ISBN : 978-602-18940-0-2

The 2nd International Seminar on New Paradigm and Innovation on Natural Sciences and its Application

PROCEEDING

iSNPiNSA

"Science for Environmental Sustainability and Public Health"

DIPONEGORO UNIVERSITY
OCTOBER 4, 2012
SEMARANG, INDONESIA

organized by :

FAKULTAS
SAINS DAN MATEMATIKA
UNIVERSITAS DIPONEGORO

supported by :

Kementrian Perindustrian

KEMENTRIAN LINGKUNGAN HIDUP
REPUBLIK INDONESIA

TABLE OF CONTENT

The Role of *Spirulina* On The Reducing Heavy Metal Concentration

Riche Hariyati & Tri Retnaningsih Soeprobowati

Department of Biology, Faculty Science and Mathematics, Diponegoro University, Tembalang - Semarang, Indonesia
Riche.hariyati@gmail.com ;trsoeprobowati@yahoo.co.id

ABSTRACT

The heavy metal released to the environment has resulted many problems for aquatic ecosystems, which in turn will influence human health.Cyanobacteria had known able to accumulate heavy metals since Cyanobacteria are high tolerance and able to live in the extreme condition. Simultaniously, Cyanobacteria were very sensitive to the heavy metals pollution. One of Cyanobacteria is *Spirulina,* a microalgae as source of food for primary consument in the marine ecosystem. This research was conducted in order to find out the potential use of *Spirulina* 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 *Spirulina* culture. The *Spirulina* population was counted every day for 14 days. The concentration of initial and 14 days heavy metals concentration in the *Spirulina* culture were measured. The highest population of *Spirulina* under Pb treatment was in the day of 8, however under treatment of Cu dan Cd, was occurred in the day of 12. In the concentration of 0.5 mg Pb, Cu, and Cd, the population growth were higher than control, means that the addition of heavy metals had induce population growth. Therefore, research is still required to continue to find out the maximum growth on the maximum heavy metals.

Keywords: *Spirulina,* heavy metals, bioremediation

1. INTRODUCTION

Spirulina is a planktonic photosynthetic filamentous cyanobacterium that forms massive populations in tropical and subtropical water bodies which have high levels of carbonate. *Spirulina* has been studied for single cell protein [1], vitamins, minerals, proteins and polyunsaturated fatty acids: gamma-linolenic acid [2] , therapeutic properties [3, antioxidant activity [4].

Spirulina can be found in many freshwater environments, including ponds, lakes, and rivers. It thrives best under pesticide-free conditions with sunlight and moderate temperature levels, but it is also highly adaptable, surviving even in extreme conditions. Microalgae are microscopic. Marine microalgae, called phytoplankton, are the base of the ocean food web. *Spirulina* is often deemed the most nutritionally complete of all food supplements, containing a rich supply of many important nutrients, including protein, complex carbohydrates, iron, and vitamins A, K, and B complex. It also has a high supply of carotenoids such as beta carotene and yellow xanthophylls which have antioxidant compound. It is also rich in chlorophyll, fatty, nucleic acids, and lipids. Thus, *Spirulina* has countless uses as a supplement for maintaining good health and for preventing diseases.
Spirulina contains rich vegetable protein (60~ 63 %, 3~4 times higher than fish or beef), multi Vitamins (Vitamin B 12 is 3~4 times higher than animal liver), which is particularly lacking in a vegetarian diet. It contains a wide range of minerals (including Iron, Potassium, Magnesium Sodium, Phosphorus, Calcium etc.), a high volume of Beta- carotene which protects cells (5 time more than carrots, 40 time more than spinach), high volumes of gamma-Linolein acid (which can reduce cholesterol and prevent heart disease). Further, *Spirulina* contains phycocyanin which can only be found in *Spirulina*.
Effluents containing metal emerged from various electroplating, tanning, pesticide and nuclear reactor and they are present as ionic species, inorganic or organic complexes or associated with collides and suspended particulate materials. These metals cannot be degraded once released into the environment and it is an increasing problem for waste water treatment. The release of heavy metals from industries into the environment has resulted in many problems for both human health and aquatic ecosystems. Algae in metal containing localities tend to concentrate metal from ambient water and pass them to higher tropic level. They form the base of the food chain and their primary productivity depends upon maintaining the level of available metal ion at a concentration between toxicity and deficiency. Accumulation of trace metals in the food chain has been considered as a major environmental hazard [5].

Being important in primary production the study of toxic effects of metal pollutant on algae is important. Utilization of phytoplanktonic algae with a high potential to adsorb heavy metals for the removal of residual metals from waste water resulting in high quality reusable efficient water and valuable biomass that could be used for different purpose. Algal biotreatment of industrial effluents be an improved integrated high rate algal ponding system in successive stages by the cultivation of filamentous forms of algae can be utilized successfully for the heavy metal removal [6].

