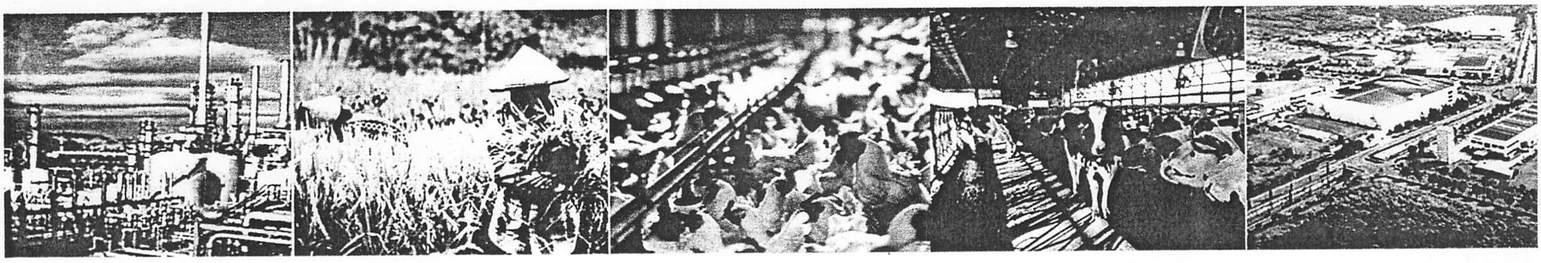
PROCEEDINGS

Prof. Dr-Ing. Ir. Suprihatin

2015 3rd International Conference on Adaptive and Intelligent Agroindustry (ICAIA)

ICAIA 2015



August 3rd - 4th, 2015
IPB International Convention Center
Bogor, Indonesia

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Bogor Agricultural University

Bogor, Indonesia

Welcome Message from The General Chairs of ICAIA 2015

On behalf of the organizing committee, it is our pleasure to welcome you to International Conference on Adaptive and Intelligent Agroindustry, Bogor, Indonesia. This is the 3rd conference on the topic that is held by the Department of Agroindustrial Technology, Bogor Agricultural University, Indonesia.

The conference is expected to provide excellent opportunity to meet experts, to exchange information, and to strengthen the collaboration among researchers, engineers, and scholars from academia, government, and industry. In addition, the conference committee invited five renowned keynote speakers, i.e. Prof Irawadi from Bogor Agricultural University; Prof Kenneth De Jong from George Mason University, USA; Dr Yandra Arkeman from Bogor Agricultural University; and Dr Guillermo Baigorria from University of Nebraska-Lincoln, USA.

The conference committee also invited Prof Noel Lindsay from University of Adelaide, Australia; Kiyotada Hayashi from National Agricultural Research Center-Tsukuba, Japan; Prof Margareth Gfrerer from Islamic State University of Jakarta, Indonesia; Dr Barry Elsey from University of Adelaide, Australia; Dr Gajendran Kandasamy from Melbourne University, Autralia; and Imperial College London-British, Prof Allan O'Connor from University of Adelaide, Australia; Dr Wisnu Ananta Kusuma from Bogor Agricultural University ,Indonesia; and Dr Frank Neumann from University of Adelaide, Australia, as invited speakers.

This conference was organized by Department of Agroindustrial Technology, Bogor Agricultural University and Asosiasi Agroindustri Indonesia, and technically sponsored by IEEE Indonesia Section. Furthermore, it was supported by Departement of Computer Science, Bogor Agricultural University; Surfactant amd Bionegergy Research Center; PT Bogor Life Science and Technology; Indonesian Ministry of Industry; PT Pachira Distrinusa; and PT Kelola Mina Laut.

I would like to take this opportunity to express my deep appreciation to the conference's committee members for their hard work and contribution throughout this conference. I would like to thank authors, reviewers, speakers, and session chairs for their support to participate in the Conference. Lastly, I would like to welcome you to join ICAIA 2015 and wish you all an enjoyable stay in Bogor.

