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The 4th International Seminar on Sustainable Urban Development

To cite this article: 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **106** 011001

IOP Conf. Series: Earth and Environmental Science **106** (2018) 011001 doi:10.1088/1755-1315/106/1/011001

Preface

First of all, praise be to Allah, the Cherisher and Sustainer of the world, for His blessing for all of us. He who has provided us a chance so that we could be here. On behalf of the Organizing Committee, it is our great pleasure to welcome you to **the 4th International Seminar on Sustainable Urban Development (ISoSUD) 2017**, held by Faculty of Landscape Architecture and Environmental Technology, Universitas Trisakti, Jakarta, Indonesia at Hotel Ciputra. To the academicians, our colleagues from overseas universities, guests, participants, students, please accept our gratitude, warm welcome and appreciation.

Let me deeply express a special appreciation to the speakers:
1) Assoc. Prof. Dr. Nada Khaleefah M. A. Alrikabi from Environmental & Urban Planner, Center of Urban and Regional Planning for Post Graduate Studies, Baghdad University, Iraq
2) Dr. Yusnani Mohd Yusof from Urban Planning, Affordable City, Universiti Brunei Darussalam
3) Prof. Dr. Pasi Lehmusluoto, from Department of Limnology and Environment Protection, University of Helsinki, Finlandia
4) Prof. Dr. Mohd. Razman Salim, from Department of Environmental Engineering, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Malaysia

Achieving the SDGs requires of governments, private sector, civil society and citizens alie to make sure we leave a better planet for future generations. All 17 Goals interconnect, meaning success in one goal affects success for others. In short word, this is the greatest chance we have to improve life for future generations. Some of the goals that in major issue of **4th International Seminar on Sustainable Urban Development** are:
- Goals No. 6: Clean Water and Sanitation
- Goals No. 7: Affordable and Clean Energy
- Goals No. 11: Sustainable Cities and Communities
- Goals No. 13: Climate Action
- Goals No. 14: Life Below Water
- Goals No. 15: Life on Land

The seminar gathers eminent speakers and scholars that are engaged in Sustainable Urban Development field. The theme for this event is:

THE SUSTAINABLE DEVELOPMENT GOALs: IMPROVE LIFE FOR FUTURE GENERATION

The sub-themes of the seminar include, but not limited to :
1) Ecological Disaster Mitigation and Adaptation
2) Urban Environemntal Management
3) Environmental Technology

This year, the committee received over than 150 papers both in oral or poster presentation from 15 universities in Indonesia and from UK, Japan, Malaysia, Italy, and Iraq as well. Selected papers will be proposed to be published in IOP Publisher Conferences Series: Earth and Environmental Science, indexing by Scopus and Thomson Reuters. Other selected papers will

IOP Conf. Series: Earth and Environmental Science **106** (2018) 011001 doi:10.1088/1755-1315/106/1/011001

be published in National Journal accredited by Ministry of Research and Higher Education of Indonesia, i.e: Aceh International Journal of Science and Technology published by Universitas Syiahkuala, Aceh and Jurnal Reaktor published by Universitas Diponegoro, Semarang.

We are very grateful to Rector of Universitas Trisakti-Jakarta, Dean of Faculty of Landscape Architecture and Environmental Technology, Head of Environmental Engineering Department, Head of Landscape Architecture Department, Head of Urban and Regional Planning Department, the members of Advisory board, the members of Steering committee, Peer Reviewers, and Organizing committee that very supported and helpful within the preparations and conduction this seminar. Our grateful deliver as well to Association of Experts in Sanitary Engineering (TP) and Environmental Engineering (TL), IATPI (Ikatan Ahli Teknik Penyehatan dan Teknik Lingkungan), for their support to the seminar. Our appreciation is also for all the participants who have actively written excellent research papers. It is desired to have a sustainable seminar to be continuously held in the future times, as we are challenged to make a sustainable building and environment for a sophisticated life. Last but not least, we would like to express our gratitude to all the session chairs, reviewers, participants, institutions for their contribution to 4th ISoSUD 2017.

We believe that this event will be able to facilitate a good networking among researchers, scientists, engineers and practitioners of with common interest especially in sharing the latest research results, ideas, development and applications in the Sustainable Urban Development. We hope you enjoy the seminar and find this experience inspiring and helpful in your professional field. We look forward to seeing you at our upcoming seminar in the next 3 years on 5th ISoSUD 2020.

The Editors
Dr. Astri Rinanti
Dr. Rositayanti Hadisoebroto
Dr. Ade Gafar Abdullah
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CONFERENCE PHOTOGRAPH


International Seminar on
August 9th


PUBLIC SPACES AND URBAN
SUSTAINABILITY OF THE TROPICAL BUILT
ENVIRONMENT:
BANDAR SERI BEGAWAN CBD
International Seminar on Sustainable Urban
SUSTAINABLE DEVELOPMENT GOALS. IMPROVING LIFE FOR FUTURE


4th International Seminar on Sustainable Urban Development
THE SUSTAINABLE DEVELOPMENT GOALS, IMPROVING LIFE FOR FUTURE GENERATIONS


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THE SUSTAINABLE DEVELOPMENT GOALS, IMPROVING LIFE FOR FUTURE GENERATIONS
Scopus
Feedstock characteristics


