Biosystem treatment approach for seaweed processing wastewater

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Wastewater obtained from the seaweed washing process often contains residual chemicals, as the seaweed is typically washed using chemicals. Here, we used a biosystem to treat wastewater obtained after seaweed processing. The research goals were to determine the effectivity and capacity of this biosystem for reducing chemical oxygen demand (COD), biological oxygen demand (BOD), and nitrites in the wastewater. We planted and prepared the biosystem bin, adapted the plants in the biosystem bin until they were ready for use, and we performed wastewater treatment using the biosystem either with or without the addition of an active bacterial suspension. The results show that addition of the active suspension significantly improved effectivity with respect to COD and nitrites (p<0.05). With respect to COD, BOD, and nitrites, the effectivity of the biosystem with an added active suspension was 83.9, 87.2, and 55.5%, respectively; the effectivity of the biosystem without the active suspension was 79.2, 83.3, and 38.7%, respectively. The capacity of the biosystem with an added active suspension was 13.226, 6.805, and 0.014mg/L/m3hour with respect to reducing COD, BOD, and nitrites, respectively; the capacity of the biosystem without an active suspension was 12.485, 6.496, and 0.009 mg/L/m3hour, respectively.

Keywords: Washing seaweed wastewater, biosystem, COD, BOD, and nitrite

INTRODUCTION

Wastewater is a major problem facing our environment. Wastewater causes water pollution, there by impacting biota death, driving the extinction of species and threatening human health. The rapid growth of a variety of industries has generated increasing waste, further threatening the environment. Depending on the source of the pollution, various indicators can be measured to determine the level of environmental pollution, including chemical oxygen demand (COD), biological oxygen demand (BOD), nitrates, nitrites, phosphates, and ammonia (Shah et al., 2013). Seaweed processing is a growing industry in many coastal regions of Indonesia. This industry processes raw seaweed material into food and beverages. Concurrently, seaweed processing also produces high quantities of wastewater that contains residual chemicals that can pollute the environment, including NaOH, H2O2, KOH, and KCl (Sedayu et al., 2007).

The effectivity of wastewater treatment should be as economical and low-risk as possible; ideally, dangerous matter should not be released into the environment.
An effective waste treatment system should therefore reduce the levels of pollutants in wastewater to levels that meet or exceed regulatory requirements. A biosystem is a biological wastewater treatment process that uses degradation via microorganisms and biofiltration via the root systems of plants. In this study, we used *Ipomoea crassicaulis*, a tropical plant that grows in sandy soil and is native to North America, Asia, South Africa, and the West Indies. Importantly, this plant can grow in both dry and wet conditions and can withstand the conditions of polluted land.

The growth of microorganisms as a suspended solid is an important factor in the biosystem process. The potential of microorganisms in an active suspended solid can be seen from the appropriate environmental benefits (Suyasa and Arsa, 2013). In addition, the effectiveness and capacity of any system for reducing the levels of pollutants is an important issue. Thus, our goal was to determine the effectiveness and capacity of our biosystem with respect to reducing COD, BOD, and nitrates.

**MATERIALS AND METHODS**

**Plants for the biosystem**

We used *Ipomoea crassicaulis* (the local name in Indonesia is *Krangkungan*). Before use, the plants were seeded in nurseries in a mixed media soil for approximately one month (Nailufary, 2008). The bath was constructed using waterproof material and was 200 cm x 60 cm x 50 cm, with a sampling port. The bath contained a 15-cm layer of coral, which was covered with a 25-cm layer of a mixture of sand and gravel. The plants were seeded in the sand and gravel layer, which was adjusted to the length and width of the roots to best accommodate the growing roots and microorganisms. Before use, the biosystem was adapted for approximately two weeks (Suyasa and Dwijani, 2007).

**Seedling the microorganism consortia in an active suspension**

One gram of soil sample was placed in an Erlenmeyer flask containing a concentrate of nutrients, minerals, and wastewater substance. The mixture was stirred until homogeneous, allowed to grow, and the density of biomass in the active microorganism suspension was measured. The suspension was measured until maximum activity was achieved. The advantage of using an active suspended solid includes the speed of growth and the density of the microorganism (Zerfita and Suyasa, 2005).