Sincerely,
Dr Yandra Arkeman
General Chairs, ICAIA 2015

WELCOMING ADDRESS

Prof. Dr. Ir. Nastiti Siswi Indrasti
Head of Agroindustrial Technology Department
Faculty of Agricultural Engineering and Technology
Bogor Agricultural University

on

3rd International Conference on Adaptive and Intelligence Agroindustry (3rd ICAIA)

Bogor, August, 3 – 4, 2015

Assalamu'alaikum Warohmatullahi Wabarokatuh
In the name of Allah, the beneficent and the merciful,

Distinguish Guest, Ladies and Gentlemen
Let me first thank you all for accepting the invitation to participate in this 3rd International Conference on Adaptive and Intelligence Agroindustry (ICAIA). In particular I would like to thank Rector of IPB (Institut Pertanian Bogor/Bogor Agricultural University) Prof. Herry Suhardiyanto for supporting this event as part of the series academic event in celebrating the 52nd Anniversary of Bogor Agricultural University.

We are certainly proud to have been able to assemble this event in IPB, Bogor. The range of participants and audience at this conference is precisely something I would like to stress. Participants who followed the event more than 150 people, coming from various countries including the USA, Australia, Japan, Vietnam, Philippine, Germany and Indonesia. The main goal of the conference is to provide an effective forum for distinguished speakers, academicians, professional and practitioners coming from universities, research institutions, government agencies and industries to share or exchange their ideas, experience and recent progress in Adaptive and Intelligent Agroindustry.

The 2015 3rd International Conference on Adaptive and Intelligent Agro-industry (ICAIA) is the third forum for the presentation of new advances and research results on various topics in all aspects of innovative agro-industry that highlights the development and improvement for today and tomorrow's global need for food, energy, water and medicine. The aim of the conference is to stimulate interaction and cohesiveness among researchers in the vast areas of innovative agro-industry. Innovative Agro-industry has the ability to adapt intelligently to future global challenges, i.e. food, energy, water, and medical. Global challenges needs a new breed of Agroindustry which could produce innovative products to fulfill the needs through advanced processing technology, production systems and business strategy supported by cutting-edge information and communication technology.

The topic for this event is "Empowering Innovative Agroindustry for Natural Resources, Bioenergy and Food Sovereignty". The topics clustered into four main parts:
Track 1 : Innovative Agroindustrial and Business System Engineering

Track 2 : Frontier Approaches in Process and Bioprocess Engineering
Track 3 : Frontier Approaches in Industrial Environmental Engineering
Track 4 : Intelligent Information and Communication Technology for Adaptive Agroindustry of the Future

This event also hosts four (4) workshops: (1) Strategies for Agroindustry Development (2) LCA for Agroindustry (3) Innovation and Technopreneurship for Agroindustry and (4) Agroindustry Informatics.

Distinguish Guest, Ladies and Gentlement,
Agroindustry transforms agricultural commodities into high value-added products. Agroindustry is industry that process agricultural products to increase their value added significantly by using technology and by considering environmental aspect and sustainability. However, with changing global demand and technology advancement, innovative agroindustry is needed in order to be competitive as well as sustainable. The challenge of future agroindustry is not merely efficiency and productivity anymore, but also the challenge to appropriately apply frontier technology as well as meeting future global demands.

Agroindustry needs to deal with the application of advance technologies and cope future global issues. Current global issues which arise and expected to exist in the future are food sovereignty, renewable energy, sustainable water management and pharmacy. The ability of agro-industry to respond the future global issues and the undoubtedly substantial increase in demand in future decades will be highly dependent on the increased application of existing technologies as well as the exploitation of new and innovative technologies.

The emergence of high technology could be applied in the agro-industry are: nanotechnology, biotechnology, bioinformatics, food processing, food packaging-waste, state-of-the-art computation and many others. The aforementioned high-technology along with computation technology could greatly advance agro-industry from a traditional system into a smart-intelligent and innovative technology. Therefore, in the new millennia, adaptive-intelligent and innovative agro-industry will contribute to solutions to global problems and brings agriculture into perfection.

Hope this conference will also discuss this issue in more detail as it is an important matter for all of us. We should no more think just how to produce high value product but it is also necessarily important how to keep our live in good quality by understanding following old saying… "You do not live at once. You only die once and live every day".

I do not to take up any more of your time with these opening remarks. Let me simply thank you once again for sharing your thoughts with us. Here's wishing every success for the conference. May Allah bless all of us.

