The Biosorption of Copper Metal Ion by Tropical Microalgae Beads Biosorbent

by Tiara Wilan

Submission date: 09-Jul-2020 10:21AM (UTC+0700)
Submission ID: 1355248957
File name: Of-Copper-Metal-Ion-By-Tropical-Microalgae-Beads-Biosorbent.docx (127.18K)
Word count: 3063
Character count: 16975

The Biosorption of Copper Metal Ion by Tropical Microalgae Beads Biosorbent

Tiara Wilan, Nanda .Astuti Lieswit o, Amelia Suwardi, Rositayanti Hadisoebroto, Melati Ferianita Fachrul, Astri Rinanti

Abstract: This study aims to remove copper (Cu2+) **hemfflTI,etals** with a biotechnological approach using microalgae beads mixed culture of Chiarella vulgaris, Chlorococcum sp., and Scenedesmus obliquus.'1ie effect of contact time and pH was examined to achieve the greatest ef11c1ency in the Gu2+ metal removal. The exponential phase of mixed microalgae cultures occurred on the 7h day. In the exponential phase, microalgae can be harvested and made as biosorbent. Biosorbent is made_into beads by mixing 0.5 g,W,dead biomass)/ gr (Na-alginate polymer). Th,e biosorbent Imm these microalgae beads is contacted with a solution contalnlng Cu2+In the pH rangeqs and contact time 0-180 minutes. Th,e highest absorption eff1c1ency of Cu2+Is 98.56% obtained at pH 5, 180 minutes of contact time, al 25 °C, and with an initial waste concentration of 25 mg/L. The biosorption process in this study follows Langmuir Isotherm model with an R^2 vall.le of 0,9994. It is proven that the biosorbenl beads of mixed culture microalgae can be used as an environmenlally friendly method to conlrol heavy Cu^{2+} metals in the waters.

Index Terms: Beads, Biosorplion, Biosorbent, Copper (Cu2+), Heavy Metal, Microalgae, Removal

1. INTRODUC_TION

Heavy metals with high concentration are harmful to living creatures. They are generally found m the waters because of their mobility on its surface [1]. Some heavy metals often found in the waters are Cu, Zn, Cr, Cd, Pb, **Ni,** and Ag. Copper Cu^{2+} ion naturally enters the environment through various natural phenomena such as from the weathenng result of dissolute minerals contained in rocks, and unnaturally through a variety of human activities, for instance, the entry of electroplating industry wastewater [2]. According to (3), Cu^{2+} tends to be toxic assuming it enters an organism's body in large amount or exceeds their tolerance limit, thereby, disrupting the_ brain, skin, liver, pancreas, and myocardium. Furthermore, It also becomes a poison wh,en the concentration is above 20 mg/kg [4] and tends to cause diseases such as neurotoxicity, acLJte toxicity, dizziness, and diarrhea [5]. Various methods have been condLJcted to separate heavy metals from water, for instance, the physical adsorption method, chemical sedimentation, mechanical filtration, and ion exchange. However, some of those methods have disadvantages, such as causing secondary pollution as a result of using chemicals and its cost-effectiveness (6]. One of the environmental! friendly a ter ative meth ds used_ to overcome the pollution problem 1s biomass or microorganism, as b_iosorpti n [7]._ The advantages of using this method are the high efficmncy In_de_toxifymg unnywastewater and the cheap cost associated with its operation (8].