THE SUSTAINABLE DEVELOPMENT GOALS
IMPROVING LIFE FOR FUTURE GENERATIONS
9th August 2017, Jakarta, Indonesia
Scopus
KEYNOTE SPEAKER
INVITED SPEAKER
CHAIRPERSON
TOSHIBA
MODERATOR
PRESENTER


Material and Methods
The sample of test prepared was asphalt concrete wearing course (AC-WC) type based on Indonesian specification for airport with the addition of BNA-R to the asphalt pen 60/70.
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Effect of immobilized biosorbents on the heavy metals (Cu^{2+}) biosorption with variations of temperature and initial concentration of waste

To cite this article: W P Siwi *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **106** 012113

Effect of immobilized biosorbents on the heavy metals (Cu^{2+}) biosorption with variations of temperature and initial concentration of waste

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Abstract. The aims of research is to studying the efficiency of copper removal by combining immobilized microalgae with optimizations of temperature and initial Copper concentration. The research was conducted in batch culture with temperature variations of 25°C, 30°C, and 35°C, as well as initial Cu^{2+} concentrations (mg/l) of 3, 5, 10, 15 and 20 using monoculture of *S. cerevisiae*, *Chlorella* sp., and mixed culture of them both as immobilized biosorbents. The optimum adsorption of 83.4% obtained in temperature of 30°C with an initial waste concentration of 17.62 mg/l, initial biomass concentration of 200 mg, pH of 4, and 120 minutes detention time by the immobilized mixed culture biosorbent. The cell morphology examined using Scanning Electron Microscope (SEM) has proved that the biosorbent surface was damaged after being in contact with copper (waste), implying that heavy metals (molecules) attach to different functional cell surfaces and change the biosorbent surface. The adsorption process of this research follows Langmuir Isotherm with the R^2 value close to 1. The immobilized mixed culture biosorbent is capable of optimally removing copper at temperature of 30°C and initial Cu^{2+} concentration of 17.62 mg/l.

Keywords: biosorbent, biosorption, heavy metals, immobilized microalgae, Langmuir Isotherm

1. Introduction

The development of industrial sectors such as mining, electroplating, agriculture, fisheries, and others increases heavy metal pollution in the environment. One of the heavy metal waste that pollutes the environment is copper (Cu). Cu is a heavy metal widely utilized in the power industry, also as fungicides and anti-pollutant paint. One of the alternative methods that can be applied to overcome the pollution problem is biosorption, a term to describe the removal of heavy metals by passive binding in biomass plants or microorganisms in a solution through the metabolic or chemical-physical steps including the removal of toxins from hazardous materials. The advantages of using biosorption method are economical, easily available, as well as environmentally friendly because it utilizes biological materials. The biosorption process is influenced by the initial concentration of metal-containing waste, temperature, pH, and biomass concentration in the solution [1]. This research was carried out by optimization of variations of temperature and initial concentration of the waste.

In general, biomass can be used as biosorbent in the form of microorganisms such as bacteria, microalgae, and fungi, whether living or dead. However, microalgae's weak structure and tiny size are not suitable for continuous operation of metal elimination. Immobilization of biomass is then implemented to overcome this problem. Such immobilization is beneficial in improving the mechanical strength and resistance to chemicals, as well as facilitating the separation of biomass and generated effluent [2]. This Cu^{2+} metal biosorption study was conducted in a batch reactor using the immobilized consortium of *Chlorella* sp. and *S. Cerevisiae* with an optimization of temperature and initial concentration of waste to treat wastewater containing Cu^{2+}.

2. Research Method

The optimal biosorption was achieved through three stages of testing, i.e., the determination of mobile and immobilized biosorbents with a concentration of 200 mg and 500 m; followed by the evaluation of the effects of temperature using variations of 25°C, 30°C, and 35°C; and continued with the optimization of initial waste concentration using variations of 3 mg/l, 5 mg/l, 10 mg/l, 15 mg/l, and 20 mg/l.

2.1. Optimization Testof Temperature

The immobilized biosorbent was contacted with 100 ml of waste containing Cu^{2+} ions with a concentration of 10 mg/l at pH 4 and in 120 minutes detention time, by aeration and regulated with temperature variations 25^0C, 30^0C and 35^0C. Afterwards, the solution was measured using AAS, and the final concentration was calculated to obtain the removal efficiency.

2.2. Optimization Test of Initial Waste Concentration

The immobilized biosorbent was contacted with 100 ml of waste containing Cu^{2+} ions with various concentrations of 3 mg/l, 5 mg/l, 10 mg/l, 15 mg/l, and 20 mg/l at the optimum temperature and pH 4, with a contact time of 120 minutes and aeration treatment. Afterwards, the solution was measured using AAS, and the final concentration was calculated to attain the removal efficiency.

2.3. Analysis of Removal Efficiency and Adsorption Capacity

The removal efficiency and metal adsorption capacity of Cu^{2+}can be calculated by the following formula [3]:

$$\text{Removal Efficiency (\%)} = \frac{Co-Ce}{Co} \times 100\% \quad (1)$$

$$\text{q (mg/g)} = \frac{(Co-Ce)\times V}{W} \quad (2)$$

3. Results and Discussion

The optimization of Cu^{2+} metal biosorption was carried out using a single culture of *S. cerevisiae*, monoculture of *Chlorella* sp., and a mixed culture consisting of *S. cerevisiae* and *Chlorella* sp. (1:1). The characterization results of electroplating industrial wastewater samples were used to acquire the initial concentration of waste by 53.674 mg/l. It was then diluted to get the intended variations of initial waste concentration for this research.