Thank you for your kind attention,
Wassalamu'alaikum Warohmatullahi Wabarokatuh

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AGENDA

Time	Activities
Monday, August 3rd 2015	
08.00 - 09.00	Registration
09.00 - 10.00	Opening Ceremony • Welcoming Address: Prof. Nastiti Siswi Indrasti (Head of DAT, Fateta, IPB) • Welcoming Speech Head of Bogor Regency • Conference Opening: Prof. Herry Suhardiyanto (Rector of IPB) • Opening Speech and Conference Opening : Minister of Industry Indonesia * • Launching Expose International program DAT
10.00 – 10.05	*Photo Session*
10.05 - 10.15	*Coffee break*
	Keynote Speech :
10.15 - 10.45	1. Prof Irawadi (Bogor Agricultural University, Indonesia)
10.45 - 11.30	2. Prof. Kenneth De Jong (George Mason University, USA)
11.30 – 12.00	3. Dr. Yandra Arkeman (Bogor Agricultural University, Indonesia)
12.00 – 12.30	4. Dr. Guillermo Baigorria (University of Nebraska, Lincoln, USA)
12.30 – 13.30	Lunch break
	Plenary Session 1 :
13.30 – 13.50	Prof. Noel Lindsay (University of Adelaide, Australia)
13.50 – 14.10	Dr. Kiyotada Hayashi (National Agricultural Research Center, Tsukuba, Japan)
14.10 – 14.30	Prof. Margareth Gfrerer (Islamic State University of Jakarta, Indonesia)
14.30 – 14.50	Dr. Barry Elsey (University of Adelaide, Australia)
14.50 – 15.10	Ir. M. Novi Saputra (Marketing Director KML Food Group)
15.10 – 15.45	*Discussion*
15.30 – 15.45	*Coffee break*
15.45 – 18.00	Parallel session A, B and C
18.00 – 21.00	Welcome Dinner

Time	Activities
Tuesday, August 4th 2015	
08.30 – 09.00	Registration
	Plenary Session 2 :
09.00 – 09.20	Dr. Gajendran Kandasamy (PhD in Physic, Melbourne University ; PhD in Innovation Imperial Collage, London)
09.20 – 09.40	Prof. Allan O'Connor (University of Adelaide, Australia)
09.40 – 10.00	Dr. Eng. Wisnu Ananta Kusuma, ST, MT (Bogor Agricultural University, Indonesia)
10.00 – 10.20	Dr. Frank Neumann (University of Adelaide, Australia)
10.20 – 10.45	*Discussion*
10.45 – 13.00	Parallel Session A, B and C
13.00 – 14.00	Lunch break
14.00 – 15.30	Parallel Workshop • Strategies for Agroindustry Development • LCA for Agroindustry • Innovation and Technopreneurship for Agroindustry • Agroindustrial Informatics
15.30 – 15.45	Coffee Break
15.45 – 16.15	Closing remark

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New Trends in Industrial Environmental Engineering & Management

Intelligent Information & Communication Technology for Adaptive Agroindustry of the Future

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Quality Improvement of Polluted River Water Used as Raw Water in Clean Water Supply by Using Biofiltration

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Abstract — The river water pollution prevails in many parts of Indonesian region, due to the industrial, commercial, residential and farming activities. In many areas the quality standard of raw water has even been violated. This leads to the increased water treatment costs as well as public health risks. The use of biofiltration system can be an effective means to overcome these problems. The technology is able to eliminate various types of raw water contaminants and therefore reduces overall treatment costs. This paper demonstrates the technical and financial benefits of applying this technology as a pre-treatment step prior to conventional coagulation and flocculation processes. The experiments showed that bioreactor filled with "honeycomb" type matrix can reduce COD levels from 122-173 to 42-92 mg/L depending on the hydraulic retention time applied, while that filled with quartz sand can reduce COD levels from 128 to 32-43 mg/L. The biofiltration systems also demonstrated the ability to reduce TSS from 56 to 5 mg/L or equivalent to 90% reduction in the case of quartz sand matrix, while honeycomb-type matrix showed slightly inferior performance. The decrease in TSS will reduce coagulant consumption in the subsequent water treatment processes. It was also observed that nitrification also took place in the biofiltration system, indicated by removal of 55-75% ammonium concentration. This will eventually reduce chlorine required for disinfection. Based on these results, an estimation of potential cost saving from the use of the biofiltration process is derived.

Key words: polluted raw water, biofiltration, pretreatment, raw water quality improvement

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I. INTRODUCTION

The river water pollution prevails in many parts of Indonesian region, due to the industrial, commercial, residential and farming activities. In many areas the quality standard of raw water has even been violated, in terms of physical (turbidity, color, solids), chemical (organic matters, nutrients, detergents, pesticides, and heavy metals), and biological contaminations (total coliforms, *Escherichia coli*, and other pathogens). Moreover, today's trend shows an increase in communities attention not only on pollutants commonly known as toxics (pesticides, heavy metals), but also to the increased levels of organic matters in the raw water that have potential health implications. The organic materials may trigger the formation of by-products, such as trihalomethane ($CHCl_3$) compounds in the water treatment plants that are applying chlorination for disinfection purposes. These byproducts are considered as carcinogenic compounds causing cancer [1] - [3].

