ISSN : 2460-0849

UNIVERSITY OF BRAWIJAYA · UNIVERSITI MALAYA · USM UNIVERSITI SAINS MALAYSIA · UTHM

icwrdep

MALANG - INDONESIA

icwrdep 2015

THE 1ST YOUNG SCIENTIST INTERNATIONAL CONFERENCE OF WATER RESOURCES DEVELOPMENT AND ENVIRONMENTAL PROTECTION

5 - 7 June 2015

PROCEEDING

Environmental Engineering & Water Technology
Integrated Water Systems & Governance
Water Science & Engineering

WATER RESOURCES ENGINEERING DEPARTMENT
FACULTY OF ENGINEERING

Secretariat:
Water Resources Engineering Department
Faculty of Engineering, University of Brawijaya
Jalan MT. Haryono no. 167
Malang 65145 - East Java - Indonesia
Phone/ Fax. (0341) 562454
email: tsa_ub@ub.ac.id; wateresdev@ub.ac.id

Conference Website:
www.wateresdev.ub.ac.id

9 772460 084005

Environmental Engineering & Water Technology

Circulation Effect of Coffee Wastewater Flow in Water Hyacinth Phytoremediation

Elida NOVITA, Sri WAHYUNINGSIH, Siswoyo SOEKARNO, Betty Siska RUKMAWATI[1]*

[1]*Department of Agricultural Engineering, University of Jember, Kalimantan Street 37Tegalboto, Jember, Indonesia*
**Corresponding author's e-mail: siskabetty@gmail.com*

ABSTRACT
Coffee processing wastewater containing high organic matter. If the coffee waste water discharged into waterways, it would contaminate and be harmful to people who consume it. Therefore, wastewater from the coffee industry must be treated before being discharged into the environment. Process employed was studied for treating coffee industry effluents using macrophyte water hyacinth (*Eishornia crassipes (Mart*.) *Solms*) in phytoremediation tank with circulation holes. Beside, it was analyzed the effect of the circulation in the aquarium wastewater treatment phytoremediation coffee at the decreasing of COD and BOD contant, turbidity, NH_3 and pH of the liquid waste. The wastewater flow were using two categories consisting four types of discharge with a different value of HRT (*Hydraulic Residence Time*). Based on this research, it was known that the roots of water hyacinth on the phytoremediation process affected the value of HRT despite the debit category and the density of water hyacinth, were similiar the other hand, it is known that the greater value of HRT, the higher the value of the reduction of coffee waste water parameters. The biggest reduction in the value of the parameter was at HRT 8 h 31 '50" where the removal efficiency of COD, BOD, turbidity, and NH3-N respectively were 97,5%, 97,6%, 75,4% and 82,1%.

KEYWORDS
Circulation; coffee liquid waste; phytoremediation; water hyacinth

INTRODUCTION

Coffee processing method that can provide a good quality result are wet processing. A large number of coffee production by wet processing methods will require washing water in large amounts. Wash water in wet processing causes wastewater contaminate the environment if it is discharged into waterbody. The high content of organic material in coffee wastewater cause pollution. Therefore the coffee wastewater needs to be processed in order to safely disposed of and in accordance with the effluent standards set.

One alternative wastewater treatment is phytoremediation. Phytoremediation is the conversion of harmful substances into harmless contaminants carried by plants (Mangkoedihardjo, 2005). Hyperaccumulator plants often used for phytoremediation water hyacinth *(Eichornia crassipes (Mart) Solms)*. According to research conducted by Rahma (2014), water hyacinth is able to reduce the COD, turbidity, and TSS in coffee wastewater. Phytoremediation is mostly done by using the batch method, when Jenie and Rahayu (1993) stated that the flow rate and diversity is an important factor to design a process. In most wastewater treatment systems, the treatment unit should be designed based on peak flow rate. It requires flow rate study to minimize the diversity of the flow rate when the process work. Although phytoremediation using water hyacinth plants in ponds with a batch method done a lot, but there is no attempt to modify and carry out studies on the flow rate of the water hyacinth pond in order

ISSN : 2460-0849

to improve the performance of hyacinth to reduce the content of the coffee wastewater. One step to study the flow rate is to provide circulation.

This research aims to design an aquarium phytoremediation wastewater of processing coffee with circulation method and to determine the time required for the wastewater flows through the circulation holes at the aquarium with varies discharge. Beside, the research were done to analyzed the effect of circulation in the aquarium coffee wastewater treatment by phytoremediation based on removal efficiency of COD, BOD, turbidity, NH3, and the pH parameters.

