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 Potential Used of Microalgae for Heavy Metals Remediation

Tri Retnaningsih Soeprobowati, Riche Hariyati

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

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 enzimatic 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 reserach 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 cocentration 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 industrail 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 accepatable 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.
Resea
rch on the microalgae had started on the use of diatom for recosntruction 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 S*pirulina, Nostoc* (Cyanobacteria)*; Chlorella vulgaris, Eklonia radiata, Scenedesmus acutus* (Chlorophyte).

In general, the heavy metal absorbtion by microalgae will increase in a high pH (8). Heavy metal required by microalgae as a trace element (≥ 3 g/cm^3) for enzimatic process, will be toxic in a high concentration [8]. This research will provide comparation of microalgae from differ 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 manitain to be stabile. The 0.5 mg concentrations of Cu, Cd and Pb were expose to the microalgae culture. Algae cultured in the walne medium without heavy metals served as controls. All experiment were performed in triplicate. Every day the population was counted for 14 days. In the begining 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 similiar 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 fluictuated, 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 aquous 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.gracillis* were 0.56 mg /L dan 0.26 mg /L, respectively. No obsered Effect Concentration *(*NOEC 96 jam) of Cd and Pb on *C.gracillis* was less than 0.56 mg Cd/L dan 0.26 mg/L, respectively [14].