The problem of river water pollution has to be resolved, especially considering that in many areas, the water is used as source of water supply for drinking water. In addition, there are urgent demands from the public suggesting the government (central or local) to increase the capacity and quality of water supply, as stated in the targets of MDG's (Millennium Development Goals). The development of an effective technology to address these challenges is needed.

Innovative technology of biofiltration can be considered as an effective solution to reduce problems in the water supply, especially in improving the quality of raw water and thus the treated water, and reducing treatment costs. Biofiltration process (known also as packed bed biofilm reactor) is a technology that utilizes microbial activity, in which solid materials are used by microorganisms as a matrix for growing, forming biofilm and consuming pollutants from the treating water as their energy source [4], [5].

This system allows prolong microorganism residence time relative to its hydraulic residence time. This provides the microorganisms to have opportunity to adapt to environmental conditions and types of

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pollutants in the system, and to establish the type and concentration of certain enzymes needed to eliminate a variety of pollutants, including recalcitrant compounds, such as pesticides and other synthetic organic compounds. These favorable conditions increase the effectiveness and stability of the system in eliminating various types of contaminants from the treating raw water. The biofilm process performance is determined mainly by two parameters, namely the surface characteristics of the support material (matrix) and biofilm thickness, which affect substrate and oxygen supply from the liquid phase [4], [6], [7].

Biofiltration system has been reported to be used for various purposes, such as for advanced wastewater treatment (tertiary wastewater treatment) [8] - [10], for the elimination of pesticides [11], and for the elimination of toxic compounds [12] - [14]. These studies are mostly geared to treat highly polluted wastewaters and partly for advanced wastewater treatment for the elimination of nutrients (nitrification, denitrification and phosphate elimination). More recently, Rattier et al. [15] studied removal of micropollutants during tertiary wastewater treatment by biofiltration with the focus on the role of nitrifiers and removal mechanisms.

Development of biofiltration system for eliminating organic matters, suspended solids and low concentration of organic pollutants found in the raw water has not been widely reported, despite of the urgent need for removal of these pollutants. There is also tremendous need to improve the quality of raw water and thus treated water at reduced treatment costs.

An increased level of organic matters in surface water sources in many parts of the world has encouraged the development of various technologies, such as the oxidation process using O_3/H_2O_2, O_3/UV, UV/H_2O_2, TiO_2/UV, H_2O_2/catalyst, Fenton, and photo-Fenton process [1]. However, these processes require high investment and operating costs, so its commercial scale application in developing countries is limited.

This paper presents the results of a preliminary study on pre-treatment of polluted river water as raw water of drinking/clean water supply using biofiltration system. The system performance is evaluated by its ability in reducing the level of water contaminants covering COD, turbidity, TSS, and ammonium. The potential technical and financial benefits derived from the technology are then analyzed.

II. METHODOLOGY

Feed Water. Water of Cihedeung River located nearby IPB Campus was used throughout the experiments. The river water has been used for the campus water supply. The river water characteristics vary depending on weather conditions. Table I shows the variation of water characteristics during rainy and dry seasons. At rainy season, the value of TSS, turbidity, color of the river water is much higher than that in dry season. The water pH is very low (acidic) in rainy conditions (pH ≈ 4.5) and nearly neutral in dry season.

TABLE I.
PHYSICAL PROPERTIES OF THE RIVER WATER DURING THE SEASONS

Parameter	Unit	Rainy condition	No rain condition (bright)
TSS	mg/L	148	39
Turbidity	FTU	160	60
Color	PtCo	550	283
pH	-	4.5	6.9

Biofiltration system. The reactors are made of plastic filled with a honeycomb type of plastic media and quartz sand as the matrix. Total volume of the reactors was 24 liters. Schematic diagram of the biofiltration system can be seen in Fig. 1. It consists of a) valves, b) recirculation pumps, c) effluent pipe, d) raw water inlet, e) matrix, and f) diffuser. The biofiltration system were filled with honeycomb-structured plastic (plastic type "Bee Nest") and quartz sand matrices, and operated in continuous mode with upflow mode of water and air flow. The flow rate (hydraulic residence time or Empty Bed Contact Time) was regulated through the aperture of installed outlet valve.