MATERIALS AND METHODS

Plant material and growth condition

Water hyacinth plant was taken from a swamp Village Gumukmas District of Gumukmas, Jember. It was cleaned first of mud and particles adhering to the plant. Hyacinth was planted with a density of 200 grams per 10 liters of waste (Rahma, 2014).

The design of the aquarium phytoremediation with circulation

Fitorediasi aquarium with circulation made using materials of clear glass with dimensions of (160 x 30 x 30)cm^3. Made an 30 cm high because, according to Orth (1989) phytoremediation depth is limited by the length of the roots of water hyacinth. Water hyacinth long roots in the waste water pond rarely reaches more than 20 cm. Because as much as possible waste water should flow from the root space, then only a little extra depth required for sedimentation and sludge buildup. So it was decided the dimensions of height / depth of the pool is 30 cm.

Cylinder reservoir made of plastic materials for rust resistant, resistant to changes in temperature and less expensive than aluminum. To remove the wastewater PVC pipes was placed and connected to taps. Circulation holes were made from glass bulkhead by a semi-circular hole with a diameter of 5 cm at the bottom or top of alternately so that water flow occurs. The circuit components phytoremediation aquarium completed its parts and with circulation can be seen in Fig. 1:

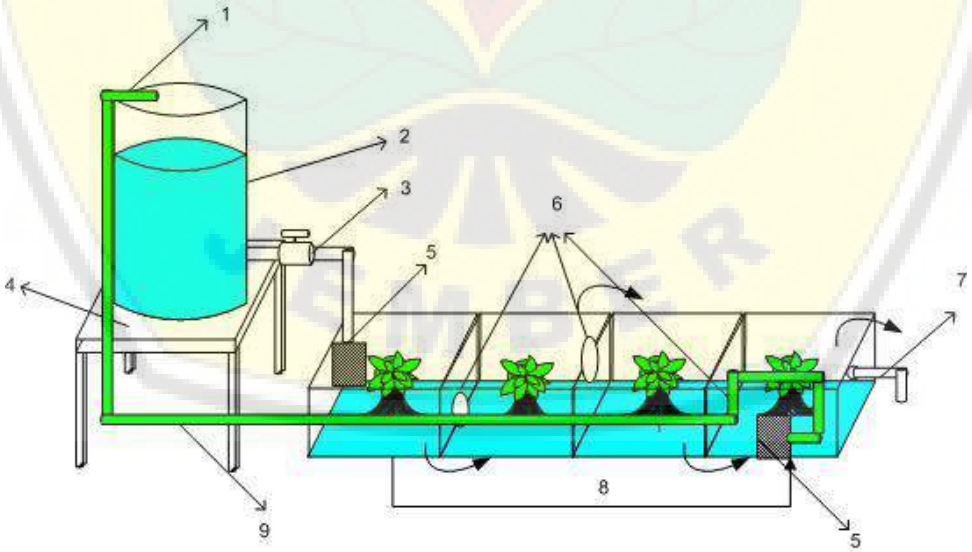


Figure 1. Phytoremediation aquarium draft of wastewater processing coffee with circulation

Notes :
1 : tap waste output
2 : liquid waste storage casks coffee before processing
3 : stop valves/discharge regulator
4 : cylinder reservoir support table
5 : aquarium pump

ISSN : 2460-0849

6 : circulation holes
7 : tap depletion
8 : glass aquarium
9 : The end of the sewage tank
Work mechanism of phytoremediation aquarium :
Circulation of the wastewater stream flows through the tank then flows into several boxes containing water hyacinth, then in the box 4th (last), coffee wastewater flowing back into the tank until there was circulation. Analysis of COD, BOD, turbidity, NH_3, and pH at the beginning and end of treatment were done to determine the value of the reduction that occurred during the waste treatment processs.