3.1. Determination of Mobile and Immobilized Biosorbents

The optimization test of Cu^{2+} metal biosorption was carried out using a single culture of *S. cerevisiae*, a monoculture of *Chlorella* sp.,a and mixed culture of *S. cerevisiae* and *Chlorella* sp. (1: 1), treated with mobile and immobilizedbiosorbents. The experiment was conducted at pH 4, a contact time of 120 minutes, an initial concentration of Cu^{2+}wastewater of 2.99 mg/l,a temperature of 30^0C, as well as initial biosorbent concentrations of 200 and 500 mg.

Based on the removal efficiency of Cu^{2+} as shown in Figure 1A, the biosorption using abiosorbent concentration of 200 mg indicated that mobile and immobilized biosorbents could adsorb Cu^{2+}ions, but the higher adsorption was delivered by immobilized biosorbent. It implies that both single culture and mixed culture are capable of performing adsorption, but higher adsorption is achieved by the mixed culture. The maximum adsorption of 71.91% was attained by the immobilized mixed culture biosorbent. Compared with the removal efficiency value shown in Figure 1B, the biosorption using a biosorbent concentration of 500 mg showed its capability to absorb even higher, reaching 81.05% using the immobilized mixed culture. It reveals that the higher the initial biosorbent concentration, the greater the yielded removal efficiency. It is in line with [3] who reported that the biosorption of Uranium (VI) by immobilized biosorbent of *A. niger* with initial concentrations ranged from 0.1 to 1.2 g/l showed that the removal efficiency of Uranium (VI) increased from 55.2% to 93.4% for an increment of initial biosorbent concentration of 0.1–0.5 g/l.

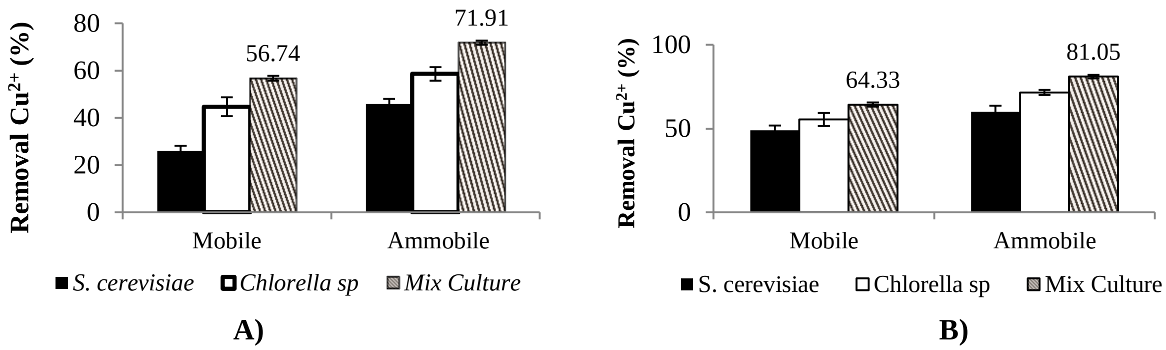

Figure 1. The relationship of Cu^{2+}removal efficiency with mobile and immobilized biosorbents at pH 4, 120 minutes contact time, initial Cu^{2+}concentration of 2.99 mg/l, as well as a biosorbent concentration of A) 200 mg and B) 500 mg

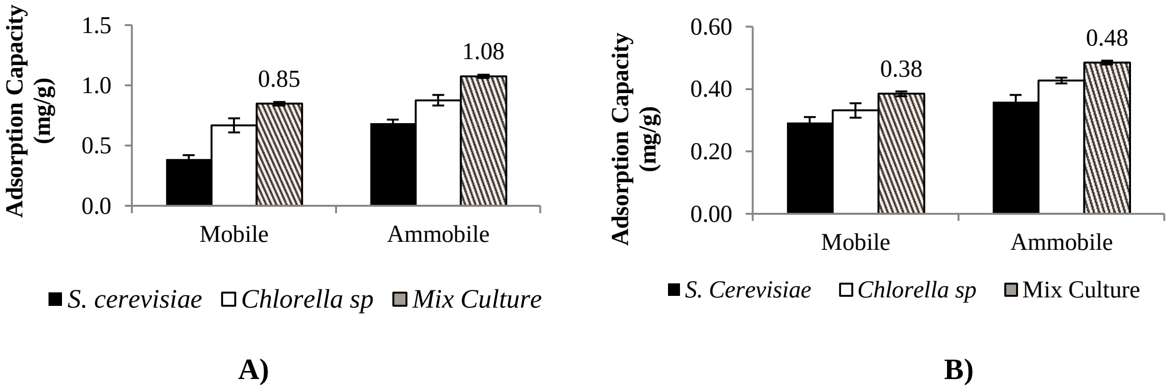

Figure 2. The relationship of Cu^{2+}adsorption capacity with mobile and immobilized biosorbents at pH 4, 120 minutes contact time, initial Cu^{2+}concentration of 2.99 mg/l, as well as initial biosorbent concentration of A) 200 mg and B) 500 mg

Adsorption capacity values in Figure 2A and Figure 2B are opposed to removal efficiencies in Figure 1 and Figure 2; the greater the initial concentration of biosorbent used, the smaller the adsorption capacities. The initial biosorbent concentration of 200 mg with mixed culturehad a higher adsorption capacity compared with the initial concentration of 500 mg biosorbent. The maximum adsorption capacity was demonstrated by the immobilized mixed culture biosorbent with a concentration of 200 mg or equal to 1.08 mg/g.