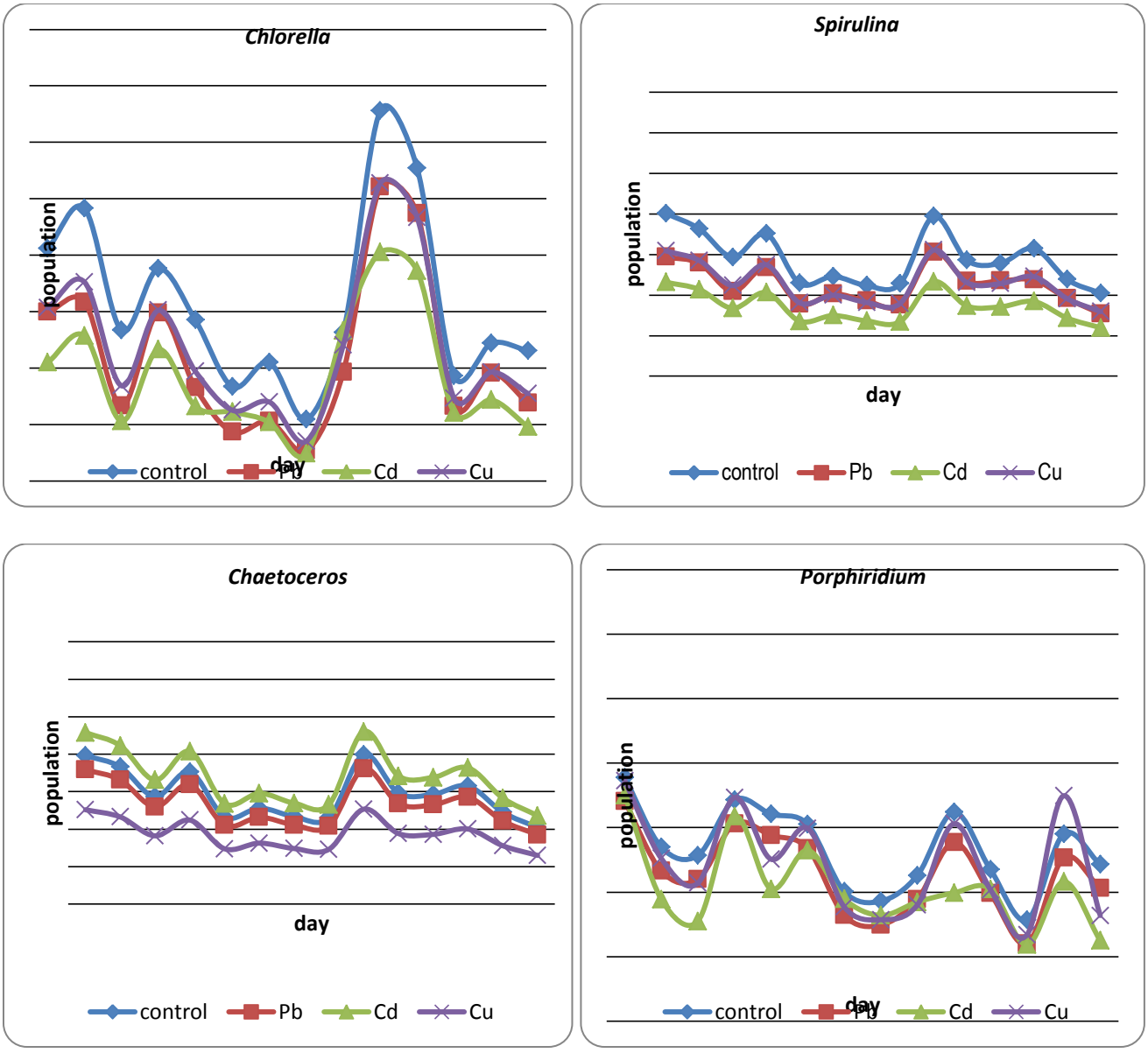

Figure 1. The population growth (x10^2 individu/mL) of *Chlorella, Spirulina, Chaetoceros,* and *Porphyridium* on the 0.5 mg Pb, Cd, and Cu exposure

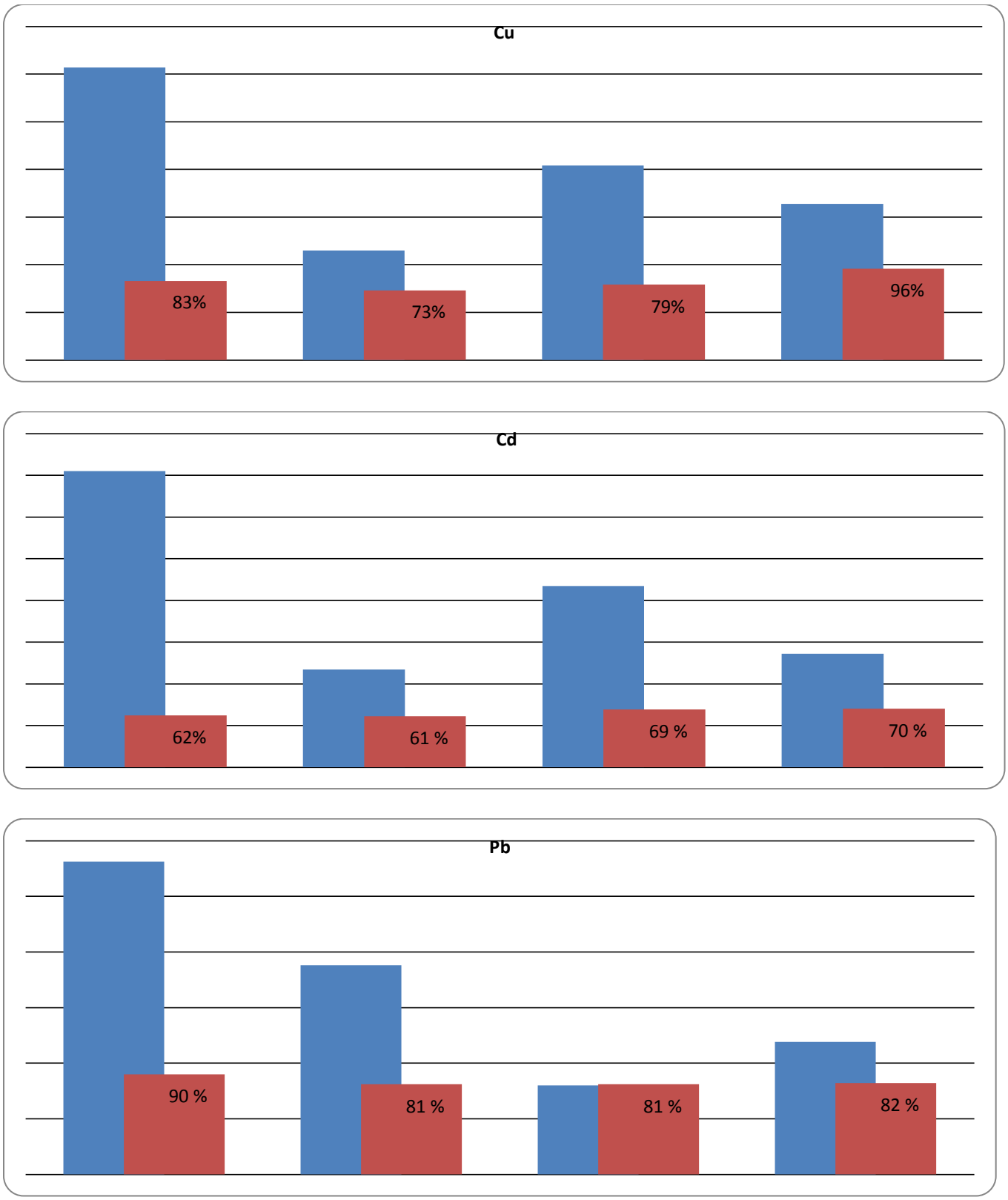

Figure 2. The population of *Chlorella, Spirulina, Chaetoceros,* and *Porphyridium* and the percentage of reduction heavy metal concentration

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,*

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 [15]. *Spirulina* sp had perform bioabsortion of Cr3+, Cd2+ and Cu2+ ions [13]. The limitation of this research was mono treatment of heavy metals concentration, furthure 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 decresing Cu.