RESULT AND DISCUSSION

Results Phytoremediation Aquarium Design Liquid Waste Processing Method Coffee with circulation

The design of the tool was conducted to determine or make it easier to measure the efficiency of circulation in the phytoremediation aquarium. Stages working mechanism on phytoremediation aquarium processing wastewater coffee with the circulation was 1. sedimentation: sedimentation process begins when the waste put into the tub. The gravity causes the separation of a substance that sinking and floating substances. Further precipitation occurs when sewage began flowed into the aquarium using the output discharge tap of wastewater with a few variations. At this aquarium, when the water flows into the aquarium through the expenditure tap directly into the first box on the aquarium, substances that can was sendimented the bottom of the aquarium. 2. Activities microorganisms: Microorganisms that play an important role in the wastewater degradation process were Nitrosomonas and Nitrobacter. Both of these bacteria were at the roots of water hyacinth. According Mangkoedihardjo et al. (2010), there were two processes in phytoremediation, which have most important role in absorbing organic materials and contaminants in the wastewater. Those where *rhizofiltration* and *rizhodegradation* which occur in the roots of water hyacinth. At this aquarium liquid waste coffee making contact with the roots of water hyacinth during the waste treatment process so that the absorption of contaminants can occur during the processing of waste in the aquarium. 3. Circulation in the aquarium: Circulation in the glass aquarium partitions and it was given a semi-circular hole. At the aquarium, circulation hole serves to drain water from one box to another. Giving bulkhead with circulation holes aims to prevent thermal and chemical stratification.

Circulation Flow Liquid Waste Coffee

Coffee wastewater streams starting from the tank, then flows with gravity and suction assistance of an aquarium pump. Phytoremediation aquarium with this circulation was an open channel. Movement on the open channel water by gravitation effect of the earth and the water pressure distribution was hydrostatic. Drainage of wastewater using four kinds of treatment discharge (QA, QB, QC, and QD) with two categories of discharge. Debit entry affected the value at Hydrolic Residence Time (HRT) in the aquarium circulation and in the parameters of the coffee wastewater. Table 1 shows of the calculation results of HRT on phytoremediation aquarium with circulation.

Table 1. Phytoremediation with HRT at the Aquarium Circulation

Category debit	Debit	Value Debit Entry (ml/s)	HRT
I	Q_A	10.09	7 hours 4 minutes 21 seconds
	Q_B	10.61	8 hours31 minutes 50 seconds
II	Q_C	18.93	2 hours 31 minutes 38 seconds
	Q_D	19.22	1 hours 53 minutes

Based on the table, it was known that HRT value were different at every discharge treatment, altough it had the same discharge. HRT difference was caused by several things, there were the roots of water hyacinth. Water hyacinth has a hairy roots with bushy hair so that even water discharge entering from the same tap, the distribution of velocities would be different. Therefore, the time required to fill the

ISSN : 2460-0849

aquarium was different, as well. According Kodoati (2009), differences in the distribution of the velocities were due to the friction on the walls of the channel, the cross section channel, and channel location. In this case, the friction coffee wastewater that flowed in the phytoremediation aquarium affected the flow distribution. In addition, to the roots of heavy water hyacinth in the aquarium (location line) also affects the difference in the distribution velocities. The effect HRT to the decrease of pollutant parameters on the coffee wastewater can be seen in Fig.2:

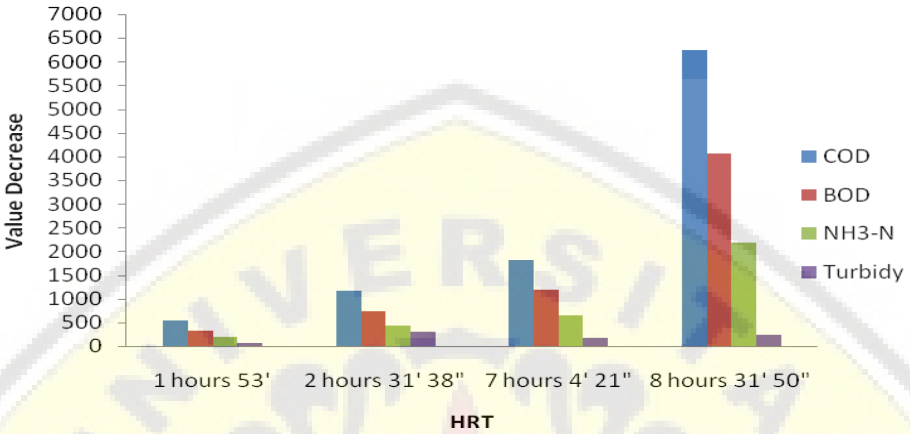


Figure 2. The correlation graph HRT with the value of the parameter reduction of coffee wastewater pollution

Based on the graph, (Fig.2) it can be seen that the greater the value of HRT then the pollutant reduction value parameters also higher. This was because the contaminants of coffee wastewater would be more and more absorbed by the roots when the coffee wastewater discharged with a small discharge, and longer contact time between the wastewater with water hyacinth roots. Besides, the circulation in the aquarium that serves to prevent thermal and chemical stratification allegedly also affected the reduction value of decrease COD, BOD, NH_3-N, and turbidy the coffee wastewater at the end of the treatment.