The results obtained in this study are consistent with [4] which observed that the adsorption capacity of immobilized *Chlorella* sp. was greater than the mobile biomass of *Chlorella* sp., reaching a removal capacity of Cu^{2+}ions of up to 24.91 mg/g. The study of [5] also reported using immobilized biosorbent of *Chlorella* sp. that had an adsorption capacity of Cu^{2+}ions of 28.5 mg/g.

Based on these matters, it can be concluded that immobilized biosorbents havea better ability to adsorb Cu^{2+} than the mobile ones. The initial concentration of 200 mg biosorbent has a higher adsorption capacity than the initial concentration of 500 mg biosorbent.

3.2. Temperature Optimization Test

At the temperature of 25°C, immobilized biosorbent could present a removal efficiency of 60.22–73.58%, while at the temperature of 30°C, it was capable of increasing the Cu^{2+}removal of up to 79.4%. At the temperature of 35°C, the adsorption efficiency gradually decreased of only up to 66.97%. It shows that the higher the temperature, the biosorbent becomes less capable of performing adsorption.

The results of this study correspond to [6] which researched the optimum adsorption temperature of heavy metals-Cr (VI), Cd, Cu^{2+}, and Ni-using immobilized mixed culture biosorbent and temperature variations ranging from 10–50°C. It observed that the efficiency of metal uptake continued to increase at a temperature of 10–30°C, then the reduction of adsorption efficiency occurred along with the temperature increase. The optimum adsorption efficiency of the contained metal of 90% was achieved at the temperature of 30°C. According to [6], a decrease in the adsorption efficiency at 40–50°C was led by the increased absorption of heavy metals from the solid to liquid phase, the surface deactivation of biosorbent, as well as the damage to the active site on the surface of biosorbent due to the disruption or the weakening bonds of active site in binding heavy metals.

3.3. Optimization of Initial Concentration of Waste Containing Cu^{2+} Ions

The optimization test of initial concentration of waste containing Cu^{2+} by immobilized biosorbent was performed at pH 4 with concentration variations of 2 mg/l, 5 mg/l, 10 mg/l, 15 mg/l and 20 mg/l; using the optimum temperature obtained at the previous test of 30°C, 120 minutes contact time, and an initial biosorbent concentration of 200 mg.

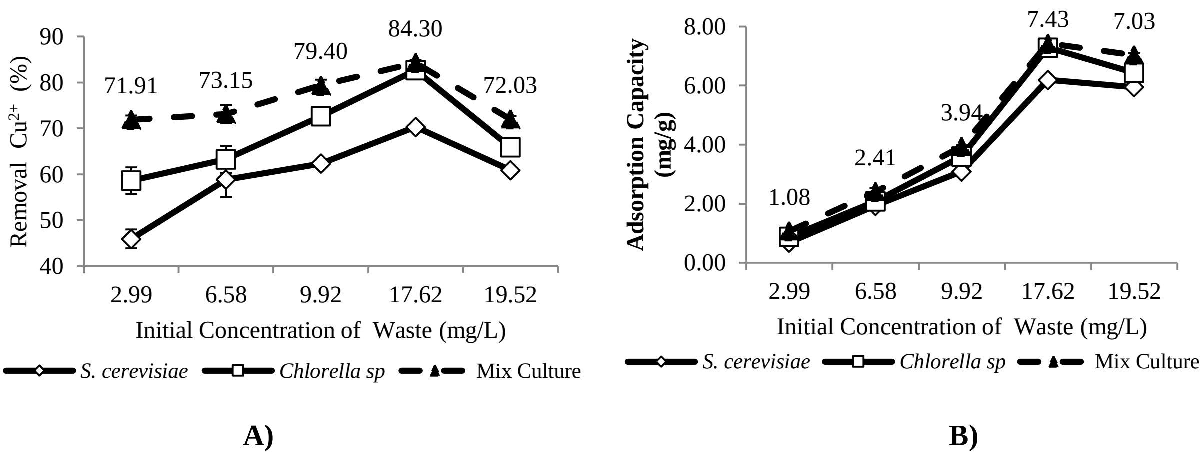

Figure 3. Effect of initial waste concentration optimization on A) the removal efficiency (%) and B) adsorption capacity (mg/g) at pH 4,120 minutes contact time, 30°C temperature, and initial biosorbent concentration of 200 mg.

Figure 3A shows that the removal efficiency of Cu^{2+} by immobilized biosorbent was increasing and the highest removal efficiency of 84.30% was obtained at a concentration of 17.62 mg/l. Figure 3A and Figure 3B show that the immobilized mixed culture biosorbent could adsorb better than the single culture due to the active site discrepancy of the biosorbents. The mixed culture has more active sites used to carry Cu^{2+} adsorption than that owned by the monoculture.

The adsorption capacity of immobilized biosorbent had the range of 0.69–7.43 mg/g on the optimization of the initial concentration of Cu^{2+} waste with variations of 2.99 mg/l, 6,58 mg/l, 9.92 mg/l, 17.62 mg/l, and 19.52 mg/l. The highest adsorption capacity of 7.43 mg/g was generated by the immobilized mixed culture biosorbent with the initial Cu^{2+} waste concentration of 17.62 mg/l.