, *Tiara Wilan, Faculty of Landscape Architecture and Environmental Technology, Department of Environmental Engineering, Universitas Trisakli, Indonesia.*

, *Nanda Astuti Ueswito Faculty of Landscape Architecture i'l11 Environmental Technology, Department of Environmental Engineering, Universitas Trisakfi, Indonesia.*

,, *Amelia Suwardi Department,i;JJE,.nvironmental Engineering, Universitas Trisakti, Indonesia.*

, *Rositayanti Hadisoebroto, Faculty of Landscape Architecture ard Environmental Technology, JJ:partment of €nvironmental €ngineering, Universitas Trisakti, IndonesB*

,, *Melali Ferianita Fachrul, Faculty of Landscape Architecture aid Environmental Technology, Department of Environmental Engineering, Universitas Trisakti, Indonesia.*

, *Astri Rinanti as Coresponding Author, Faculty of Landscape Architecture and Environmental Technology, Department of Environmental €ngineering, Universitas Trisakti, Indonesia. €-mail: astririnanti@trisakti.ac.id*

Furthermore, the biomasses used for biosorption are microalgae, bacteria, fungi, and plants (9]. Microalgae is one of the biomass which can also cause water problems such as blooming algae. Algae blooming can have a negative impact on the aquatic environment because it can disrupt aquatic ecosystems due to the inhibition of sun penetration as a raw material for producers in photosynthesis so that it will cause an imbalance of aquatic ecosystems (10]. The abundance of microalgae can be used as a heavy metal absorbing biomaterial **(11].** Howev,er, a microbe with the most significant ability in absorbing heavy metals is microalga, which has a functional group capable of binding metal ions, especially carboxyl, amine, metal sulphate, and sulphonate functional group located in the cell wall inside the cytoplasm (4). The advantages associated with using microalgae are due to its environmentally friendly biological materials which are recyclable, and its cheap maintenance cost (12]. According to (13], the adsorption of heavy metal ions usingi microorganisms is reversible and the process occurs quickly. The biosorption process utilizes living or dead biomass because ii occurs on the surface of the microalga cell wall. However, using dead biomass is more advantageous because it does not need nutrient supply regularly for growth (14].

Many factors affect the biosorption process towards heavy metals some of these are the biomass characteristics, temperature, pH, initial waste and biosorbent concentration, contact time and width of the surface area. The immobilization also known of microalg e biomass is used to avoid the reactor clogging (15]. Immobilization is the physical absorption of biomass or cell localization into the polymer (1'6]. Algiinate chitosan, cellulose, polyurethane, polyvinyl alcohol, acrylic, and gelatin are some polymers used to immobilize biomass **(17].** However, in this research, it is used as a polymer. This research aims to obtain the highest biosorption efficiency of heavy metal Cu LJsing immobilized microalga by optimizing the environment condition during the process.

2 MATERIAL AND MIETHODS

2.1 Materials

Materials that used for this research are: Chlorella vulgaris, Scenedesmus obliquus, dan Chlorococcum sp., aquades, Na-

Alginat, CaCh.6H2O, alkohol, HCI and Microalgae Growth materials: KNO3, KH2PO4, MgSO4.7H2O, EDTA, FeCh.6H2O, ZnC12, H3B0s, CaCb.6H2O, MnCl2.4H2O, and (NH4)6.*Mo1.*O24.4H2O

2.2 Microalgae Cultivation

Microalg|a Chlorella Vulgaris, Chlorococcum sp., and Scenedesmus obliquus were grown in the batch culture using an art1f1c1al growth media PHM (Provasoli Haematococcus Media). Its cultivation was carried out on the 30 L photobioreactor and 1 L Erlenmeyer flask, with a microalgae and PHM media ratio of 1:9. The environment condition was set at room temperatu e of 25 ± 2°C, pH 6, lighting intensity of 3500 lux, and an airflow rate of 0.3 Liter/second. The growth of this mixed culture microalgae was determined using the optical density method, with the absorbance value measured using UV-Vis spectrophotometer using a wavelength of 680 nm. After obtaining the absorbance value, the growth cLJrve could be used to obtain the exponential phase.

