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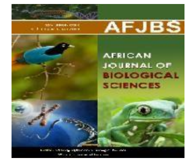

Research Paper Open Access

Application of Banana Stem Eco-enzymes to Reduce Ammonia, Nitrate, and Nitrite Levels in Sea Grape Aquaculture Effluents

I Gusti Ngurah Agung Suryaputra

Applied Chemistry Study Program, Department of Chemistry, Universitas Pendidikan Ganesha, Singaraja, Bali 81116

E-mail: surya@fulbrightmail.org

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Abstract

The aim of this study was to develop an aquaculture effluent treatment method employing eco-enzymes derived from the stems of banana trees. In this study, the levels of ammonia, nitrate, and nitrite in aquaculture effluents were measured using the Hach DR900 colorimeter. The results showed that the addition of 3 mL, 6 mL, and 9 mL of banana stem eco-enzymes reduced ammonia levels by 69.60%, 87.38%, and 93.20%, respectively. Meanwhile, the addition of 3 mL, 6 mL, and 9 mL of banana stem eco-enzymes reduced nitrate levels by 62.76%, 78.62%, and 72.41%, respectively. Also, the addition of 3 mL, 6 mL, and 9 mL of banana stem eco-enzymes reduced nitrite levels by 52.10%, 68.07%, and 66.39%, respectively. Therefore, banana stem eco-enzymes have the potential to be applied in water treatment.

Keywords: eco-enzyme; banana stem; aquaculture effluents; nutrients

Introduction

West Bali grows sea grape (Caulerpa racemosa) as one of its export commodities. Nonetheless, according to interviews with aquaculture owners, production has decreased by approximately 20% (due to isopod outbreaks) before the pandemic and 64% (due to the combination of isopod outbreaks and the pandemic) after the pandemic. Other aquaculture farms in the same region are also experiencing the same problems, thus they must be resolved soon.

Observations in the aquaculture area have revealed that the seawater used for aquaculture is pumped from the shore and circulated to the ponds. In the meantime, aquaculture effluent is discharged directly to the shore without treatment, causing eutrophication due to the high concentrations of nutrient-rich feed residues. This nutrient accumulation can induce isopod outbreaks in seaweed farming and become one of the causes of infection in fish farming (Endo et al., 2021).

Aquaculture effluent treatment methods that are safe for the environment have been studied over the years. These include artificial wetlands (Sindilariu et al., 2007), algae (Kim et al., 2019; Tossavainen et al., 2019; Viegas et al., 2021), and bacteria (Shao et al., 2019; John et al., 2020). However, these methods have proven ineffective and are relatively time-consuming. In addition, changes in temperature and wastewater composition can slow down or stop the process. Consequently, a method of treatment that is resistant to environmental variations is necessary.

Eco-enzymes have the potential to effectively remediate aquaculture effluents and withstand environmental changes. Eco-enzymes have a wide range of applications (Tang & Tong, 2011; Nazim & Meera, 2017), including the treatment of aquaculture effluent (Rasit & Mohammad, 2018; Rasit et al., 2019; Galintin et al., 2020). These studies have not, however, focused on nutrients or dissolved organic treatments. Because banana stems can be used as coagulants in polluted river water (Kakoi et al., 2016), this study will develop an aquaculture effluent treatment method employing these banana stem-derived eco-enzymes.

Materials and Method

a. Preparation of Banana Stem Eco-enzyme

The eco-enzyme was produced from banana stems. The ratio used was 3:1:10 for banana stem, brown sugar, and water. Banana stems were cut into small pieces and placed in a large plastic bottle, then mixed with brown sugar and water. Three months were spent storing the vial in a dry, cool location at room temperature. To release the gas during storage, the container was opened daily for the first two weeks, then every other day for the remaining three to four weeks. After three months, the eco-enzyme was filtered and ready to use.

b. Sampling of Aquaculture Effluents

Aquaculture effluents were collected on August 23, 2023, from a sea grape aquaculture area in the Musi Area, Gerokgak, Bali. The samples were placed in a dark container and then transported to the laboratory for further experimentation.

c. Treatment of Aquaculture Effluents Using Banana Stem Eco-enzyme

Before experimentation, banana stem eco-enzyme was diluted with water at a ratio of 1:1000. The Hach DR900 was used to measure the levels of ammonia, nitrate, and nitrite in effluent that had been filtered with a 0.7-um GF/F filter prior to treatment.