Researchers [7] stated that the higher the concentration of metal ions, the more the amount of the substance adsorbed to the achievement of the optimum concentration. Once the optimum concentration is obtained, the biosorbent has surely been saturated. According to [8], the increase of the biosorption ability is directly proportional to the increase in concentration. It relates to the effect of stresses that occur, ergo increasing all ionic transfers and leading to a higher adsorption of metal ions.

3.4. Analysis of Fourier Transform Infra-Red (FTIR)

The analysis of Fourier Transform Infra-Red (FTIR) was conducted to determine changes in functional groups of biosorbent cells before and after being contacted with Cu^{2+} as they were estimated binding the Cu^{2+} ions. FTIR results of different wave lengths indicate a change of functional groups as listed in Table 1 which describes the wave lengths used, the functional groups, and the content changes of the functional groups of immobilized biosorbent cells.

Table 1. FTIR analysis of biosorbent before and after being in contact with Cu^{2+}.

Functional Groups	*S. cerevisiae* Before (%)	*S. cerevisiae* After (%)	*Chlorella* sp. Before(%)	*Chlorella* sp. After (%)	Mixed Culture Before(%)	Mixed Culture After (%)
C-H (alkene)	97.71	95.86	97.60	94.45	96.03	94.45
C-O (carboxylix acid)	98.19	-	98.44	-	96.89	-
C-N (amine-amide)	98.19	96.73	98.44	95.84	96.63	95.84
C-H (alkene)	97.84	95.07	98.25	95.77	98.94	98.20
C=C (alkene, aromatic ring)	97.67	94.28	98.06	95.76	96.88	93.12
C=O (aldehyde, carboxylic acid)	97.62	-	98.48	98.43	98.45	95.83
O-H (phenol)	-	98.26	-	98.91	-	98.17
C≡C (alkalo)	-	98.68	-	98.79	-	98.79

Changes in functional groups that occurred to the immobilized biosorbents of *S. cerevisiae*, *Chlorella* sp., and mixed culture showed that the functional groups were involved in the adsorption process of Cu^{2+}ions. Changes of functional groups of biosorbents were present either in the form of losses of both formerly existed and non-existed functional groups or changes in the levels of biosorbent functional groups.

Previously, alterations of the biosorbent surface observed through SEM has explained that the occurred changes were due to the involvement of functional groups attached to the cell wall of the biosorbent during the biosorption process. It was reinforced by the FTIR results afterward that indicated a change of functional groups before and after the biosorbent being in contact with Cu^{2+}. The aspect affecting the loss or reduction of functional groups contained in the biosorbent as described by [9] is the chemical adsorption by bonding with a number of functional groups (hydroxyl, carboxyl, carbonyl, and amino groups) contained on the surface of the microalgal cell, ensuing exchanges of monovalent and divalent ions such as Na, Mg, and Ca in the cell walls to be replaced by heavy metal ions.

4. Conclusion

Both of mobile and immobilized biosorbents were capable of absorbing Cu^{2+}, but the higher adsorption of 71.91% was delivered by the immobilized biosorbent. Both single culture and mixed culture biosorbents were capable of performing adsorption as well, but the higher adsorption of 71.91% was achieved by the mixed culture. Temperature and initial waste concentration affect the adsorption of Cu^{2+} ions by single culture biosorbents of *S. cerevisiae* and *Chlorella* sp., as well as the immobilized mixed culture biosorbent. The optimum Cu^{2+} adsorption efficiency of 83.4% occurred at a temperature of 30°C, an initial waste concentration of 17.62 mg/l, an initial biosorbent concentration of 200 mg, pH 4, and 120 minutes contact time by the immobilized mixed culture biosorbent. FTIR test results indicated changes of functional groups of both formerly existed chains such as carboxylic acids and formerly non-existed chains as phenols and alkynes, as well as reduced levels of functional groups after the immobilized biosorbent had been being in contact with Cu^{2+} ions.

Acknowledgment
The authors would like to thank Directorate for Research and Community Services as well as Directorate General for Strengthening Research and Development at the Ministry of Research, Technology, and Higher Education Indonesia for funding this study through Universities Prime Research Grant Program (Penelitian Unggulan Perguruan Tinggi-PUPT) 2016.

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Effect of immobilized biosorbents on the heavy metals (Cu2+) biosorption with variations of temperature and initial concentration of waste

by Perpustakaan Faltl

Effect of immobilized biosorbents on the heavy metals (Cu^{2+}) biosorption with variations of temperature and initial concentration of waste

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Abstract. The aims of research is to studying the efficiency of copper removal by combining immobilized microalgae with optimizations of temperature and initial Copper concentration. The research was conducted in batch culture with temperature variations of 25°C, 30°C, and 35°C, as well as initial Cu^{2+} concentrations (mg/l) of 3, 5, 10, 15 and 20 using monoculture of *S. cerevisiae*, *Chlorella* sp., and mixed culture of them both as immobilized biosorbents. The optimum adsorption of 83.4% obtained in temperature of 30°C with an initial waste concentration of 17.62 mg/l, initial biomass concentration of 200 mg, pH of 4, and 120 minutes detention time by the immobilized mixed culture biosorbent. The cell morphology examined using Scanning Electron Microscope (SEM) has proved that the biosorbent surface was damaged after being in contact with copper (waste), implying that heavy metals (molecules) attach to different functional cell surfaces and change the biosorbent surface. The adsorption process of this research follows Langmuir Isotherm with the R^2 value close to 1. The immobilized mixed culture biosorbent is capable of optimally removing copper at temperature of 30°C and initial Cu^{2+} concentration of 17.62 mg/l.
Keywords: biosorbent, biosorption, heavy metals, immobilized microalgae, Langmuir Isotherm