Cyanobacteria are characterized by high tolerance and can exist in various extreme conditions: in hot springs, in snow, in water rich in salts, etc. Simultaneously, they are very sensitive to the pollution by heavy metals [6].

One of the organism is known to have the potential for algal biosorption microscopic size or microalgae. From various studies note that different species of microalgae, especially from among the green algae (Chlorophyte), brown algae (Phaeophyte), and red algae (Rhodophyte) either alive (living cells) or in the form of dead cells (biomass) and biomass mobilization for ions adsorb metal. Algae alive utilized as a bioindicator of heavy metal pollution in the aquatic environment whereas in the form of algal biomass and mobilize biomass used as biosorben (biological material absorbing heavy metals) in wastewater treatment [7].

Spirullina are known to accumulate heavy metals from industrial effluents. These oxygen-evolving organisms quickly respond and adapt to stress conditions in general and heavy metals in particular [6]. They have developed natural methods of resistance towards heavy metals, viz., and a reduction in metal intake by extracellular sequestration, localization / compartmentalization inside the cell or energy-dependent efflux One of the vast and various alga groups are cyanobacteria and *Spirulina* is one of them. A possibility to use *Spirulina* dry biomass for remediation of sewage waters from cadmium is shown by [8].
Growth of *Spirulina* such as environmental factors light, temperature, salinity, pH, and nutrient use (carbon, nitrogen, sulfur, and phosphorus). Light has a great influence on the chemical composition of algal photosynthesis. Generally decrease in intensity of light will increase the chlorophyll a and other pigments (chlorophyll b, chlorophyll c, fikobilliprotein, and carotenoids), while high-intensity light will degrade chlorophyll a and other pigments [9].
Temperature is one of the factors that influence the biochemical composition of algae. Temperature effect on membrane lipid composition and content. The reduced temperature growth under optimal conditions increase the unsaturated fatty acids in membrane systems. Increased stability and fluidity of cell membranes especially the thylakoid membrane (increase of unsaturated fatty acids in membrane lipids) protects photosynthesis from fotoinhibisi at low temperature [9].

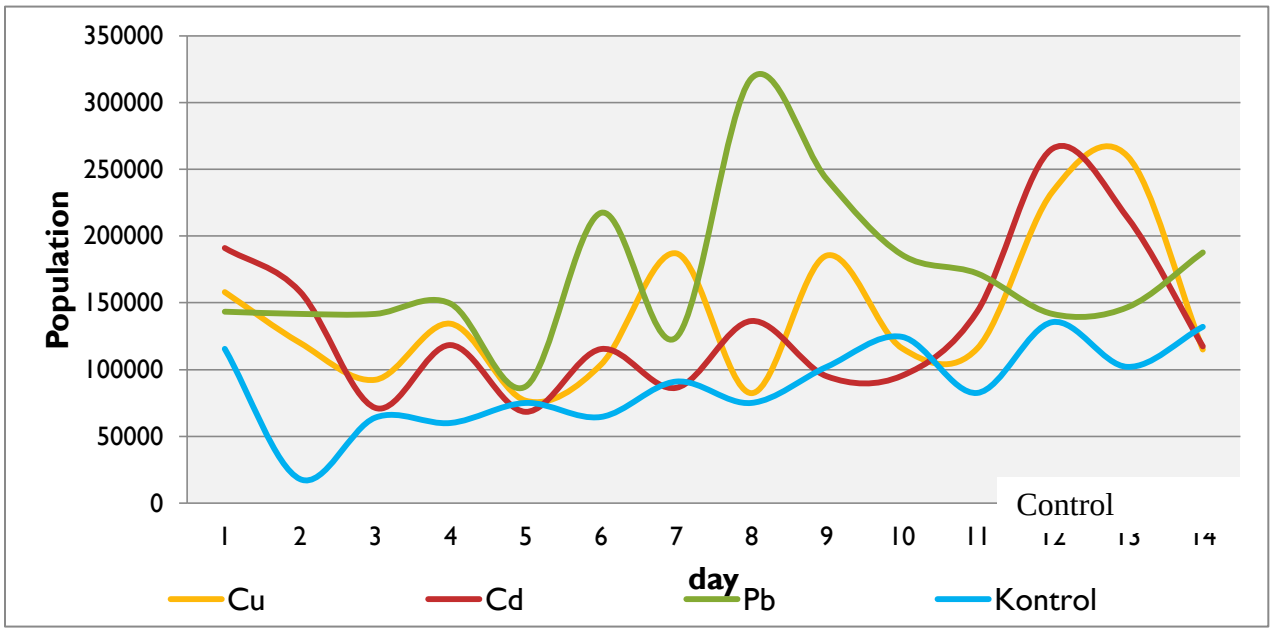
Spirullina can survive in the range of salinity 0.5 to 2 times the concentration of sea water [10]. In conditions of salinity less than 3.5%, microalgae not compete live with other microalgae when grown in open culture. Salinity of 4.6% does not inhibit the growth process. Nevertheless, with a range of 3.5-4.5% salinity can stimulate optimal growth [9]. *Spirulina* takes the form of nutrient and micronutrient makronutrient. Examples of macro nutrients for its growth are organic compounds such as N, K, MG, S, P and CL. While the micro nutrients are Fe, Cu, Zn, Mn, B . Each nutrient has specific functions for the growth and density of organisms without neglecting the influence of the environment.

