The Potential Used of Microalgae for Heavy Metals Remediation

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ABSTRACT

Bioremediation is a biologically environmental cleaning process from pollutant. Phytoremediation is the use of plant (lower to higher plants) to clean up polluted terestrial or aquatic ecosystem, due to their ability to absorb pollutant and an efficiently mechanism on the accumulation of water, nutrients, and mineral. Microalgae require heavy metals for enzymatic process, however, at a high concentration may toxic. Microalgae are primary producer in aquatic ecosystem, therefore have an important role in the food web. Most of microalgae are live in the water as a plankton and contribute 50% of water oxygen, the rest are in the humic places.

This research was conducted in order to find out the potential use of microalgae, particularly Chlorella, Spirulina, Chaetoceros, and Porphyridium to remediate heavy metals of lead (Pb), cadmium (Cd) and copper (Cu). On the experimental research, 0.5 mg heavy metals were added to the 1 L microalgae culture. The microalgae population was counted every day for 14 days. The concentration of initial and 14 days heavy metals concentration in the microalgae culture were measured.

Chlorella has the highest population on the Pb, Cd and Cu treatments, with the reduction of heavy metal concentration on the culture media were 90%, 62%, and 83%, respectively. Porphyridium culture had shown the highest reduction of Cu and Cd concentrations of 96% and 70% respectively, although its population was a half of Chlorella population. Spirulina had the lowest population on the Cd treatment with the reduction of Cd concentration on the media was 73%. Chaetoceros had the lowest population on the Pb treatment with its reduction of 81%. Seems that the microalgae species showed different respond to heavy metals. Further research has to be developed to determine the percentage of heavy metal that accumulated on the microalgae.

Keywords: bioremediation, heavy metals, microalgae, Chlorella, Spirulina, Chaetoceros, Porphyridium

1. INTRODUCTION

One of the major water pollution is heavy metals, particularly from industrial waste. Traditionally, heavy metals can be removed physically or chemically which is often ineffective and/or very expensive, specific to each metal ion [1]. New technology had to be develop to reduce heavy metal concentrations to environmentally acceptable level at low cost. This new technology of bioremediation is the process of cleaning the environment from pollution using organism in-situ or ex-situ [2]. In the earlier development, bioremediation only used microorganism, however recently plant even lower plant such as microalgae had been develop for phytoremediation. This green technology offer alternative environmental friendly of restoration caused by surface area that able to absorb substantial efficiently on the water, mineral, nutrient as well as absorb selective ion and adapt on a high concentration of heavy metal [3]. Microalgae is a good biodegradator since it able to bound heavy metal ion on the cell wall; the stock of microalgae is easily founded, low cost, minimum sludge, and no need additional nutrient. However, its small size, and easily degraded by microorganism was its disadvantages.

Research on the microalgae had started on the use of diatom for reconstruciton past environmental change [4,5,7] and as bioindicator of water quality [5]; research on phytoplankton in relation to the trophic state[6]. Based on those research, there was a significant correlation on the microalgae and heavy metal reduction.

Research on the use of microalgae as a bioremediation agent was partially done per genus/species, such as on Spirulina, Nostoc (Cyanobacteria); Chlorella vulgaris, Eklonia radiata, Scenedesmus acutus (Chlorophyte).
In general, the heavy metal absorption by microalgae will increase in a high pH (8). Heavy metal required by microalgae as a trace element (≥ 3 g/cm³) for enzymatic process, will be toxic in a high concentration [8]. This research will provide comparison of microalgae from different division on reducing heavy metal concentration in the water.

2. MATERIALS AND METHODS

Stock of Chlorella, Spirulina, Chaetoceros, and Porphyridium was collected from BBATP Jepara. Walne medium was use for microalgae culture. pH, temperature, salinity, and light intensity were maintained to be stable. The 0.5 mg concentrations of Cu, Cd and Pb were expose to the microalgae culture. Algae cultured in the walle medium without heavy metals served as controls. All experiment were performed in triplicate. Every day the population was counted for 14 days. In the beginning and end of experiment the concentration of Cu, Cd and Pb was measured.

3. RESULTS

The relative growth of microalgae expose by 0.5 mg Cu, Cd, and Pb on Chlorella, Spirulina, Chaetoceros, and Porphyridium were have the similar pattern, reduced the population growth below the control. The lowest Chlorella population was on Cd expose, In the day of 10, in all treatments, the population reached maximum growth, then sharply decrease on the day of 11 and 12.