The mixture of 900 mL of aquaculture effluent and 3 mL of diluted eco-enzyme was then placed in a glass beaker equipped with a magnetic stirrer. Every 10 minutes, water samples were collected, filtered with a 0.7-um GF/F syringe filter, and analyzed for ammonia, nitrate, and nitrite levels.

Results and Discussion

Eco-enzymes are enzymes that can be produced by decomposing organic waste, brown sugar, and water for up to three months (Wikaningrum & Anggraino, 2022). Eco-enzymes have been demonstrated to have a number of applications, such as reducing nitrite concentrations in water (Wikaningrum & Anggraina, 2022), reducing contamination and enhancing water odor (Benny et al., 2023), and purifying wastewater from factories and farms (Sambaraju & Lakshmi, 2020). Eco-enzymes can also be used as organic plant fertilizers, which can enhance plant growth and health (Fadilla et al., 2023).

In this research, eco-enzymes derived from the stems of banana trees are applied to reduce the levels of nitrate, nitrite, and ammonia in aquaculture waste. Comparatively, eco-enzymes typically derived from fruits were utilized.

a. Reduction of Ammonia, Nitrate, and Nitrite Levels in Aquaculture Effluents by The Addition of Fruit Eco-enzymes

The addition of fruit eco-enzymes to aquaculture effluent decreased the levels of nitrate, nitrite, and ammonia. However, the incorporation of varying amounts of eco-enzyme resulted in distinct decrease patterns. With the addition of 3 mL and 6 mL of the eco-enzymes, ammonia levels decreased and achieved a stagnant level after 50 minutes of mixing. With the addition of 9 mL of fruit eco-enzyme, however, the eco-enzyme levels reached a steady state faster in 40 minutes (Figure 1). After 60 minutes of mixing, the addition of 3 mL, 6 mL, and 9 mL of fruit eco-enzyme, the initial ammonia levels in aquaculture effluent were reduced by 58.25%, 58.25%, and 81.55 %, respectively.

In terms of nitrate levels in aquaculture effluent, the addition of 3 mL of fruit eco-enzymes decreased the level significantly until a 40-minute plateau. The addition of 6 mL of fruit eco-enzyme decreased nitrate levels drastically for the first 20 minutes, then slowed to a constant level after 50 minutes. Figure 1 demonstrates that the addition of 9 mL of eco-enzymes accelerated the time required to reach constant concentrations in 40 minutes. After 60 minutes of mixing, the addition of 3 mL, 6 mL, and 9 mL of fruit eco-enzyme reduced the initial nitrate levels in aquaculture effluent by 65.52%, 71.03%, and 68.28%, respectively.

Compared to ammonia and nitrate, the addition of 3 mL and 6 mL of fruit eco-enzymes decreased nitrite levels more slowly. However, the addition of 9 mL of the eco-enzymes accelerated the decrease in nitrite levels, which reached a constant level within 30 minutes (Figure 1). When 3 mL, 6 mL, and 9 mL of fruit eco-enzyme were added to aquaculture effluent and mixed for 60 minutes, the initial nitrite levels dropped by 58.82%, 65.55%, and 67.23%, respectively.