2.3 Microalgae J!S Biosorbent Preparation

The cult1vatecl m1croalgae was then harvested and separated using the centrifugation method at the speed of 4000 rpm for 20 minutes. The separated biomass was then dried in an oven for 24 hourn at a temperature of 80°C till a microalg,ae powder was obtained and ready to be immobilized. The resulted microalgiae powder was then weighed and mixed with sodium alginate (2"/o, w/v) dissolved in 200 ml of demineralized aqua using a magnetic stirrer. After mixing it completely, the solution was dropped using a syringe into CaCl2. 2H2O O.1 M solution and stirred concurrently, using a magnetic stirrer. The beads we e then moved into CaCi2 5 **mM** solution and stored in a refrigerator for 24 hours to perfect its formation. After 24 hours, the beads were washed with distilled water, stirred using a magnetic stirrer for 30 minutes and filtered on a cloth.

2.4 Artificial Cu^{2+} Waste Preparation

The artificial wastewater made of sulphate copper (CuSO4.5H2O) was dissolved in distilled water till the concentration reached 1000 ppm as the main solution. Furthermore, the determined concentration of Cu^{2+} was dissolveqJtased on the concentration needed with the pH value set**by** adding HCI 0.1 N or NaOH 0.1 **N** solution.

2.5 Biosorption with pH and Contact Time Optimation

The pH was set using HCI and NaOH solLJtion until it recorded values of 4, 5, and 6. FLJrthermore, the concentration of Cu^{2+} solution in the waste was 25 mg/L, while the weight of the biosorbent beads was 10 grams and the temperature 25 ± 2°C. The biosorbent beads and waste were contacted in the 1500 ml photobioreactor, with aeration given from the bottom using a hose to make contact between the biosorbent beads and waste solution. This process was carried out within the contact times of 60, 120, and 180 minutes. After the biosorption process, metal Cu^{2+} was analyzed using AAS (Atomic Absorption Spectrophotometry).

2.6 Removal and Desorption of Cu^{2+}

After AAS analysis, the removal efficiency of Cu^{2+} can be counted using the equation below:

%Removal Efficiency = [(C1a) - c(b) / C1ai] x 100% (1)

C1aJ = Initial Waste Concentration of Cu^{2+} ; C_{1bl} = Final Waste Concentration of Cu^{2+}

log| qe log k + (1/n log C)

2.1 Isoterm Adsorption

The adsorption isotherm study showed the capacity of the biosorbent beads required to carry out the adsorption. This is, however, explained by the isotherm of equilibrium sorption which is indicated by a certain constant. which expresses the surface and affinity characteristics of the biosorbent. This reseiuch utilizes two models of isotherm, namely Langmuir and Freundlich.

In Langmuir, when C is plotted against C/QE, constant b and **QM** are obtained. The value of 1/b indicates the slope, while 1/qm.b is the intercept. The maximum capacities of adsorption and qm are obtained from the intercept and slope [18]. This model of this equation is:

C!qe = (1lb.qm) + (C/qm) (2)

C is the DI concentration of the waste after the biosorption process (riig/L), qe 1s the amount of adsorbed copper ion (mg/g), b 1s the coefficient of Langmuir, and qm is the adsorption capacity of the biosorbent beads (mg/g).

The Freundlich isotherm model uses the assumption that adsorption runs in physics. The equation required to obtain its constantsis:

$qe = k.\ C^{11}$ (3)

. (4)

k and .n . are _Freundlich adsorption capacity (mg1/g) and adsorption 1ntensity.