ACKNOWLEDGMENT

Thanks to Biological students of 2010 for their practical work on Protist. Thanks to Haikal, Her Nur Yoga, Devi, Purwati, Syarif Prasetyo for compiling data.

REFERENCES

[1] C. Lamai; M. Kruatrachue, P. Pokethitiyook, E.S. Upatham, and V. Soonthornsarathool. Toxicity and Accumulation of Lead and Cadmium in the Filamentous Green Alga C*ladophora fracta* (O.F. Muller ex Vahl) Kutzing: A Laboratory Study. In *ScineceAsia* 3 2005, 31: 121-127

[2] R.L. Crawford and D.L. Crawford, D.L. Bioremediation: principles and applications. 2005. Cambridge University Press. NewYork.

[3] K. Chojnacka. Biosorption And Bioaccumulation In Practice. 2009. Nova Science Publishers, Inc. New York

[4] T.R. Soeprobowati, S.W.A. Suedy; T.A. Rahardjo; and K.A. Maryunani. Paleorecosntruction of ecological changes, in mangrove ecosystems based on diatom communities. 2007. *International Seminar Advances in Biological Science: Contribution towards a better human prosperity,* Faculty of Biology Gadjah Mada University, Yogyakarta, 7-8 September 2007.

[5] T.R. Soeprobowati, S. Hadisusanto, P. Gell, and A. Zawatszki. Diatom for Recosntruction The Past Environmental Condition Of Rawa Pening Lake, Java, Indonesia. 2010. *International Conference on Environmental Pollutin, Restoration, and Management.* SETACAsia-Pacific, Ho Chi Minh, Vietnam

[6] T.R. Soeprobowati, P. Gell, And S.W.A. Suedy; T.A. Rahardjo; Dan K.A. Maryunani., 2007. Diatom Stratigraphy Of Mangrove Ecosystems On The Northern Coast Of Central Java. *Journal Of Coastal Development* 2012. 15 (2):197-208

[7] T.R. Soeprobowati, S.Hadisusanto, P. Gell, and A. Zawatszki. The Past Environmental Conditions Of Rawapening Lake, Java, Indonesia: Reconstruction Using Fossil Diatoms. *Am. J. Environ. Sci.* 2012. 8 (3): 334-344.

[8] G. Banfalvi. Celluler effects of heavy metals. 2011. Springer. London.

[9] N.B. Prihantini, B. Putri, and R. Yuniati Pertumbuhan *Chlorella* spp. dalam medium ekstrak tauge (MET) dengan variasi ph awal. *Makara Sains* 2005. **9 (1)**: 1-6

[10] Kusrinah. Penurunan konsentrasi logam berat Kadmium air laut oleh *Chlorella* sp dalam skala laboratyorium. 2001. Skripsi Jurusan Biologi FMIPA UNDIP. Semarang.

[11] R. Hariyati. Pertumbuhan dan Biomassa *Spirulina* sp. dalam Skala Laboratoris. *BIOMA* 2008.**10(1):** 19-22

[12] F.A. Al-Rub, A. El-Naas, M.H., Ashour, and M. Al-Marzouqi. Biosorption of copper on *Chlorella vulgaris* from single, binary and ternary metal aqueous solutions. *Process Biochemistry* 2006.**41(2):** 457-464.

[13] K. Chojnacka , A. Chojnacki, H. Gorecka . Biosorption of Cr3+, Cd2+ and Cu2+ ions by blue–green algae Spirulina sp.: kinetics, equilibrium and the mechanism of the process. *Chemosphere* 2005. 59:75–84.

[14] M.D. SetiawatiUji toksisitas kadmium dan timbal pada mikroalga *Chaetoceros gracilis.* Skripsi , 2009. Departemen Ilmu dan Teknologi Kelautan, Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor

[15] L. Brinza , M.J. Dring, and M. Gavrilescu . Marine micro- and macro-algal species as biosorbentsfor heavy metals. *Environ Eng Manage J* 2007. 6:237–51.