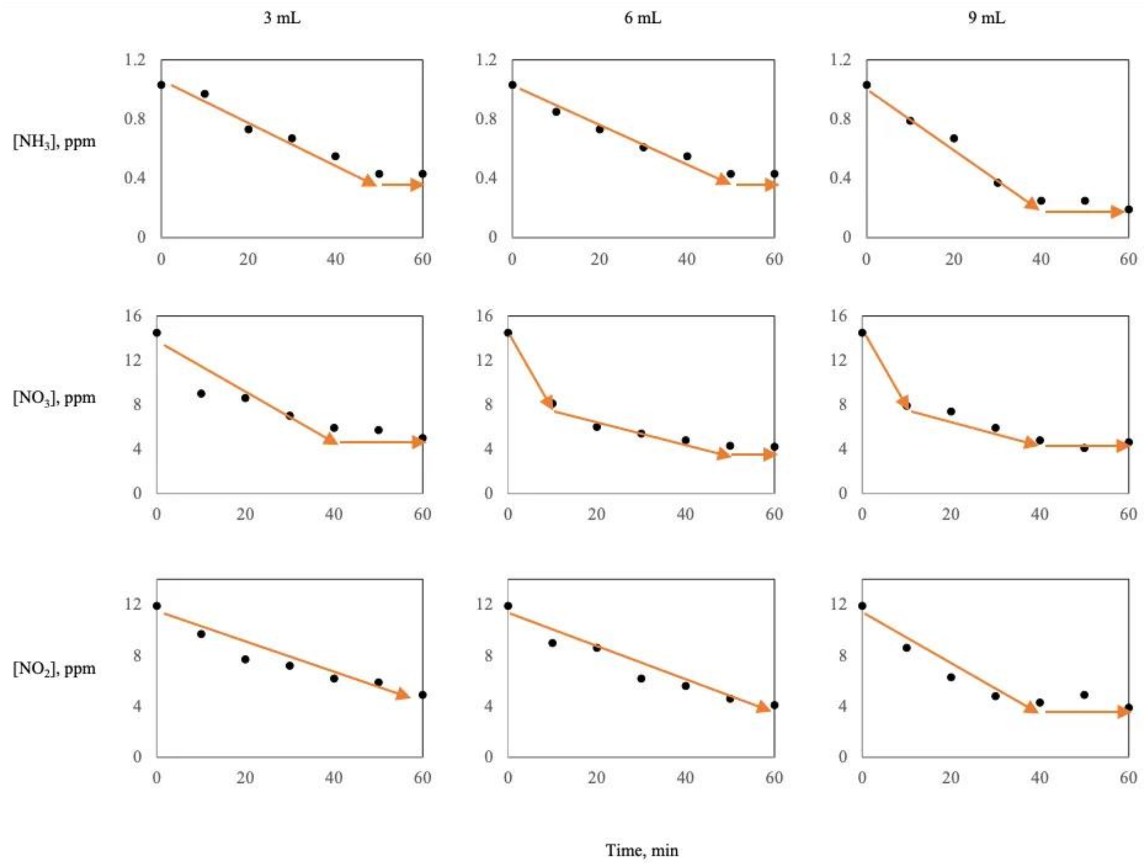

Fig. 1. Ammonia, Nitrate, and Nitrite Levels with the Addition of 3 mL (Left), 6 mL (Middle), and 9 mL (Right) of Fruit Eco-enzyme during 60 Minutes of Mixing.

b. Reduction of Ammonia, Nitrate, and Nitrite Levels in Aquaculture Effluents by the Addition of Banana Stem Eco-enzymes

Figure 2 shows that adding 3 mL, 6 mL, and 9 mL of banana stem eco-enzymes greatly reduced the amount of ammonia in aquaculture waste. The level of ammonia may have continued to drop for another 60 minutes after mixing. After 60 minutes of mixing, the addition of 3 mL, 6 mL, and 9 mL of the eco-enzymes reduced ammonia levels by 69.60%, 87.38%, and 93.20%, respectively.

In contrast, the concentration of nitrate remained unchanged following the introduction of 3 mL of eco-enzymes derived from banana stems for a duration of 30 minutes. The nitrate concentration did not reach a constant level with the addition of 6 mL of the eco-enzymes, although it showed a decreasing concentration after 20 minutes of mixing. With the addition of 9 mL of eco-enzyme, it is evident that the reduced nitrate concentrations reached a stagnant level within 20 minutes (Figure 2). After 60 minutes of mixing, the addition of 3 mL, 6 mL, and 9 mL of banana stem eco-enzymes reduced nitrate levels by 62.76%, 78.62%, and 72.41%, respectively.

The addition of 3 mL of banana stem eco-enzymes reduced the nitrite concentration in aquaculture effluent until it reached a steady state after 30 minutes. This constant nitrite level was observed 20 minutes after the addition of 6 mL and 30 minutes after the addition of 9 mL of banana stem eco-enzyme (Figure 2). After 60 minutes of mixing, the addition of 3 mL, 6 mL, and 9 mL of banana stem eco-enzyme reduced nitrite levels by 52.10%, 68.07%, and 66.39%, respectively. The eco-enzyme derived from banana stems is significantly more efficient at reducing nitrite levels in water than the eco-enzyme derived from papaya fruit and spinach vegetables, which can only reduce nitrite levels by 49.4% after 7 hours of mixing (Wikaningrum & Anggraina, 2022). This also proves that different eco-enzymes will yield different results related to improving water quality (Patel et al., 2021).

