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THE POTENTIAL BIOREMEDIATION OF LEAD USING MICROALGAE

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ABSTRACT

The exposure of lead to environmental compartments, especially water bodies, has been a major concern for the past decades. It simultaneously altered the physical and chemical nature of the water and harmed its aquatic life. To tackle this problem, many techniques have been developed such as adsorption, filtration, electrochemical separation and bioremediation. Bioremediation, however, posses several advantages over other methods. It is green and relatively low maintainance cost, provide an interesting solution to lead problem. Microalgae is often reportedly effective as bioremediation agent, with multiple benefits including easy to handle and effective removal rate. Here we try to discuss recent development of lead bioremediation using several species of microalgae. A general impact of lead to aquatic life and the mechanism of lead detoxification on the microalgae body were also discuss thoroughly, providing a clear glimpse of the potential for further development.

INTRODUCTION

Water is an important resource for humans and organisms' life. Most human activities need water such as agriculture, plantations, household activities, industry, and so on. Human health can not be separated from the intake of water into the body every day. Not only humans, but water is also important for the survival of various organisms, especially aquatic organisms that need water as their habitat. Therefore, it is necessary to maintain the quality of various water sources.

However, the various human activities themselves, if not managed properly, can produce various kinds of pollutants that enter water sources such as rivers, seas, reservoirs, lakes, and also groundwater, causing pollution and decreasing water quality. The characteristics of polluted waters include physical characteristics such as a pungent odor, color, very cloudy water, changes in taste, and high temperatures. The pungent smell of water can be caused by the high process of decomposition of organic matter by microorganisms. Turbidity of the water can indicate the number of suspended particles and can also be caused by the increase of microorganisms in the water. Temperatures that exceed water quality standards can be caused by the entry of dissolved chemicals in large enough quantities (Al Idrus, 2014).

One of the pollutants that can pollute waters is lead (Pb). Lead in the waters can accumulate in aquatic organisms such as fish, shrimp, shellfish, and so on. If the animals are consumed by humans, lead can also enter and accumulate in the human body so that it can interfere with health (Pratiwi, 2020). The adverse effects of lead on human health include nausea, fatigue, bleeding gums, difficulty breathing, decreased sex drive (Laila, 2013), high blood pressure, anemia, changes in behavior (Ardillah, 2016), and so on. While the negative impacts for animals include damage to the kidneys, lamellae, intestines of fish, and so on (Hayatun, 2019). Therefore, efforts to overcome lead pollution in waters need to be carried out.

Microalgae are photosynthetic microscopic organisms that can be prokaryotic or eukaryotic. Microalgae can live in solitary or in colonies with varying colors depending on the dominant pigment they contain (Biologionline, 2021). Several studies have proven that microalgae can be used in lead bioremediation processes. This article aims to describe the potential of various types of microalgae in absorbing lead.

LEAD AND ITS IMPACT ON HUMAN AND ANIMALS HEALTH

Lead (Pb) is a non-essential heavy metal for the body. Lead can exist in the environment in organic or inorganic forms. These heavy metals enter water bodies due to mining, coal burning, cement manufacturing, use in gasoline (Usman et.al, 2013), battery manufacturing, soldering, ammunition, metal water pipes, paint, and petrol (Tamele and loureiro, 2013). 2020). These metals enter the human body through lead-based paint, dust, water, soil, tableware, folk medicines (Debnath et.al, 2019), and when consuming foods containing lead.

Lead that enters the human or animal body can cause several adverse effects on health. Lead enters the human or animal body through the respiratory tract, digestion, and dermal contact (Laila, 2013). After entering, the lead will be absorbed and transported to other organs by the blood. Lead then accumulates in blood, tissues, bones (Tamele and loureiro, 2020).

Various negative impacts can be felt by humans who are lead poisoning. Symptoms of lead poisoning are:

1. Nervous system dysfunctions such as poor attention span, headaches, irritability, loss of memory and dullness for adults, and acute encephalopathy (persistent vomiting, ataxia, seizures, papilledema, impaired consciousness, and coma) for infants (Tamele and loureiro, 2020).
2. Renal dysfunction: dysfunction of the proximal tubules, manifesting as aminoaciduria, glycosuria, phosphaturia with hypophosphatemia, increased sodium and decreased uric acid excretion, progressive interstitial fibrosis, a reduction in the glomerular filtration rate, and azotemia (Tamele and loureiro, 2020).
3. Disrupt the Cardiovascular system: Hypertension is another sign of Pb poisoning. Lead-blocked blood vessels can lead to im-mediate heart attack and death (Debnath et.al, 2019).
4. Disrupt the reproductive system: inhibition of menstruation, ovulation and follicular growth, delayed vaginal opening, and a decrease in frequency of implanted ova. If the blood of pregnant women contains lead, then lead will be passed through the placenta to the fetus, causing prematurity, intrauterine deaths, and low birth weight (Debnath et.al, 2019).
5. Disrupt bone function: Osteopenia, osteoporosis, and osteomalacia with increased bone fragility in humans