The population growth of Spirulina and Chaetoceros decrease until day of 5, then adapted phase for 3 days (day of 5 to 8), reach first peak at day of 4 then sharply increase and reach second peak at day of 9, followed by reduction of population. For Spirulina and Chaetoceros, the maximum population was similar to the initial population. It means that Pb, Cd, and Cu had stressed the population growth of Spirulina. Porphyridium shown different pattern compare to others. The population were fluctuated, First peak population growth were on the day of 4, 10, and 13. Based on this experiment, it was also found that Spirulina, Chaetoceros, and Porphyridium has 8 days life cycle, whereas Chlorella has 14 days life cycle (Figure 1).

The positive effect of heavy metals treatment was shown on the population growth of Chlorella, that has the highest population compare with others. The reduction of Pb, Cd, and Cu on the 14 days exposure were 90%, 62%, and 83%, respectively.

Porphyridium culture had shown the highest reduction of Cu and Cd concentrations of 96% and 70% respectively, although its population was a half of Chlorella population. Spirulina had the lowest population on the Cd treatment with the reduction of Cd concentration on the media was 73%. Chaetoceros had the lowest population on the Pb treatment with its reduction of 81% (Figure 2). Seems that the microalgae species showed different respond to heavy metals. Further research has to be developed to determine the percentage of heavy metal that accumulated on the microalgae.

4. DISCUSSION

Chlorella had a high reproduction, 1 single cell could reproduce into 10,000 cell within 24 hour memiliki tingkat reproduksi yang tinggi, setiap sel Chlorella mampu berkembang menjadi 10,000 sel dalam waktu 24 jam [9]. The heavy metal uptake by Chlorella was very selective due to the strength bound of heavy metals with cell wall, especially protein. In the laboratory, Chlorella may able to reduce cadmium (Cd) concentration of 30,61% on the 1.57 ppm [10]. The use of Cyanobacteria for heavy metal pollution was interesting to be done, since Cyanobacteria is celluler organism that easy found, spread habitat, easily to culture. In the normal case, the population growth of Spirulina reach peak in the day 7 [11]. However, under heavy metal exposure, its peak tent to be delayed into day 10. Spirulina is a good biosorbent for heavy metals. Spirulina able to absorb Cr, followed by Cu, and Cd [12, 13]. This research shown similar result, the reduction of aqueous Cu concentration (73%) was higher than Cd concentration (61%).

Cd had inhibition concentration for Chaetoceros gracilis on the concentration of 1.3 mg/L, whereas Pb on the concentration of 0.7 mg/L. The Lowest Observed Effect Concentration (LOEC 96 hour) of Cd and Pb on C.gracilis were 0.56 mg /L dan 0.26 mg /L, respectively. No observed Effect Concentration (NOEC 96 jam) of Cd and Pb on C.gracilis was less than 0.56 mg Cd/L dan 0.26 mg/L, respectively [14].
Figure 1. The population growth (x10^2 individu/mL) of Chlorella, Spirulina, Chaetoceros, and Porphyridium on the 0.5 mg Pb, Cd, and Cu exposure.
Pb and Cd has reduce the growth of *Cladophora fracta* when metal concentration were increased. This might be due to the fact that Pb induces the activity of the enzyme peroxidase that is involved in the degradation of indoleacetic acid (IAA), the hormone which stimulates plant growth and multiplication [1]. Several studies have reported on the effects of heavy metal on microalgal growth. *Chlamydomonas reinhardtii, Chlorella salina,*

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Chlorella sorokiniana, Chlorella vulgaris, Chlorella miniata, Chlorococcum sp, Cyclotella cryptica, Lyngbya taylorii, Phaeodactylum tricornutum, Porphyridium purpureum, Scenedesmus abundans, Scenedesmus quadricauda, Scenedesmus subspicatus, Spirogyra sp., Spirulina platensis, Stichococcus bacillaris and Stigeoclonium tenue have found as biosorbents for heavy metal ions \[i\]. Spirulina sp had perform bioabsortion of Cr\(^{3+}\), Cd\(^{2+}\) and Cu\(^{2+}\) ions \[ii\]. The limitation of this research was mono treatment of heavy metals concentration, further research require to be develop on different concentration.

5. CONCLUSION

Different microalge perform different population growth under heavy metal exposure. The concentration of 0.5 Pb, Cd, and Cu had reduce the population of Chlorella, Spirulina, Chaetoceros, and Porphyridium. Chlorella, and Chaetoceros was good for reducing Pb, whereas Porphyridium was good for decreasing Cu.

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