Measurement parameters COD and BOD

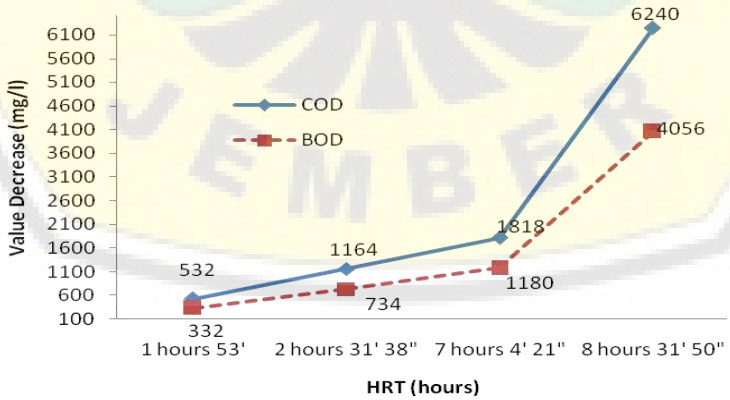


Figure 3. Influence Graph HRT Decline Against COD and BOD

Based on the graph, of fig. 3 it was known that the longer HRT the higher the reduction of value COD and BOD content of the coffee processing wastewater. The bigest reduction in the value of HRT was 8 hours 31 minutes 50 seconds with the amount reduced of COD and BOD were respectively 6,250 mg/L and 4,056 mg/L and the highest efficiency was 97.50% and 97.55%, respectively the process of reduction in the levels of contaminants in wastewater using aquatic plants was a collaboration between plants and microbes associated with these plants. Circulation flow in the aquarium would help flatten

ISSN : 2460-0849

the distribution of oxygen vertically. This even distribution of oxygen would helps the microbes to reduce the content of COD and BOD in waste because oxygen is one of the living viz microbe.

There are several things that affect the efficiency of COD and BOD impairment, i.e. The is smoothness of circulation, which was influenced by the performance of circulating pumps. So in order the circulation running smoothly, the circulation pump must be controlled so as not experiencing blockage. One function of providing circulation to the wastewater treatment was to prevent thermal stratification. According to Fatima (2010), a thermal stratification was event of temperature difference between the two layers so that water was not mixed and had different chemical and biological properties. With the cessation of the circulation at the time of the coffee wastewater treatment would cause the effectiveness of COD and BOD were not maximum because of an increase in temperature in the wastewater that did not circulate and thermal stratification could not be avoidid.

Measurement parameters of NH3-N

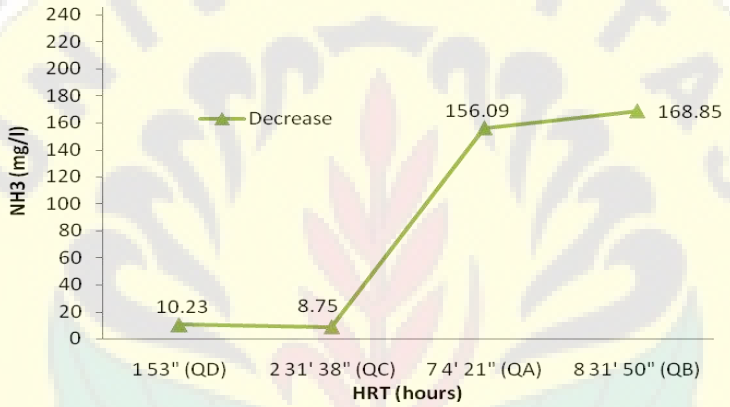
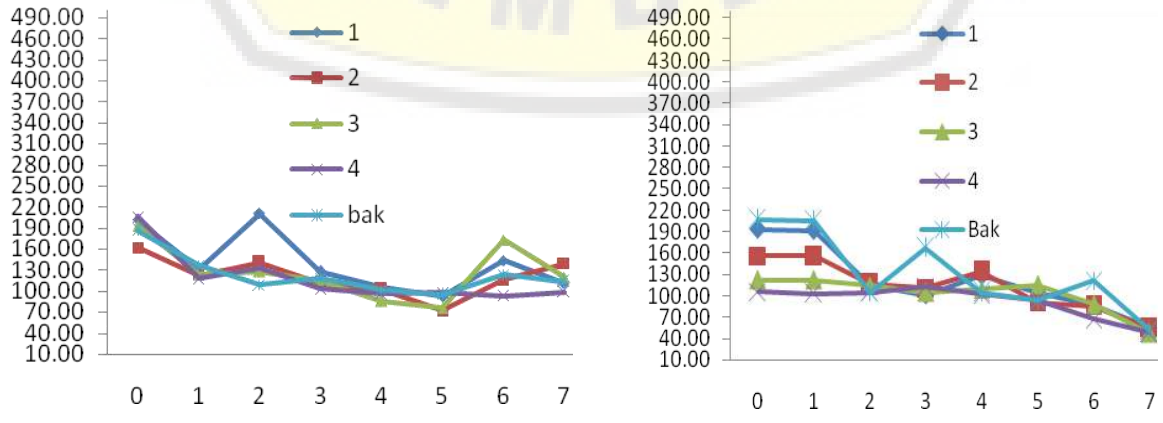