**Application of the biosystem for treating seaweed wastewater**

The treatment was performed in the bath described above, which contained *Ipomoea crassicaulis* that had been adapted for two weeks. The effective capacity of the bath for treating wastewater was approximately 100 liters. The wastewater was washed into the bath and stabilized for 24 hours. Observations were then made by measuring the levels of COD, BOD, nitrites, and pH at 8, 16, 24, 32, 40, and 48 hours or until the measurements reached a plateau (Suyasa and Dwijani, 2007). The effluent from the treatment was also observed for both color and odor. The data obtained with respect to nitrites, COD, and BOD then were plotted against treatment time in order to obtain the curve that shows the maximum capacity of the biosystem for reducing levels of pollutants in wastewater.

**Determination of the effectiveness and capacity of the biosystem**

The effectiveness (as a percentage) and the capacity of the biosystem for reducing pollutant levels were determined using the following equations (Metcalf and I. Eddy, 1991):

\[
\% eff = \frac{(Q_a - Q_b)}{Q_a} \times 100
\]

where \(Q_a\) = initial concentration (mg/L) and \(Q_b\) = final concentration (mg/L).

\[
Capacity = \frac{(A - B)}{V \times R}
\]

where \(A\) = initial concentration (mg/L), \(B\) = final concentration (mg/L), \(V\) = the volume of the biosystem (m\(^3\)), and \(R\) = residence time (hours).

**RESULTS AND DISCUSSION**

COD is the oxygen demand that organic and inorganic chemical pollutants require in order to be oxidized. Organic and inorganic pollutants can be present as dissolved or suspended solids in a liquid. COD load is based on the degradable and non-degradable substances as an oxidation load in the environment. Thus, treating wastewater that contains COD will help improve the health of the environment (Santi, 2010). We found that our biosystem decreased COD by 117.32 mg/L in 8 hours. After 48 hours of treatment with and without the addition of an active suspension, COD decreased to 70.48 mg/L and 91.12 mg/L, respectively (Figure 1). Thus, adding the active suspension to the biosystem decreased pollutants in the wastewater. In the first 16 hours of treatment, COD decreased at a similar rate regardless of whether the active suspension was included; after this time point, COD decreased much more rapidly in the biosystem with the active suspension. After 48 hours of treatment, the biosystem reduced COD to under 100 mg/L, regardless of whether the active suspension was included. The time course was parallel with the growth of microorganisms in the active suspension, which started at 24 hours and peaked at 48 hours. Thus, sufficient numbers of microorganisms can break down the organic compounds, producing organic acid. This process helps dissolve the minerals needed by
microorganisms and plants, as well to neutralize the alkaline media (Sastrawidana et al., 2008).

According to the Indonesian Government Roles for Quality Standard of Domestic Wastewater, the maximum allowable COD level is 100 mg/L. Thus, our biosystem achieved this standard within 40 hours of treatment when the active suspension was included and within 48 hours of treatment when the suspension was not included.

Figure 2 shows the time course of BOD. Without the addition of the active suspension to the biosystem, BOD initially decreased to 109.3 mg/L (from a starting level of 224.6 mg/L), then increased to 129.7 mg/L until 24 hours of treatment; after 24 hours, BOD decreased steadily. In contrast, when the active suspension was added to the biosystem, BOD decreased steadily during the entire treatment time. After 48 hours of treatment with and without the active suspension, BOD was reduced to 28.60 mg/L and 37.5 mg/L, respectively, from an initial level of 224.6 mg/L (Fig. 2). Thus, after 40 hours, both treatments decreased BOD to the level allowable by the Indonesian Government Roles for Quality Standard of Domestic Wastewater (60 mg/L).