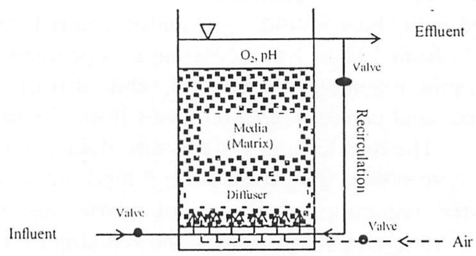


Fig. 1. Schematic diagram of biofiltration system used in the experiments

Acclimatization. Microbial acclimatization was done by operating the reactor continuously at 4 hour HRT. During acclimatization influent and effluent values of COD, turbidity, TSS and ammonium were monitored.

Experimental works. Experiments were carried to evaluate the performance of two types of matrix media, namely quartz sand and honeycomb-structured plastic. The bioreactors were operated at different loads (effected by adjusting flowrate and pollutant concentration). The observed parameters cover pollutants removal efficiency, effluent quality, and system stability against shock loads.

Jar Test. Jar test using a standard 1000 mL of 6 beaker glass was performed to determine the optimum dose of coagulant PAC (Poly Aluminum Chloride) at various levels of raw water turbidity and TSS. One beaker was used as a control, and the five other beaker were added with different doses of PAC. The coagulation was conducted by stirring at 120 rpm for 1 minutes and then allowing the samples to settle for 30 minutes. The jar test results were used as a basis for evaluating the financial implication from the use of the bioreactor system, by determining the relationship of pre-treated water quality (TSS and turbidity levels) against the reduced needs of coagulant (PAC).

Laboratory analysis. Samples were taken directly from the inlet and outlet of packed bed reactor and then analyzed for organic substances (COD), turbidity, TSS, and ammonium. The organic material was analyzed according to SK SNI M-72-1990-03, Ammonium (NH_4^+) was analyzed in accordance with APHA procedure (2005) [16], and was measured using the absorbance of light by using spectrophotometer type DR/2000 at a wavelength of 810 nm. Turbidity was examined by similar method with TSS measurement only differ in wavelength. Color was measured using spectrophotometer DR/2000 with a wavelength of 450 nm, while the pH was measured by pH-meter electrically.

III. RESULT AND DISCUSSION

A. Pollutants Removal

Acclimatization. Acclimatization was intended to grow microorganisms in the media, forming a layer of biofilm by utilizing the available substrates and nutrients in the fed water and to get them adapted to the environmental conditions. Microorganisms that grow attached on the media surface play a key role in degrading the organic materials or adsorbing the inorganic suspended solids. Biodegradation activity increases with the increase of the number and concentration of microorganisms. The end of the acclimatization is characterized by the achievement of pseudo-steady state conditions, indicated by a stable level of pollutant reduction and residual concentration in the effluent. The longer the time of operation, the better the microorganisms getting adapted to its environment and thus the higher the rate of pollutants elimination. In this experiment acclimatization took about a month.

Degradation rate of pollutants. After the formation of biofilm on the media during the acclimatization phase, experiments were performed to observe the influence of the contact time (hydraulic residence time) on the reduction of various types of water pollutants. Results showed that the reduction of organic matters, turbidity, TSS, and ammonium increased with increasing hydraulic retention time. The rate of pollutant degradation varies depending on the type of pollutant. Soluble materials are more easily degraded biologically than suspended materials. The degradation rate of organic matters was faster at the first three hours contact time and decreases with increasing contact time. The remaining pollutants with longer contact time are considered as biologically-difficult-to degrade substances. With increasing the adaptation time and the concentration of microorganisms (biofilm thickness), the degradation rate is expected to be improved and the remaining residual pollutants can minimized.

COD is an important parameter that indicates the concentration of organic materials in the water samples. By using biofiltration system filled with honeycomb-structured matrix (plastic type "Bee Nest"), COD can be reduced from 122-173 mg/L to 42-92 mg/L depending on the hydraulic retention time applied, while the biofiltration system filled with quartz sand can reduce COD of 128 mg/L to 32-43 mg/L. Fig. 2 shows the influent and effluent COD of the biofiltration system filled with plastic type "Bee Nest" (a) and quartz sand (b) matrices.