Figure 4. Effect Graph HRT Decline Against NH3-N

The bigest reduction in the value of the NH3-N (ammonia) content was the residence time of 8 hours 31 minutes 50 seconds with a value reduction of 168.85 mg/L and the highest efficiency was 86.8%. Value reduction of NH3-N (ammonia) was the highest in the longest HRT because NH3-N (ammonia) is absorbed more on the roots of water hyacinth. Giving the circulation would the nitrification process. Nitrification process was important because ammonia compounds can be used by phytoplankton and aquatic plants after converted to nitrite and nitrate by bacteria in the nitrification process.

Measurement of turbidity



(a) (b)

ISSN : 2460-0849

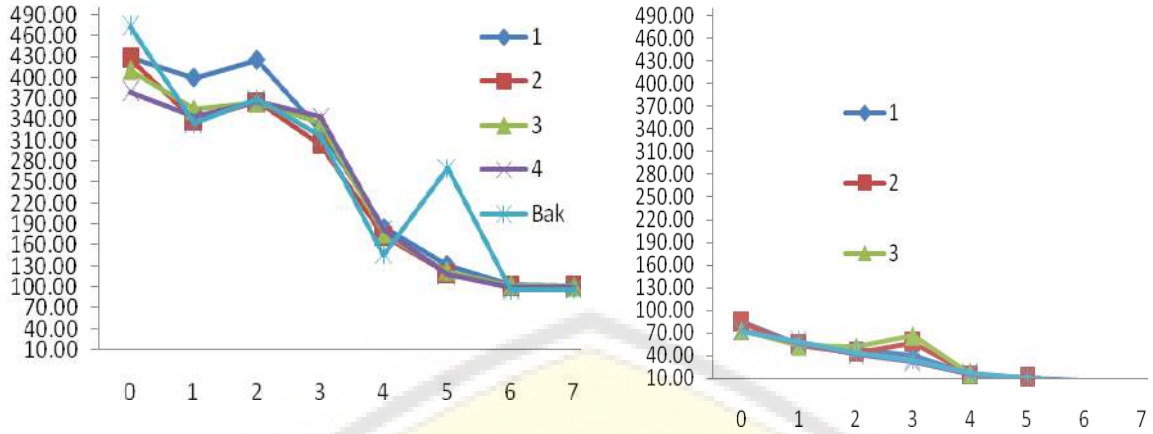


Figure 5. Decreasing Turbidity

Circulation flow was able to decrease the turbidity values before and after treatment. At almost all of discharge treatments (QA, QB, QC, and QD), it could increase and decrease turbidity every day. It was due to the flow turbulence in the circulation holes that cause turbidity changes every day. Decreasing in turbidity caused by the roots adsobsi of water hyacinth on rhizofiltration process as claimed by Mangkoedihardjo et al. (2010) that rhizofiltrasi an adsorption process or precipitation contaminants on the roots or absorption into the roots. Adsorption or absorption process was ionic bonds, where this process occurs because of differences in ionic charge and ionic contaminants roots in the waste.