3: ResLJltsAnd Discussion

3.1 Cultivation of M1croalgae

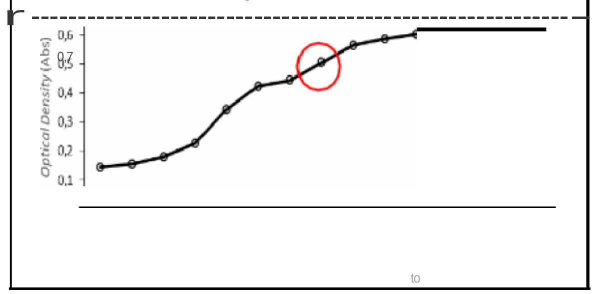

***Fig. 1.** The Microaiffi}'Ei't:u!tivation Graph*

In the exponential phase, the photosynthesis activity occurred high to form protein during the growth period (19). The growth curve illustrated in Figure 1, shows that the mixed culture microalgae reached the exponential phase from the 3rd to 11th day. The harvesting of the microalgae was conducted on the ?1h_ day, which was in the middle of the exponential phase, 1Js1ng centnfug1at1on and biofloculation methods. This was carried out during this period because the greatest increase in biomass occurred on that day. The harvesting of the microalgae was in the middle of the exponential phase with the aim of obtaining the most biomass and the assumption that the walls of microalgae have been fully formed during growth, so that they are ready and can be used as biosorbents when absorbing heavy metals. The results were then dried and made as beads to be used in the biosorption process.

3.2 pH and Contact Time Optimation

The a_dsorption of Cu2+ ion in the biosorption process as a pH and time function is shown in Figure 2. The pH value and contact time are some of the factors that influence the biosorption process.