The microorganisms were added to the media as an active suspension in order to control the organic substances produced and to use them in the biodegradation process to yield stable products. The dynamic pattern of the treatment without the active suspension was caused by a shortage of microorganisms during the treatment. Along with a change in pH, the growth of microorganisms occurs gradually. Thus, the number of microorganisms in the active suspension improved the biosystem’s ability to reduce BOD. The microorganisms in the active suspension tend to use dissolved minerals from the breakdown of chemical compounds under acidic conditions. Rahma R. et al (2012) found that active suspension best influence in lowering the levels of COD and BOD of wastewater. The addition of the active suspension had a stronger effect on COD than on BOD. The initial nitrite concentration in wastewater that was
used to wash seaweed was 0.668 mg/L. After being treated in the biosystem, the level of nitrites decreased. As shown in Figure 3, the level of nitrites was reduced considerably more in the biosystem that contained the active suspension. Nitrite levels declined in the active suspension treatment rapidly from the start of treatment until 8 hours, after which the nitrite levels continued to decrease gradually.

The level of nitrites can be reduced due to absorption by suspended organic material and/or by the use of nitrobacteria. Nitrobacteria use energy from the oxidation of nitrite ions (NO₂⁻) to nitrate ions (NO₃⁻) in order to satisfy carbon needs. Nitrites are oxidized to nitrates under aerobic conditions (Zerlita and Suyasa, 2005). Thus, the addition of the active suspension to the treatment can boost the reduction of nitrite levels. As shown in Figure 3, adding the active suspension to the biosystem reduced nitrite levels to 0.297 mg/L after 48 hours. Without the active suspension, nitrite levels were only reduced to 0.409 mg/L after 48 hours.

The final nitrite levels were well below the Indonesian Government Roles for Quality Standard of Domestic Wastewater, which state that the maximum allowable nitrite level is 0.5 mg/L. With the active suspension, the minimum time required to reduce the levels of nitrites under the quality standard level was 8 hours. During this time, pH also decreased, reaching neutral values (pH 7.35). The use of Ipomoea crassicaulis supported the absorption of substances into the media. With respect to biofiltration, this process occurred via the plant’s root fibers, which are good medium for microbial growth. Thus, interactions between microbes and plant roots can help meet the need for important nutrients (Nailufary, 2008).

According to Equation 1, the effectivity of the biosystem with the active suspension with respect to reducing COD was 83.90% after 48 hours of treatment; the effectiveness with respect to meeting the quality standard was 81.76%. The effectivity of the biosystem with the active suspension with respect to reducing BOD was 87.30% after 48 hours of treatment; without the active suspension, effectivity was 83.30%. With respect to reducing nitrite levels, effectivity was 55.54 and 38.70% with and without the active suspension, respectively. Based on an ANOVA analysis, effectivity differed significantly between the biosystem with the active suspension and the biosystem without the active suspension with respect to COD and nitrite levels (Duncan’s multiple range test; p<0.05).

The ability of the biosystem to reduce COD, BOD, and nitrite levels can be considered when developing a constructed wetland with the addition of an active suspension that contains microorganisms. Based on the effectiveness of the biosystem with respect to treating wastewater, we determined the capacity of the biosystem to reduce COD, BOD, and nitrite levels. With the active suspension, the biosystem had the capacity to reduce COD by 13.226 mg/L/m³ hour; without the active suspension, the capacity was 12.485 mg/L/m³ hour. With respect to reducing BOD, the biosystem with the active suspension had a capacity of 6.805 mg/L/m³ hour; without the active suspension, the capacity was only 6.496 mg/L/m³ hour. With respect to reducing nitrite levels, the biosystem with the active suspension had a capacity of 0.014 mg/L/m³ hour; without the active suspension, the capacity was only 0.009 mg/L/m³ hour.

CONCLUSIONS

1. The addition of an active suspension to a biosystem considerably improves the biosystem’s ability to reduce COD, BOD, and nitrites in wastewater.
2. The improved BOD reduction in the biosystem with the active suspension and was not significant, as both treatments provide a sufficient number of microorganisms to degrade compounds.
3. The use of a biosystem is a feasible and effective method for reducing COD in wastewater.
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REFERENCES


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