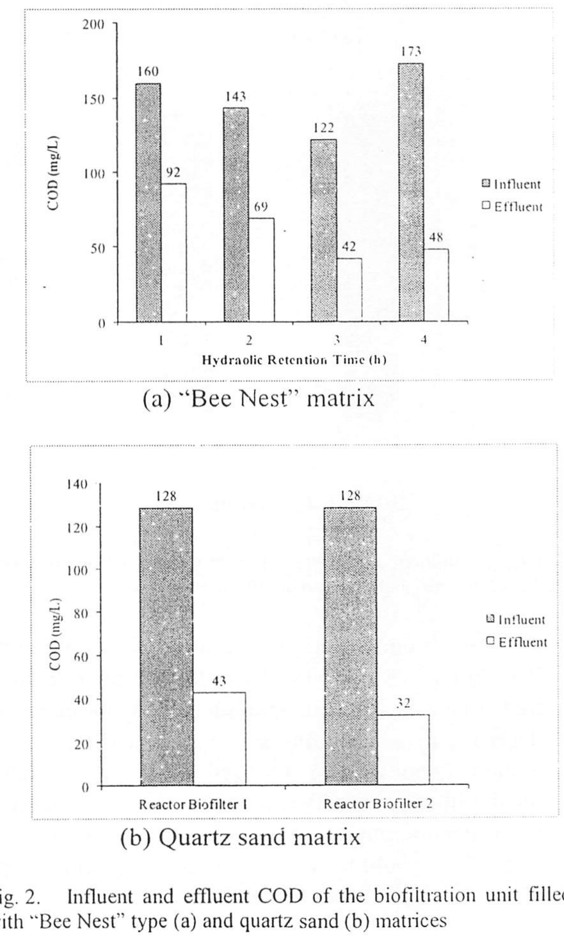
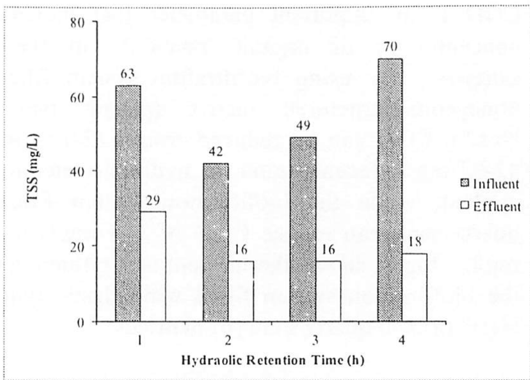
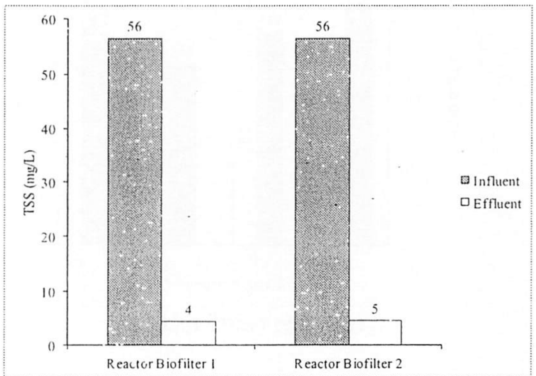


Fig. 2. Influent and effluent COD of the biofiltration unit filled with "Bee Nest" type (a) and quartz sand (b) matrices

TSS can be reduced significantly using biofiltration system filled with honeycomb plastic or quartz sand (Fig. 3). In term of TSS reduction, biofiltration system filled with quartz sand was better than that with honeycomb plastic matrix because the former has an additional physical effect on TSS removal in addition to the biological effects (biodegradation by biofilm). The biofiltration system filled with quartz sand was able to reduce the TSS from 56 mg/L to 5 mg/L, equivalent to 90% reduction. The decrease in TSS will reduce water turbidity and coagulant consumption in subsequent water treatment processes. The relationship between TSS and the required coagulant and its relation to the financial implication are discussed in Section B.