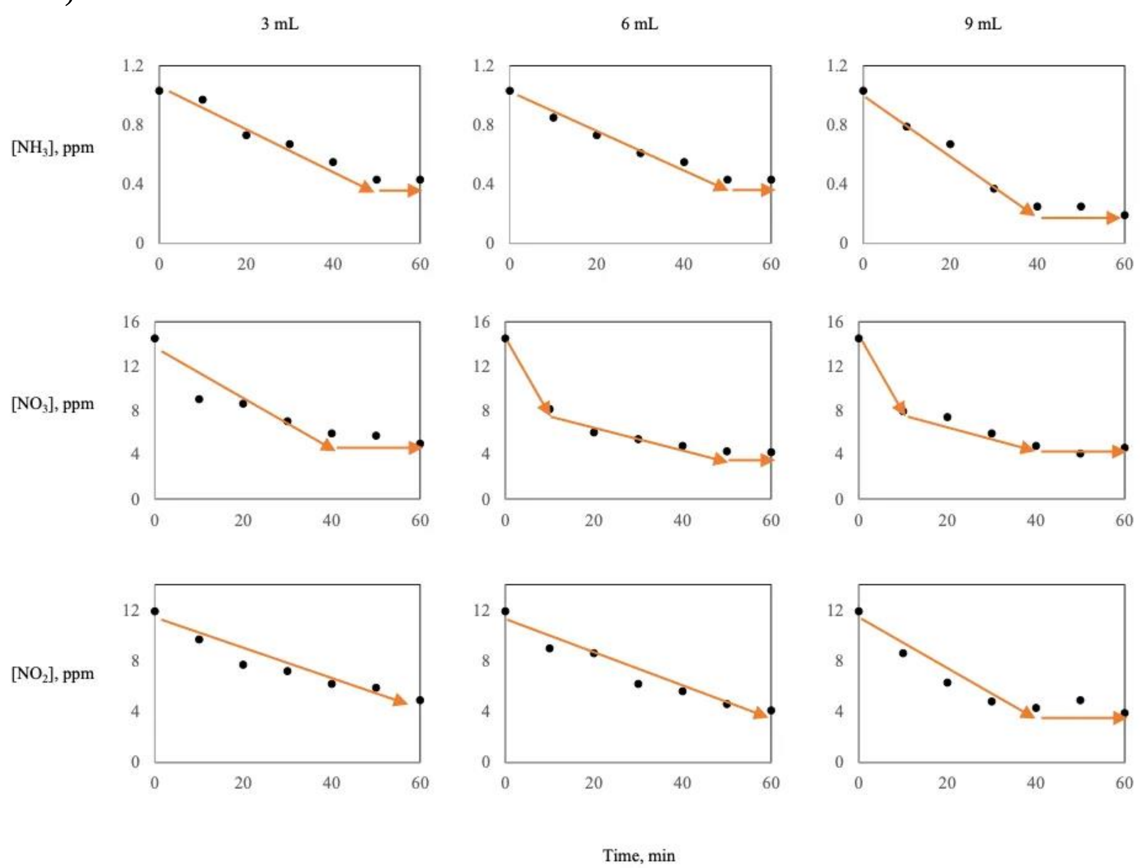

Fig. 2. Ammonia, Nitrate, and Nitrite Levels with the Addition of 3 mL (Left), 6 mL (Middle), and 9 mL (Right) of Banana Stem Eco-enzyme during 60 Minutes of Mixing.

c. Efficiency of Ammonia, Nitrate, and Nitrite Reduction by the Addition of Fruit Eco-enzyme and Banana Stem Eco-enzyme

The results showed that the addition of eco-enzymes to aquaculture effluents will reduce ammonia, nitrate, and nitrite levels. Compared to the common fruit eco-enzymes, the eco-enzymes made from banana stems provide higher efficiency in reducing ammonia, nitrate, and nitrite levels (Figure 3). The reduction of ammonia levels in aquaculture effluent was more effective with the addition of a higher volume of banana stem eco-enzymes. However, in reducing nitrate and nitrite levels, the highest efficiency was obtained when adding 6 mL of banana stem eco-enzymes (Figure 3).