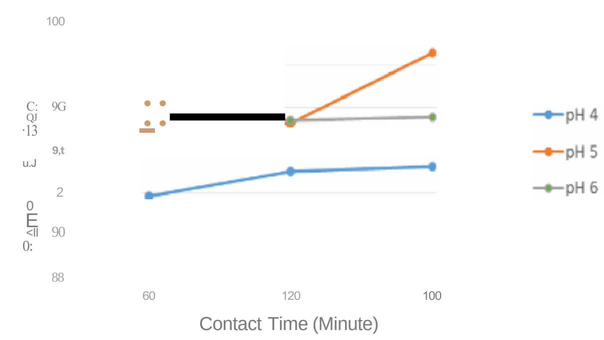

Fig. 2. *pH and Contact Time Optimation*

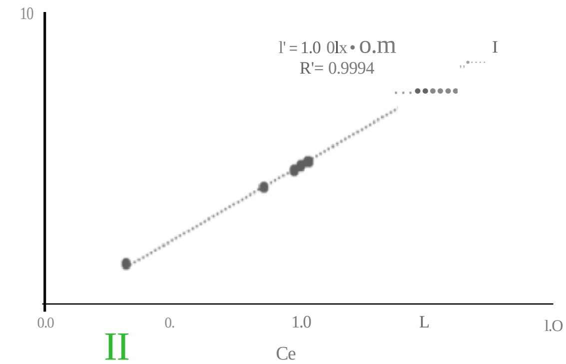

Fig. 3. *Langmuir Isotherm Graph*

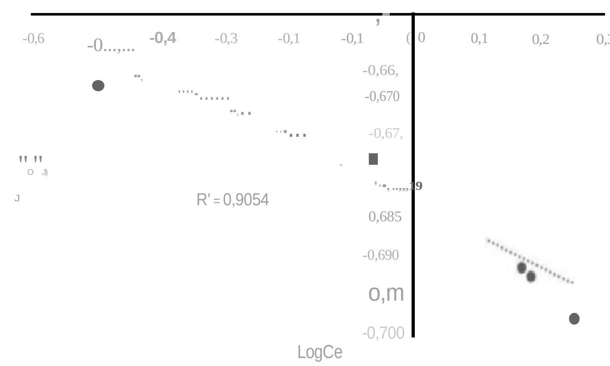

Fig. 4. *Freundlich Isotherm Graph*

The removal efficiency of Cu^{2+} at pH 4 tended to be higher, at the contact times of 120 and 180 minutes (Fig 2). On the other hand, at pH 5 the removal efficiency at contact time of 60 minutes and 120 minutes tended to show similar number and when tt reached contact time of 180 minutes, the efficiency increased significantly. However, pH 4,5, and 6 shows great removal efficiency of Cu^{2+} with **valR** above 90%. This happens because at pH above 3, el'ectrostatic attraction between copper ions and algal with negative chargied cells surface would occur which will enchance the adsorption (20]. The maxim um absorption value of Cu^{2+} occurred at pH 5 with a contact time of 180 minutes, and elimination efficiency above 98.56%. When compared with the research result of a researcher (21] who used a mixed c1J1lture of S. cerevisiae and Chlorella sp. immobilized with pH 4 and contact time of 120 minutes to absorb Cu^{2+} wtth the elimination efficiency of 81.05%, this research result is better and more efficient in absorbing Cu^{2+}. The optimization of pH in this research showed the most effective value for a biosorbent to absorb Cu^{2+} ion of copper. According to (22], pH affects the protonation of the metal-binding site exposed by the cell surface. As seen in Figme 2, the beads of mixed microalga appeared to provide less efficient elimination at pH 4. This was possible because tts three types failed to work optimally at a lower pH value. At pH 4, the removal efficiency increases continually on the elimination efficiency. This means that from 60 to 120 minutes, tt increased up to 1.23%, thereby, gaining up to 0.24% at the contact time of 180 minutes. This proves that the longer the biosorption process conducted, the better

the elimination efficiency obtained.

3.3 Adsorption Isotherm

According to the calculation using the eq1J1ation (2), the R^2

value obtained for the Langmuir isotherm (Figure 3) in this research was 0,9994. Figure 4 shows the Fre1J1ndlich constant

and the coefficient of correlation regression from the copper biosorption process in this research. The R^2 values for the Freundlich isotherm were 0,9054.

The constant value of both isotherm models are shown in Table 1. Langmuir isotherm shows the adsorption capacity of this process is 0,1972 mg/g and b indicates Langmuir constant with the vallJle of 21,797. For Freundlich isotherm model, k indicates the adsorption capacity with value of 0,2073 mg/g and n value of 25,380.

TABLE 1

LANGMUIR AND FREUNDLICH CONSTANT VALUE

Isotherm	Constant	Value
Langmuir	qm	0,1972
	b	21,797
Freundlich	K	0,2073
	n	25,380

The R^2 value is used as the crtteria for both models of isotherm (23]. Its value for Langmuir **islllerm** was bigiger than Freundlich. Therefore, it indicated that i'lie biosorption process following Langmuir isotherm was proof that it stops at one monolayer, and consistent with the functional binding (24].

4 CONCLUSION

The biosorbent beads of mixed culture microalga Chlorella

Vulgaris,Chlorococcum sp., and Scenedesmusobliquus were capable ofacting as aneffective biosorbent t reduce Cu ^{2}+i water. The microalgae reached the exponential phase on 7'-

a_y,which shows that the mixedm1croalgae 1scapable of living synerg1stically. The maximum percentage of _cum eliminationusingmicroalgae beadso urred _at pH 5wnh a contact time of 180 rrfJtes. The b1oso pt on process 15 properly explained well using the Langmuir isotherm model 2

withthe R value of0.9994, qm of0,1972 mg/g andb constant of21,797.

ACKNOWLEDGEMENTS

De author would like to thank the Repub_lic of Indone ia lilinistry of Research, Technology and Higher Educat10n (RISTEKDIKTI) for funding this research through.the Student Creativity Research Proposal Program (PKM-PE) in 2019.

REFERENCES

(1) S. Shamim, Biosorption Heavy Metals, IntechOpen, 2018

(2) **M.A.** Hossain, H.H. Ngo, W.S. Guo, T. Setiadi, -Adsorption and Desorption of Copper (11) Ions Onto Garden Grassll, Bioresour Technol, vol. 121, pp. 386-395, Jul. 2012.

(3) K. Vilayaraghan, J.R. Jegan, K. Palanivela, **M.** Velan, -Copper Removal from Aqueous Solution by Marine Green Alga Ulva Reticulall Electronic J. Biotecnol, vol. 7, no. 1, April 2004.