(a) "Bee Nest" matrix



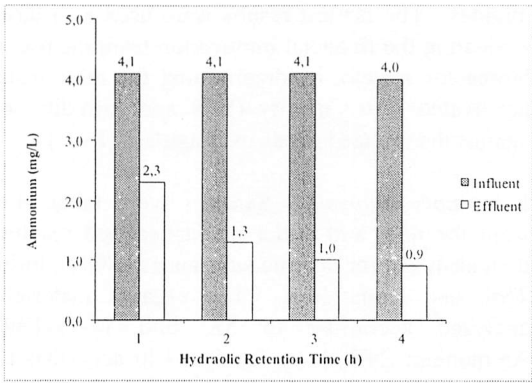
(b) Quartz sand matrix

Fig. 3. Influent and effluent TSS of the packed bed reactor with "Bee Nest" (a) and Quartz sand (b) matrices

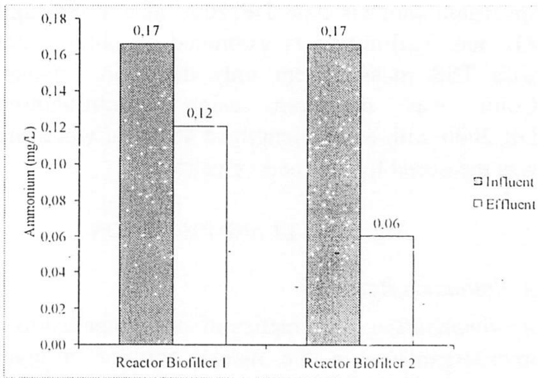
Besides elimination of dissolved organic matter (COD) and TSS, it was observed that nitrification also took place in the biofiltration system, indicated by a decrease in ammonium concentration (Fig. 4). In a technical context, a reduced level of ammonium results in reduced chlorine required for disinfection in the water treatment process. The ammonium removal of 55-75% could be achieved depending on the type of matrix used as shown in Table II.

B. Benefits Analysis

The following paragraphs discuss the technical and financial benefits of biofiltration system for the pre-treatment of raw water from the polluted river water. The analysis is based on the experimental results, where the use of biofiltrations has decreased TSS and ammonium levels that lead to reduced consumption of coagulant and chlorine. TSS is one of the most important parameters of raw water quality, where the higher the level of TSS in the water, the higher the turbidity. Fig. 5 shows the linear relationship between TSS level and turbidity as well as color.



(a) "Bee Nest" matrix



(b) Quartz sand matrix

Fig. 4. Influent and effluent ammonium of the packed bed reactor with "Bee Nest" (a) and quartz sand (b) matrices

TABLE II.
PERCENT OF POLLUTANTS REMOVAL (AT 3 HOUR HRT)

Parameter	Matrix material	
	Plastic type "Bee Nest"	Quartz sand
TSS	70	90
Turbidity	65	80
COD	65	75
Ammonium	75	55

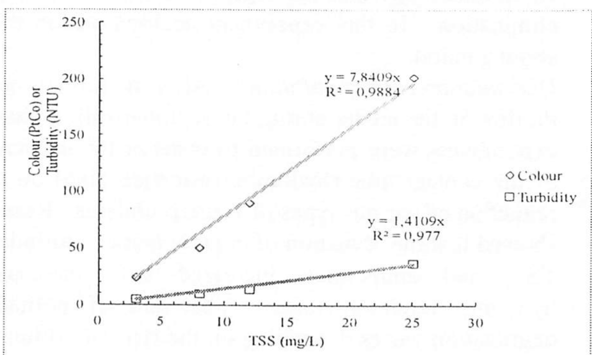


Fig. 5. The relationship between TSS level and color and turbidity in raw water

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In water treatment, the levels of TSS and turbidity determine the amount of coagulant requirements. The higher the levels of TSS and turbidity of the raw water, the higher the amount of the coagulant needed for water treatment. Fig. 6 shows the relationship between turbidity and TSS in the raw water with the optimum dose of PAC. Although the quantitative relationship is influenced by the characteristics of the water, the relationship is useful for indirect estimation of the potential saving of coagulant. With help of Fig. 6 it is estimated that a reduction of TSS from 25 mg/L to 8 mg/L results in a reduction of PAC requirement from 0.04 to 0.005 mL/L or equivalent to a saving of PAC by 87 percent.