(Debnath et.al, 2019)

The various negative effects of lead on the animal body are:

1. Hemocytic congestion in efferent vessels and multiple hyperplasias were observed in gill filaments, resulting in the narrowed lymphatic lacuna in Litopenaeus vannamei (Usman et.al, 2013).
2. Histopathological gill lesions, temporary disturbances in sodium regulation, and showed a classical response to stress in Prochilodus lienatus (Martinez et.al, 2004).
3. Inhibit growth and reduce the activity of acidic protease and lipase enzymes in tilapia (Gonzales et.al, 2020)
4. Damage to the hepatopancreas of 91.11% in giant prawns (Macrobrachium rosenbergii De Mann) (Musallamah, 2012).
5. Etc

THE EFFECTIVENESS OF MICROALGAE FOR LEAD BIOREMEDIATION IN WATER

Efforts to overcome heavy metal pollution such as lead is by bioremediation. Bioremediation is an attempt to remove or neutralize pollutants by using living things through metabolic processes. The bioremediation mechanism can be carried out by organisms by reducing, degrading, mineralizing, or transforming more toxic pollutants into less toxic ones. Factors that affect the bioremediation process include the chemical nature and concentration of pollutants, the physicochemical characteristics of the environment (pH, temperature, oxygen, and nutrients), and their accessibility to existing microorganisms. (Sharma, 2019).

Microalgae can act as heavy metal bioremediation. Microalgae that can be used for bioremediation of various heavy metals include *Spirogyra* sp.*, Spirulina platensis, Cyanothece* sp.*, Scenedesmus quadricuada, Nannochloropsis* sp.*, Chlorella vulgaris, Botryococcus braunii, Neochloris oleoabundans, Neochloris oleoabundan* (Nateras-ramirez et.al, 2022), and others. so. This is because microalgae can absorb heavy metal ions. Microalgae has good prospects as bioremediation because it is a low-cost raw material, big adsorbing capacity, and no secondary pollution etc.

Several studies have proven the ability of some algae to absorb lead. Nisak et.al (2013) have compared the ability of *Nannochloropsis* sp. and *Chlorella* sp. as a lead bioremediation agent. The results showed that 0.9 ppm Nannochloropsis sp. and Chlorella sp can reduce lead levels in the water environment by 11.4701% and 10.0160%, respectively. Waluyo (2020) also investigated the potential of *Nannochloropsis oculata* for lead bioabsorption. The results showed that 1.3 ppm *N. oculata* in waters had an efficiency of absorbing lead of 55%. Masithah et.al (2011) reported that 0.9 ppm *Spirulina* sp. can reduce lead levels in water by 12.54%. Fitri et.al (2021) reported that *Chlorella vulgaris* can reduce lead levels of Pb(II) 80.6% for 21 days. Nimisha and Jo-seph (2020) reported that lead removal efficiency by *Spirogyra maxima* was more than 90% for 30 days.

Microalagae has potential as a bioremediation agent because it has polyphosphate bodies to store other nutrients and acts as a detoxifier (Dwivedi, 2012). In addition, certain microalgae such as *Nannochloropsis* sp. contain amine, amide, sulfate, and carboxylate functional groups that can bind to metal ions (Nisak et al, 2013).

Spirulina sp. has a very high protein content from 55% to 77%. In the bioremediation process, proteins and polysaccharides play an important role in binding heavy metals because heavy metal ions will bond with the carboxyl groups of proteins and the hydroxyl groups of polysaccharides (Masithah et.al, 2011).

Conclusion

From the discussion, it can be concluded that multiple species of microalgae has the potential to reduce lead from water compartment up to 90% in 30 days observation. Several species which have been reported potentially used as bioremediation agent including *Spirogyra sp., Spirulina platensis, Cyanothece sp., Scenedesmus quadricuada, Nannochloropsis sp., Chlorella vulgaris, Botryococcus braunii, Neochloris oleoabundans, Neochloris oleoabundan.* The presence of polyphosphate and various functional group in the microalgae's cell, help them to detoxify excess amount of lead in their body. A further research for optimalization is needed to boost the development of microalgae in lead bioremediation.

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