(4) N. Ahalya, T. V. Ramachandra and R.D. Kanamadi, -Biosorption of Heavy Methodll, Indian of Biotechnology, vol. 7, pp. 159-169, 2010.

[5] S.H. Abbas, 11.M. Ibrahim, T.M. Mostafa, A.H. Solaymon, -Biosorption Of Heavy Metals : A **Reviewl**, Journal of Chemical Science and Technology, vol. 3 no. 4, pp. 74- 102, 2014.

(6) I. Oboh, E. Aluyor, T. Audu, -Biosorption of Heavy Metal Ions from Aqueous Solutions Using a Biomaterialll, Leonardo J. Sci, vol. 14, pp. 58-65, 2009, , January-June 2009.

[7] N.L. Nafie, P. Taba, A. Irawati, dan C. Rosdiati, -Pb (11) Metal Ion Biosorption By Using Thalassia hemprichii Seagrass Biomass On Barrang Lampo lslandll, Marina Chimica Acta, vol. **11,** no **1,** April 2010.

(8) N.C. Feng, X. Guo and S. Liang, -Kinetic and thermodynamic studies on biosorption of Cu(II) by chemically modified orange peelll, Transactions of Nonferrous Metals Society of China, vol. 19, no. 5, pp. 1365_1370, October 2009.

[9] K.S. Kumar, H.U. Dahms, E.J. Won, J.S. Lee, K.H. Shin.llMicroalgae: A Promising Tool For Heavy Metal Remediationll, Ecotoxicol,ogy and Environmental Safety, vol. 113, pp. 329-352, March 2015.

(10) A. Rinanti and R. Purwadi, -Utilization of Blooming Microalgae in Bioethanol Production without Hydrolysis Processll, Proceedings of the 2018 Sustainable City National Seminar. DOI:http://d .doi.org/10.25105/psnkb.v1i1.2908, 2018.

(11] R. Fadilah and H.D. Ariesyady, -Analysis of Microalgae Abundance and Diversity in Stabilization Ponds of Wastewater Treatment Plants Based on Conventional and Molecular Biology Analysisll. InstitutTeknologiBandung, Bandung, 2012.

(12) S.K. Kumar, K. Ganesan, and P.V. Subba Rao, -Phycoremediation of heavy metals by the three-color forms of Kappaphycusalvareziill, J. Hazard. Mater,vol. 143, pp. 590-592, 2007_

113 1A.Rinanti,M.F.Fachrul,R.Hadisoebroto,M.D.S.Silalahi, -Biosorption Of Cu (11) By Scenedesmus obliquus: Optimization In Phovasoli Haemotococcus Medium: Japanll,InternationalJournal of Geomate,Vol.15,no. 52, pp. 45 – 52, 2018 –

114 1N. Kuyucak, B. Volesky, -Biosorbents for recovery of metals from industrialll, 1988.

(15) A. Rinanti, **M.F.** Fachrul, R. Hadisoebroto and **M.** Silalahi, -Improving Biosorption of Cu(I1)-Ion Artificial Wastewater By Immobilized Biosorbent Of Tropical Microalgaell, International Journal Of Geomate, Vol.13, no. 36, pp. 06-10, August 2017.

(16) C. Wang and J. Chen, -Biosorption for Heavy Metals Removal and Their Futurell, Biotechnol.Adv., vol. 27, no. 2, pp. 195-226, Mar.-Apr. 2009.

[17) L.G. Covizzi, E.C. Giese, E. Gomes, R.F.H. Dekker, R. Silva, -Immobilization of Microbial Cells and Their Biotechnological Applicationsll, Seminar: Ciencias Exatas e Tecno16gicas, vol. 28, pp. 143-160, 2007.

(18) T. Akar, Z. Kaynak, S. Ulusoy, D. Yuvaci, G. Ozsari, S. Tunali-Akar, -Enhanced Biosorption of Nickel(II) Ions by Silica-gel Immobilized Waste Biomass: Biosorption Characteristics in Batch and Dynamic Flow Modlell, J. Hazard Mater, vol. 163, pp. 1134-1141, 2009.