PH measurement

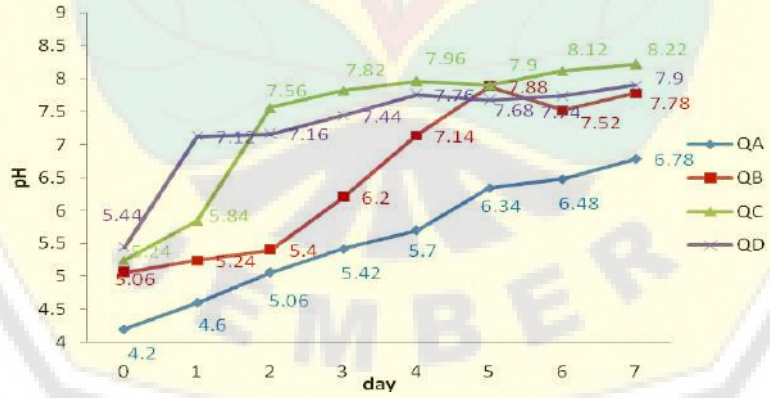


Figure 6. Incresing pH

Based on the chart of Fig.6, it was known that the pH of the wastewater coffee processing of coffee at the end of treatment were 6,8; 7,8; 7,9; and 8,2 it increase before treatment and the initial pH changes from acidic to neutral. It was happened due to the circulation flow in the coffee wastewater phytoremediation aquarium. In addition, the increase or decrease in the pH could be affected by several things: the plankton respiration/photosynthesis of plants and plankton/plant.

CONCLUSIONS

Study of the flow rate on the phytoremediation process design could be carried out by the method of different discharge circulation. The process occured in the aquarium were: sedimentation, Nitrosomonas microorganisms activity and Nitrosobacter in the aquarium, and the circulation in the aquarium.

ISSN : 2460-0849

Value of Hydrolic Residence Time (HRT) on phytoremediation aquarium with circulation was 1 hour 53 minutes; 2 hours 31 minutes 38 seconds; 7 hours 4 minutes 21 seconds; and 8 hours 31 minutes 51 seconds. Besides discharge HRT value was also influenced by the roots of water hyacinth. Value of Hydrolic Residence Time (HRT) influenced the reduction in the value of the parameters COD, BOD, NH_3-N, turbidity, and pH of the coffe wastewater. Providing circulation in the phytoremediation aquarium coffee wastewater treatment was able to reduce the content of COD to be 69,4% -97.5%; BOD of 69.4% -97.5%; NH_3-N 15.8% - 86.8%; turbidity 59.5% - 96.2% and the pH of acidic to be neutral.

REFERENCES

Fatima, S. (2010). Sifat Fisika, Kimia, Air Siklus Hidrologi dan Sumber Air. http://file.upi.edu/Direktori/FPMIPA/JUR._PEND._KIMIA/196802161994022-Soja_Siti_Fatimah/ Kuliah_Kimia_ terapan_pada_ jurusan_agro_ industri/ kIMIA_AIR-1/ Sifat_Fisika,_ Kimia_Air,_Siklus_Hidrologi ,_Dan_Sumber_Air_Di.pdf . visited 27 April 2015

Kodoatie, R. (2009). Hidrolika Terapan Aliran Pada Saluran Terbuka dan Pipa. Yogyakarta, Andi Publiser.

Mangkoedihardjo, S. (2005). Fitoteknologi dan Ekotoksikologi dalam Desain Operasi Pengomposan Sampah, Seminar Nasional Teknologi Lingkungan III ITS, http://www.its.ac.id/sarwoko-enviro-seminar %20 sampah%20TL.pdf, visited 30 Januari 2015

Mangkoedihardjo, S., Sarwoko, dan Samudro.(2010). Fitoteknologi Terapan. Yogyakarta, Graha Ilmu.

Mason, C.F. (1994). *Biology of Fresh Water Pollution*. New York: Longman Scientific and Technical

Navarro, A.R., Rubio, M.C., dan Maldonado M.C. (2011). A Combined Process to Treat Lemon Industry Wastewater and Produce Biogas. Clean Teachnology Environ Policy. Tucuman, Argentina.

Orth, H. (1989). *Hyancinthus-Air* (Eceng Gondok) Untuk Membesihkan Air Limbah Industri-Memanfaatkan Air Limbah. Jakarta, Yayasan Obor Indonesia.

Rahma, H. (2014). Fitoremedisi Limbah Cair Mocaf Dengan Menggunakan Enceng Gondok *(Echornia crassipes (Mart.) solms)*. Jember, Departement of Agricultural Engineering Universitas Jember.

ISSN : 2460-0849