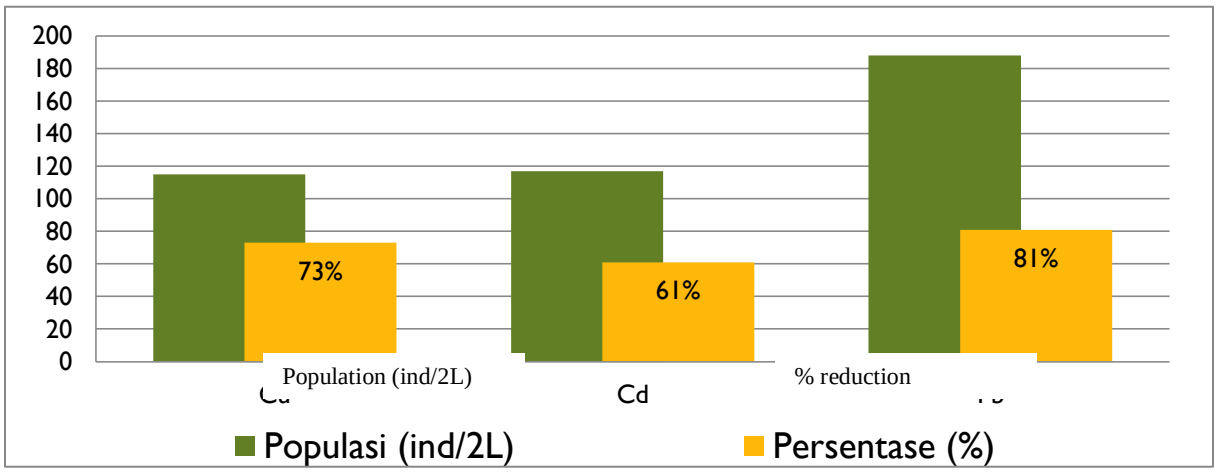
2. MATERIALS AND METHODS

This research requires vessel volume 3L, Pasteur pipette, hand counters, glass objects, microscopes, pH meters, hand reflaktometer, slides - glass cover, and SRC. Preparation consists of several stages, sterilization and medium cultivation, preparation of sea water as a cultivation medium for microalgae, preparation of inoculant, fertilizer cultivation and aeration equipment. All equipments to be used are sterilized first. Sterilization is intended to eliminate or minimize the presence of microorganisms or substances bullies on tools and cultivation media that will be used during the study. The medium used is water with a salinity of 28 ppt. *Spirulina* were taken from stock cultures BPPBAP Jepara and the metal used is Cu, Cd and Pb with a concentration of 0.5 ppm, and a vessel with no treatment as a control. The composition of the equipment carried in a closed room and the light comes from fluorescent lamp. Parameters observed during the study include: (1) Abundance of cells every day for 14 days in the main study.(2) additional parameters including temperature (^{o}C), salinity (ppt), and pH of the water in the cultivation medium.

3. RESULT

From the results of the study showed that the administration with heavy metals in the culture of heavy metal Pb *Spirulina* has the highest rate of absorbance compared with other types of heavy metals, ie by 81%. As for the Cd *Spirulina* can absorb up to 73% and 61% Cu. Heavy metal lead (Pb) may toxic due to bioaccumulation of the system, ie an increase in the concentration of chemical elements in the body of living things that cannot be degraded by the body, and toxicity properties (poison) in living organisms even at relatively low concentrations. In addition the lead (Pb) in the bloodstream and the brain can cause blood hemoglobin synthesis disorders, neurological disorders (nervous system), disorder of the kidneys, reproductive system, acute or chronic disease of the nervous system, and impaired lung function. Besides the accumulation of lead (Pb) in the body also can lower IQ, especially in young children. Some types of algae can absorb Pb, one of which is Chlorella sp. Lead (Pb) is absorbed can be taken and refined into metallic Lead (Pb) through a certain process.