(19) **N.** Das, R. Vimala, P. Karthika, -Biosorption of Heavy Metals-an overviewll, Indian Journal of Biotechnol, vol. 7, pp. 159-169, 2008.

[20) F.A.A. Al-Rub, **M.H.** El-Naas, Anshour, **M.** AI.-Marzouq.i, -Biosorption of copper on Chlorella vulgaris from single, binary and ternary metal aqueous solutionsll Process Biochemistry, vol. 41, pp. 457-464, 2006.

[21) W.P. Siwi, A. Rinanti, M.D.S. Silalahi, R. Hadisoebroto, M.F. Fachrul, -Effect of immobilized biosorbents on the heavy metals (Cu^{2+}) biosorption with variations of temperature and initial concentration of wastell IOP Cont. Ser. Earth. Env. Science, vol. 106, 2018.

[22) Z. Aksu, T. Kutsal, -A comparative study for biosorption characteristics of heavy metal ions **with** C. vulgarisll, Environ. Technol. , vol. **11,** no.10, pp. 979- 987, 1990.

(23) D. Pradhan, L.B. Sukla, B.B. Mishra, **N.** Devi, -Biosorption for removal of hexavalent chromium using microalgae Scenedesmus sp..11 Journal of Cleaner Production, doi: 10.1016/j.jclepro.2018.10.288, 2018.

(24) G. Bayramoglu, I. Tuzun, G. Celik, -Biosorption of mercury(II), cadmium(II) and lead(II) ions from aqueous system by microalgae Chlamydomonasll, International Journal of Mineral Processing, vol. 81, no. 1, pp. 35-43, October 2006.

The Biosorption of Copper Metal Ion by Tropical Microalgae Beads Biosorbent

ORIGINALITY REPORT

4%	2%	3%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Al-Rub, F.A.A.. "Biosorption of copper on Chlorella vulgaris from single, binary and ternary metal aqueous solutions", Process Biochemistry, 200602 Publication	1%
2	www.ijeat.org Internet Source	1%
3	Mala Oktaviyana Lussa, Asih Wijayanti, Riana Ayu Kusumadewi, Rositayanti Hadisoebroto. "The Mixing Speed Effect and Mass of Adsorbent On Copper (Cu) Removal from Wastewater by Water Hyacinth Leaves", E3S Web of Conferences, 2020 Publication	1%
4	mdpi.com Internet Source	<1%
5	www.matec-conferences.org Internet Source	<1%
	Moni U. Khobragade Khobragade, Anjali Pal.	

6 "Batch and Continuous Fixed-Bed Column Adsorption for the Removal of Ni (II) from Aqueous Solutions using Surfactant-Treated Alumina", Recent Patents on Engineering, 2016 <1%

Publication

---

7 Jacques Romain Njimou, Andrada Măicăneanu, Cerasella Indolean, Charles Péguy Nanseu-Njiki, Emmanuel Ngameni. " Removal of Cd (II) from synthetic wastewater by alginate–Ayous wood sawdust ( ) composite material ", Environmental Technology, 2016 <1%

Publication

---

8 eprints.covenantuniversity.edu.ng <1%

Internet Source

---

9 tel.archives-ouvertes.fr <1%

Internet Source

---

10 Nathalie Vanhoudt, Hildegarde Vandenhove, Natalie Leys, Paul Janssen. "Potential of higher plants, algae, and cyanobacteria for remediation of radioactively contaminated waters", Chemosphere, 2018 <1%

Publication

---

11 Ashfaq Ahmad, A.H. Bhat, Azizul Buang. "Biosorption of transition metals by freely suspended and Ca-alginate immobilised with Chlorella vulgaris : Kinetic and equilibrium modeling", Journal of Cleaner Production, 2018 <1%

Publication

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		