1. Introduction

The development of industrial sectors such as mining, electroplating, agriculture, fisheries, and others increases heavy metal pollution in the environment. One of the heavy metal waste that pollutes the environment is copper (Cu). Cu is a heavy metal widely utilized in the power industry, also as fungicides and anti-pollutant paint. One of the alternative methods that can be applied to overcome the pollution problem is biosorption, a term to describe the removal of heavy metals by passive binding in biomass plants or microorganisms in a solution through the metabolic or chemical-physical steps including the removal of toxins from hazardous materials. The advantages of using biosorption method are economical, easily available, as well as environmentally friendly because it utilizes biological materials. The biosorption process is influenced by the initial concentration of metal-containing waste, temperature, pH, and biomass concentration in the solution [1]. This research was carried out by optimization of variations of temperature and initial concentration of the waste.

In general, biomass can be used as biosorbent in the form of microorganisms such as bacteria, microalgae, and fungi, whether living or dead. However, microalgae's weak structure and tiny size are not suitable for continuous operation of metal elimination. Immobilization of biomass is then implemented to overcome this problem. Such immobilization is beneficial in improving the mechanical strength and resistance to chemicals, as well as facilitating the separation of biomass and generated effluent [2]. This Cu^{2+} metal biosorption study was conducted in a batch reactor using the immobilized consortium of *Chlorella* sp. and *S. Cerevisiae* with an optimization of temperature and initial concentration of waste to treat wastewater containing Cu^{2+}.

2. Research Method

The optimal biosorption was achieved through three stages of testing, i.e., the determination of mobile and immobilized biosorbents with a concentration of 200 mg and 500 m; followed by the evaluation of the effects of temperature using variations of 25°C, 30°C, and 35°C; and continued with the optimization of initial waste concentration using variations of 3 mg/l, 5 mg/l, 10 mg/l, 15 mg/l, and 20 mg/l.

2.1. Optimization Testof Temperature

The immobilized biosorbent was contacted with 100 ml of waste containing Cu^{2+} ions with a concentration of 10 mg/l at pH 4 and in 120 minutes detention time, by aeration and regulated with temperature variations 25^0C, 30^0C and 35^0C. Afterwards, the solution was measured using AAS, and the final concentration was calculated to obtain the removal efficiency.

2.2. Optimization Test of Initial Waste Concentration

The immobilized biosorbent was contacted with 100 ml of waste containing Cu^{2+} ions with various concentrations of 3 mg/l, 5 mg/l, 10 mg/l, 15 mg/l, and 20 mg/l at the optimum temperature and pH 4, with a contact time of 120 minutes and aeration treatment. Afterwards, the solution was measured using AAS, and the final concentration was calculated to attain the removal efficiency.

2.3. Analysis of Removal Efficiency and Adsorption Capacity

The removal efficiency and metal adsorption capacity of Cu^{2+}can be calculated by the following formula [3]:

$$\text{Removal Efficiency (\%)} = \frac{Co-Ce}{Co} \times 100\% \quad (1)$$

$$q\ (\text{mg/g}) = \frac{(Co-Ce)\times V}{W} \quad (2)$$

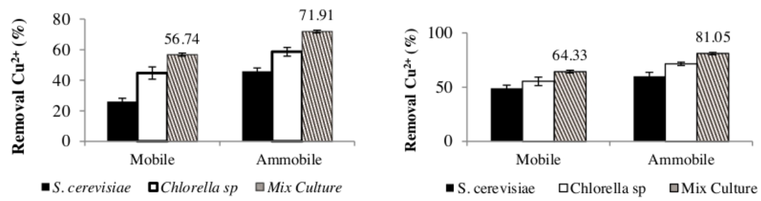
3. Results and Discussion

The optimization of Cu^{2+} metal biosorption was carried out using a single culture of *S. cerevisiae*, monoculture of *Chlorella* sp., and a mixed culture consisting of *S. cerevisiae* and *Chlorella* sp. (1:1). The characterization results of electroplating industrial wastewater samples were used to acquire the initial concentration of waste by 53.674 mg/l. It was then diluted to get the intended variations of initial waste concentration for this research.

3.1. Determination of Mobile and Immobilized Biosorbents

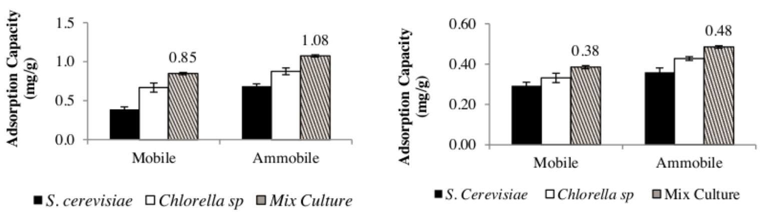
The optimization test of Cu^{2+} metal biosorption was carried out using a single culture of *S. cerevisiae*, a monoculture of *Chlorella* sp.,a and mixed culture of *S. cerevisiae* and *Chlorella* sp. (1: 1), treated with mobile and immobilizedbiosorbents. The experiment was conducted at pH 4, a contact time of 120 minutes, an initial concentration of Cu^{2+}wastewater of 2.99 mg/l,a temperature of 30^0C, as well as initial biosorbent concentrations of 200 and 500 mg.