4. DISCUSSION

Algae can be used as bioindicator of heavy metal pollution in the aquatic environment while the algal biomass in the form of biomass and used as biological material absorbing heavy metals in wastewater treatment. In general, the use of algae as bioindicator and biosorben. Algae have a high enough capacity to adsorb heavy metals because the algae are functional groups that can perform the binding of the metal ion. The functional groups, especially carboxyl, hydroxyl, amine, sulfudril, imadazol, sulfate and sulfonate present in the cytoplasm of the cell wall. *Spirulina platensis* play an important role in the environmental fate of toxic

metals and metalloids with physico-chemical and biological mechanisms effecting transformations between soluble and insoluble phases. Such mechanisms are important components of natural processes being of potential application to the treatment of contaminated materials. This study led to the conclusion that *Spirulina platensis* rapid cadmium adsorption rate and made them well suited for the removal of cadmium in wastewater. In addition, living cells of *Spirulina platensis* were found to have high tolerance to cadmium and can be regarded as an attractive adsorbate option for the biosorption of heavy metal contaminant. Thus *Spirulina platensis* biomass is suitable for fast remediation of industrial waste waters contain cadmium by the way of biosorption.The binding of the metal ion to the cell wall compounds is the possible mechanism behind the surface adsorption of the metal ion. Capsular material or extracellular polysaccharide found in Cyanobacteria carry sulphonated (SO_3) and carboxyl (COO^-) charge and promote ionic and electrostatic binding of the carboxylic and uronic acid moieties with the positively charged cation [6]. Studies on the mechanism of uptake of cadmium in *Spirulina platensis* cell have clearly indicated the metal ion on the surface. Adsorption of the cadmium was about 67% on the cell surface.

Rangsayatorn *et al*. [8]. reported that cadmium was rapidly adsorbed by *S. platensis* during the first 5 min and by *C. Regularis* within 6 min, respectively. Such rapid uptake of heavy metals by living cells is very significant when the cells are used in bioremediation process. Jayant Doke *et al*. (2004) reported that Ni was removed up to 57% and Pb up to 97% the total bacterial count was reduced up to 75% in the growth period of eight days by using *Spirulina* sp. [9].

CONCLUSION

Concentration of 0.5 ppm heavy metals Cu, Cd, and Pb were added to the culture of *Spirulina* sp, did not inhibit the rate of growth and the average number of the highest population in the culture of *Spirulina* sp found in cultures treated with the addition of Pb metal. *Spirulina* sp seen from the test data of heavy metals, the most effective has the ability to absorb heavy metals Pb, namely by 81%.

ACKNOWLEDGMENT

Thanks to Her Nur Yoga, Devi, Purwati, FOR HELPING IN THE LABWORK, AND Kenanga Sari for data analysis.

REFERENCES

[1] Anupama, P.R., 2000. Value-added food: single cell protein. Biotechnology Advances. 18: 459–479.
[2] Miranda, M.S., Cintra, R.G., Barros, S.B.M., Filho, J.M. 1998. Antioxidant activity of the microalga *Spirulina maxima*. *Brazilian J. of Medical and Bio. Res.* 31: 1075–1079.
[3] Belay, A., Ota, Y., Miyakawa, K., Shimamatsu, H., 1993. Current knowledge on potential health benefits of Spirulina. *Journal of Applied Phycology.* 5: 235–241.
[4] Estrada, J.E., Bescós, P., Villar Del Fresno, A.M.. 2001. Antioxidant activity of different ractions of *Spirulina platensis* protean extract. *Farmaco* 56: 497–500..
[5] Rao, V. N. R. and Gowrinathan, K. P., (1995). Influence of Environmental factors on the toxicity of heavy metal to estuarine diatoms. Bull. Pure. App. Sci. 11B (1-2): 39-44.
[6] Subramanian, G. and Uma, L. (1996) Cyanobacteria in pollution control. Journal of Scientific & Industrial Research. 55: 685-692.
[7] Chojnacka, K. 2009. Biosorption And Bioaccumulation In Practice. Nova Science Publishers, Inc. New York
[8] Rangsayatorn, N.; Upatham, E.S.; Kruatrachue, M.; Pokethiliyook, P.; and Lanza, G.R. 2002. Phytoremediation potential of Spirulina (Arthrospira) platensis: biosorption and toxicity studies of cadmium. *Environmental Pollution* **119(1):** 45-53
[9] Jayant Doke V., Raman, K. and Ghole, V.S. (2004). Treatment of anaerobically digested wastewater using *Spirulina* sp. Inter. J. Algae,**6** (4): 1610 -1015.
[9] Richmond A. 2004. *Handbook of Microalgal Culture: Biotechnology and Applied Phycology:* Oxford. Blackwell Science. 577 hlm
[10] Borowitzaka MA dan Borowitzaka LJ. 1988. *Dunaliella*. Dalam Borowitzaka MA dan Borowitzaka LJ. (Eds). *Microalgal Biotechnology.* Cambridge: Cambridge University Press.