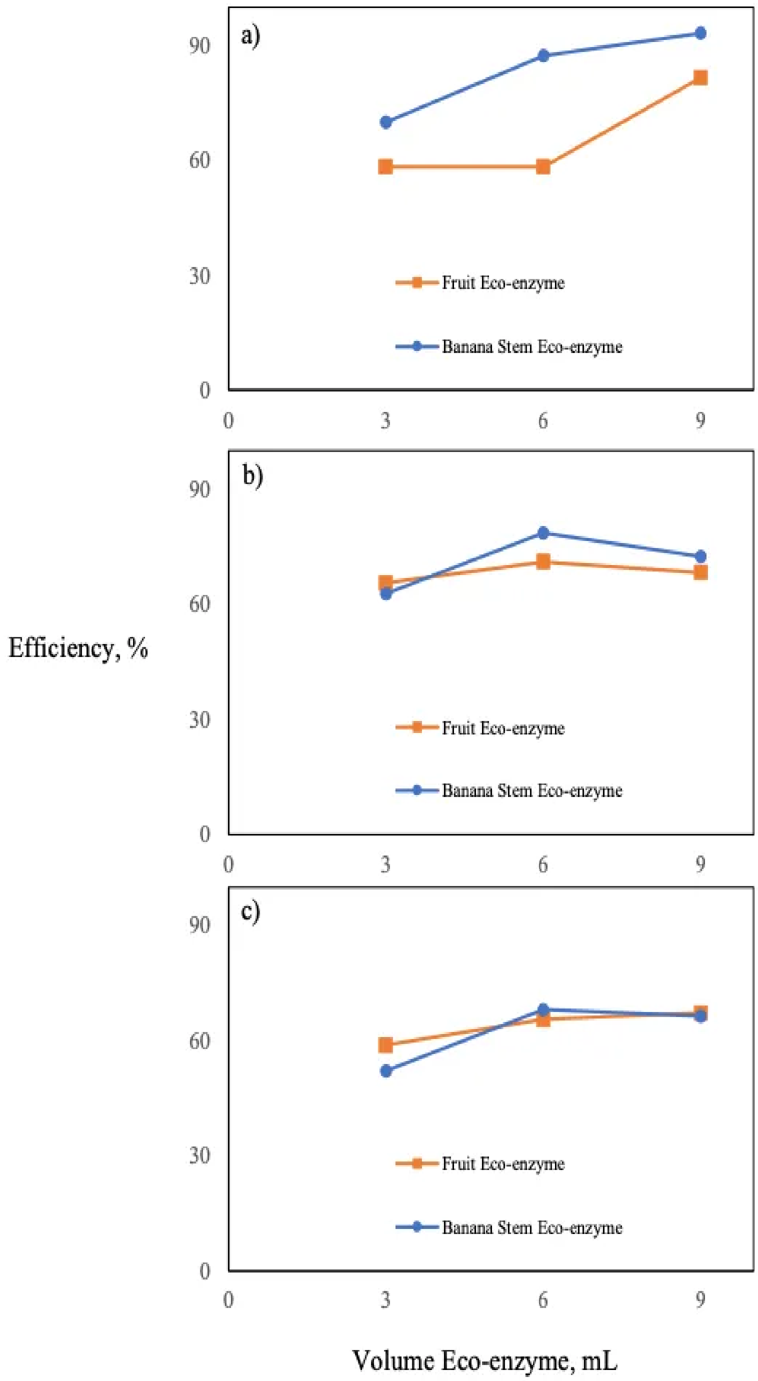

Fig. 3. Efficiency of Ammonia, Nitrate, and Nitrite Reduction by The Addition of Fruit Eco-enzyme and Banana Stem Eco-enzyme.

Conclusion

The addition of eco-enzymes to aquaculture effluents will reduce ammonia, nitrate, and nitrite levels. Compared to common fruit eco-enzymes, eco-enzymes made from banana stems provide higher efficiency. The reduction of ammonia levels in aquaculture effluent was more effective with the addition of a higher volume of banana stem eco-enzymes. However, the highest efficiency was obtained when adding 6 mL of banana stem eco-enzymes.

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