyme (pH 3.8; COD 172.41 mg/l) and 0.5% eco enzyme (pH 4.1; COD 146.95 mg/l) were also analyzed. Concentrations >0.01% were selected to prevent excessive enzyme reduction during the dilution process.

Because the selected eco enzyme concentration (10%) had a low pH (4.12), which would have reduced the pH of the synthetic river water, the experiments were conducted under two different treatments: i) synthetic river water plus eco enzyme and ii) neutralized synthetic river water plus eco enzyme.

Experimental pH

Figure 3 presents the pH of the synthetic river water and the neutralized synthetic river water with eco enzyme concentrations of 0.01%, 0.5%, and 1% over time. It shows that the un-neutralized river water samples plus eco enzyme had the lowest pH. This reflects the acidity of the undiluted eco enzyme due to its high content of various organic acids, such as acetic and citric acid: the higher the organic acid content, the lower the pH [22].

As shown in Figure 3, over time, the pH increased only in the 1% eco enzyme solutions plus synthetic river water and plus neutralized synthetic river water. At this concentration, the COD removal equilibrated on day 8, while the 0.01% and 0.5% eco enzyme concentrations equilibrated on day 6. The capability of the enzyme in splitting off organic molecules at a concentration of 1% was higher than that at the other concentrations. The organic matter digestion process may proceed a longer time at higher eco enzyme concentrations. In the final phase of digestion, the pH will tend to increase towards neutral condition.

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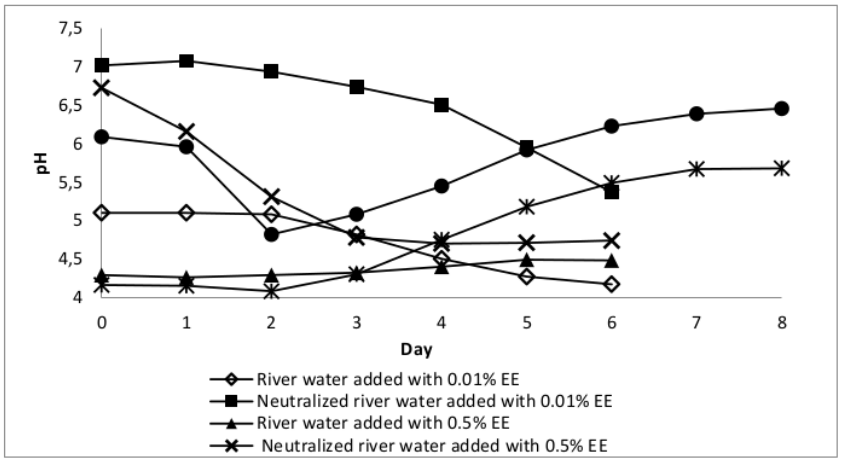

Figure 3 The pH of river water and neutralized river water with various eco enzyme (EE) concentrations over time.

Experimental COD Value

The COD over time at eco enzyme concentrations of 0.01%, 0.5%, and 1% are presented in Figure 4. The concentrations of COD were analyzed from mixture of eco enzyme at certain percentages and synthetic river water of 240 mg/l. In the beginning of the experiments, the COD concentration increased, after which it decreased over time.

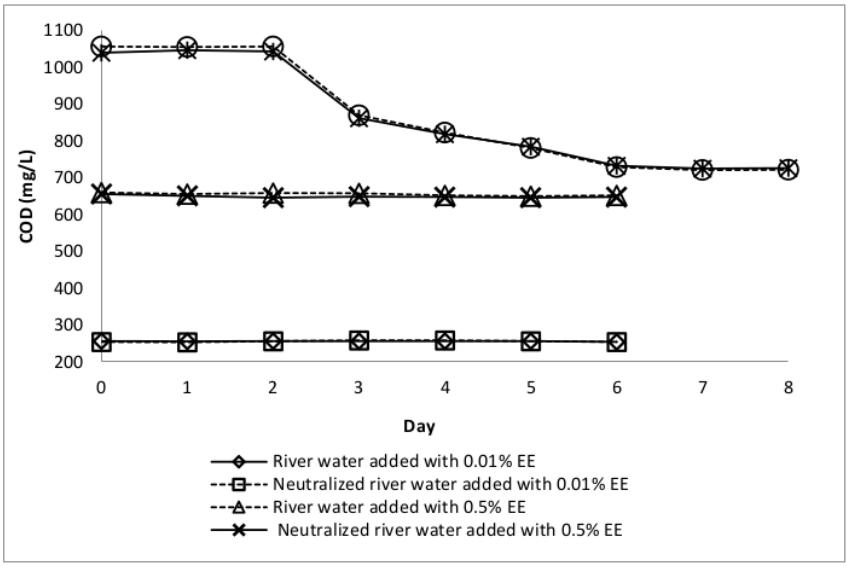

Figure 4 COD over time with eco enzyme (EE) concentration.

Only the COD of the synthetic river water at an eco-enzyme concentration of 1% decreased over time. Citric acid in the eco enzyme solution affects the activities of extracellular polymeric substances (EPS) present in wastewater. Generally, EPS bind to cations to form flocs [22],[23]. However, citric acid in eco enzyme solutions interferes with the binding and removal of these cations and prevents the formation of flocs [24]. According to

Yang *et al.* [25], the dominant organic compounds in EPS are proteins, which are hydrolyzed into amino acids, ammonia, and carbon dioxide, including carbohydrates that are hydrolyzed into either polysaccharides or reducing sugars. The concentration of citric acid in eco enzyme has been found to be 14 mg/l (tomato based) and 35 mg/l (orange based) [24].

According to Rasit et al. [24], the higher the organic acid content of the eco enzyme, the lower the pH. As shown in Figure 3, at the start of the experiment, the pH of the 1% eco enzyme solution was lower than that of the 0.01% and 0.5% eco enzyme solutions. This could indicate that the organic acid content of the 1% eco enzyme solution was higher than that of the other solutions. At a concentration of 1% of the eco enzyme solution, the COD content of the synthetic river water decreased by 31.69%. However, even though there was a decrease in COD, the application of eco enzyme did not appear to significantly reduce the final COD, as the equilibrated COD was 722 mg/l, which was higher than the initial COD (240 mg/l) of the synthetic river water.

Conclusion

This study indicates that the addition of eco enzyme caused a decrease in the pH and an increase in the COD of the synthetic river water. A reduction in COD was achieved with a concentration of 1% eco enzyme to both the neutralized and the un-neutralized synthetic river water. However, although the equilibrated COD was reduced by 31.69%, this was higher than the COD content of the synthetic river water before addition of the eco enzyme. It appears that eco enzyme alone cannot improve the quality of polluted river water. The use of higher concentration of eco enzymes may be capable to improve river water quality. However, to keep the river's pH neutral and prevent organic concentrations from soaring, the application of eco enzymes cannot be carried out directly in water bodies but must be done in special treatment ponds.

Acknowledgments

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