Based on the removal efficiency of Cu^{2+} as shown in Figure 1A, the biosorption using abiosorbent concentration of 200 mg indicated that mobile and immobilized biosorbents could adsorb Cu^{2+}ions, but the higher adsorption was delivered by immobilized biosorbent. It implies that both single culture and mixed culture are capable of performing adsorption, but higher adsorption is achieved by the mixed culture. The maximum adsorption of 71.91% was attained by the immobilized mixed culture biosorbent. Compared with the removal efficiency value shown in Figure 1B, the biosorption using a biosorbent concentration of 500 mg showed its capability to absorb even higher, reaching 81.05% using the immobilized mixed culture. It reveals that the higher the initial biosorbent concentration, the greater the yielded removal efficiency. It is in line with [3] who reported that the biosorption of Uranium (VI) by immobilized biosorbent of *A. niger* with initial concentrations ranged from 0.1 to 1.2 g/l showed that the removal efficiency of Uranium (VI) increased from 55.2% to 93.4% for an increment of initial biosorbent concentration of 0.1–0.5 g/l.



A) B)

Figure 1. The relationship of Cu^{2+}removal efficiency with mobile and immobilized biosorbents at pH 4, 120 minutes contact time, initial Cu^{2+}concentration of 2.99 mg/l, as well as a biosorbent concentration of A) 200 mg and B) 500 mg



A) B)

Figure 2. The relationship of Cu^{2+}adsorption capacity with mobile and immobilized biosorbents at pH 4, 120 minutes contact time, initial Cu^{2+}concentration of 2.99 mg/l, as well as initial biosorbent concentration of A) 200 mg and B) 500 mg

Adsorption capacity values in Figure 2A and Figure 2B are opposed to removal efficiencies in Figure 1 and Figure 2; the greater the initial concentration of biosorbent used, the smaller the adsorption capacities. The initial biosorbent concentration of 200 mg with mixed culturehad a higher adsorption capacity compared with the initial concentration of 500 mg biosorbent. The maximum adsorption capacity was demonstrated by the immobilized mixed culture biosorbent with a concentration of 200 mg or equal to 1.08 mg/g.

The results obtained in this study are consistent with [4] which observed that the adsorption capacity of immobilized *Chlorella* sp. was greater than the mobile biomass of *Chlorella* sp., reaching a removal capacity of Cu^{2+}ions of up to 24.91 mg/g. The study of [5] also reported using immobilized biosorbent of *Chlorella* sp. that had an adsorption capacity of Cu^{2+}ions of 28.5 mg/g.

Based on these matters, it can be concluded that immobilized biosorbents havea better ability to adsorb Cu^{2+} than the mobile ones. The initial concentration of 200 mg biosorbent has a higher adsorption capacity than the initial concentration of 500 mg biosorbent.

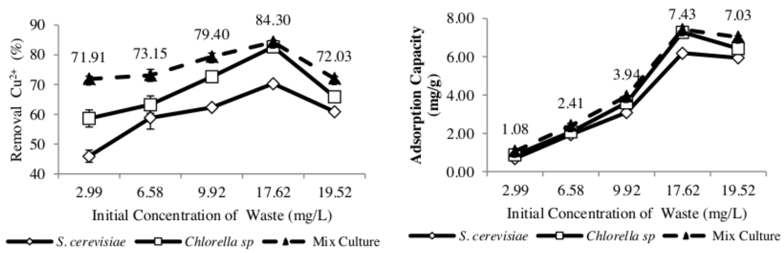
3.2. Temperature Optimization Test

At the temperature of 25°C, immobilized biosorbent could present a removal efficiency of 60.22–73.58%, while at the temperature of 30°C, it was capable of increasing the Cu^{2+}removal of up to 79.4%. At the temperature of 35°C, the adsorption efficiency gradually decreased of only up to 66.97%. It shows that the higher the temperature, the biosorbent becomes less capable of performing adsorption.

The results of this study correspond to [6] which researched the optimum adsorption temperature of heavy metals-Cr (VI), Cd, Cu^{2+}, and Ni-using immobilized mixed culture biosorbent and temperature variations ranging from 10–50°C. It observed that the efficiency of metal uptake continued to increase at a temperature of 10–30°C, then the reduction of adsorption efficiency occurred along with the temperature increase. The optimum adsorption efficiency of the contained metal of 90% was achieved at the temperature of 30°C. According to [6], a decrease in the adsorption efficiency at 40–50°C was led by the increased absorption of heavy metals from the solid to liquid phase, the surface deactivation of biosorbent, as well as the damage to the active site on the surface of biosorbent due to the disruption or the weakening bonds of active site in binding heavy metals.

3.3. Optimization of Initial Concentration of Waste Containing Cu^{2+} Ions

The optimization test of initial concentration of waste containing Cu^{2+} by immobilized biosorbent was performed at pH 4 with concentration variations of 2 mg/l, 5 mg/l, 10 mg/l, 15 mg/l and 20 mg/l; using the optimum temperature obtained at the previous test of 30°C, 120 minutes contact time, and an initial biosorbent concentration of 200 mg.



A) **B)**

Figure 3. Effect of initial waste concentration optimization on A) the removal efficiency (%) and B) adsorption capacity (mg/g) at pH 4,120 minutes contact time, 30°C temperature, and initial biosorbent concentration of 200 mg.

Figure 3A shows that the removal efficiency of Cu^{2+} by immobilized biosorbent was increasing and the highest removal efficiency of 84.30% was obtained at a concentration of 17.62 mg/l. Figure 3A and Figure 3B show that the immobilized mixed culture biosorbent could adsorb better than the single culture due to the active site discrepancy of the biosorbents. The mixed culture has more active sites used to carry Cu^{2+} adsorption than that owned by the monoculture.

The adsorption capacity of immobilized biosorbent had the range of 0.69–7.43 mg/g on the optimization of the initial concentration of Cu^{2+} waste with variations of 2.99 mg/l, 6,58 mg/l, 9.92 mg/l, 17.62 mg/l, and 19.52 mg/l. The highest adsorption capacity of 7.43 mg/g was generated by the immobilized mixed culture biosorbent with the initial Cu^{2+} waste concentration of 17.62 mg/l.

Researchers [7] stated that the higher the concentration of metal ions, the more the amount of the substance adsorbed to the achievement of the optimum concentration. Once the optimum concentration is obtained, the biosorbent has surely been saturated. According to [8], the increase of the biosorption ability is directly proportional to the increase in concentration. It relates to the effect of stresses that occur, ergo increasing all ionic transfers and leading to a higher adsorption of metal ions.

3.4. Analysis of Fourier Transform Infra-Red (FTIR)

The analysis of Fourier Transform Infra-Red (FTIR) was conducted to determine changes in functional groups of biosorbent cells before and after being contacted with Cu^{2+} as they were estimated binding the Cu^{2+} ions. FTIR results of different wave lengths indicate a change of functional groups as listed in Table 1 which describes the wave lengths used, the functional groups, and the content changes of the functional groups of immobilized biosorbent cells.

Table 1. FTIR analysis of biosorbent before and after being in contact with Cu^{2+}.

Functional Groups	*S. cerevisiae* Before (%)	*S. cerevisiae* After (%)	*Chlorella* sp. Before(%)	*Chlorella* sp. After (%)	Mixed Culture Before(%)	Mixed Culture After (%)
C-H (alkene)	97.71	95.86	97.60	94.45	96.03	94.45
C-O (carboxylix acid)	98.19	-	98.44	-	96.89	-
C-N (amine-amide)	98.19	96.73	98.44	95.84	96.63	95.84
C-H (alkene)	97.84	95.07	98.25	95.77	98.94	98.20
C=C (alkene, aromatic ring)	97.67	94.28	98.06	95.76	96.88	93.12
C=O (aldehyde, carboxylic acid)	97.62	-	98.48	98.43	98.45	95.83
O-H (phenol)	-	98.26	-	98.91	-	98.17
C≡C (alkalo)	-	98.68	-	98.79	-	98.79

Changes in functional groups that occurred to the immobilized biosorbents of *S. cerevisiae*, *Chlorella* sp., and mixed culture showed that the functional groups were involved in the adsorption process of Cu^{2+}ions. Changes of functional groups of biosorbents were present either in the form of losses of both formerly existed and non-existed functional groups or changes in the levels of biosorbent functional groups.

Previously, alterations of the biosorbent surface observed through SEM has explained that the occurred changes were due to the involvement of functional groups attached to the cell wall of the biosorbent during the biosorption process. It was reinforced by the FTIR results afterward that indicated a change of functional groups before and after the biosorbent being in contact with Cu^{2+}. The aspect affecting the loss or reduction of functional groups contained in the biosorbent as described by [9] is the chemical adsorption by bonding with a number of functional groups (hydroxyl, carboxyl, carbonyl, and amino groups) contained on the surface of the microalgal cell, ensuing exchanges of monovalent and divalent ions such as Na, Mg, and Ca in the cell walls to be replaced by heavy metal ions.

4. Conclusion

Both of mobile and immobilized biosorbents were capable of absorbing Cu^{2+}, but the higher adsorption of 71.91% was delivered by the immobilized biosorbent. Both single culture and mixed culture biosorbents were capable of performing adsorption as well, but the higher adsorption of 71.91% was achieved by the mixed culture. Temperature and initial waste concentration affect the adsorption of Cu^{2+} ions by single culture biosorbents of *S. cerevisiae* and *Chlorella* sp., as well as the immobilized mixed culture biosorbent. The optimum Cu^{2+} adsorption efficiency of 83.4% occurred at a temperature of 30°C, an initial waste concentration of 17.62 mg/l, an initial biosorbent concentration of 200 mg, pH 4, and 120 minutes contact time by the immobilized mixed culture biosorbent. FTIR test results indicated changes of functional groups of both formerly existed chains such as carboxylic acids and formerly non-existed chains as phenols and alkynes, as well as reduced levels of functional groups after the immobilized biosorbent had been being in contact with Cu^{2+} ions.

Acknowledgment
The authors would like to thank Directorate for Research and Community Services as well as Directorate General for Strengthening Research and Development at the Ministry of Research, Technology, and Higher Education Indonesia for funding this study through Universities Prime Research Grant Program (Penelitian Unggulan Perguruan Tinggi-PUPT) 2016.

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