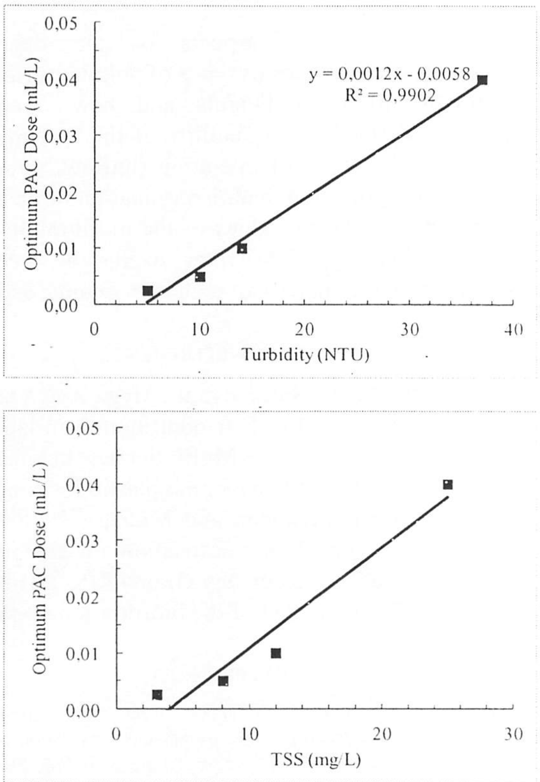

Fig. 6. The relationship between turbidity (upper) and TSS in the raw water (lower) with the optimum dose of PAC in the water treatment (liquid PAC with 10% activity)

Ammonium in the raw water cannot be effectively eliminated using a conventional water treatment system, so that ammonium would remain in the treated water. The remaining ammonium reacts with chlorine (Cl_2) and therefore increases the disinfectant requirement in the water treatment according to the following chemical equation [17]:

$$NH_4^+ + Cl_2 + 2HOCl \rightarrow NCl_3 + 2H^+ + Cl^- + 2H_2O$$

Ammonium in the raw water can be oxidized to nitrate (nitrification) in the biofiltration system. Reduced level of ammonium means also reduction of chlorine for the disinfection process. As per the above chemical equation, one mole (18 g) of ammonium requires one mole (71 g) of chlorine. This means that a reduction of 18 g ammonium in raw water lead to a saving of 71 g chlorine.

From the above discussion, it is clear that both TSS and ammonium in raw water affects the chemicals requirement in the water treatment process. In other words, reductions of TSS and ammonium can reduce the need for chemicals, both coagulant (PAC) and disinfectant (chlorine). This preliminary study showed that the biofiltration systems reduced the level of TSS from 56.4 to 4.5 mg/L, which is equivalent to a decrease in the use of liquid PAC from 0.079 to 0.006 mL/L (jar test result). At the same time, the ammonium level can be removed from 1.5 to 0.5 mg/L, which is equivalent to a reduction in chlorine requirement from 6.3 to 2.1 mg/L (stoichiometric calculation). Assuming the price of liquid PAC is Rp 4,500,- /L and chlorine Rp 5,200,-/kg, a water treatment plant with capacity of 100 L/s equipped with biofiltration can save Rp 1,017,007,488,- /year from coagulant (PAC) and Rp 67,550,569, -/year from chlorine consumption.

C. Application of biofiltration

From the description above, it is obvious that pre-treatment of polluted water using biofiltration system would improve the quality of raw water and the quality of treated water, or improve the water treatment plant capacity. Fig. 7 shows the recommended set up of biofiltration unit within the typical series of unit operation of water treatment processes. The addition of this unit will not interfere with the design and operation of the existing water treatment systems significantly.

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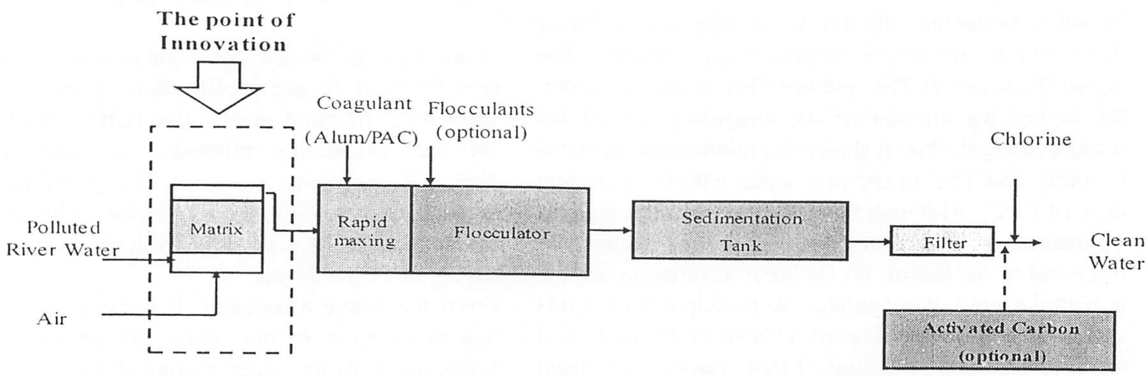

Fig. 7. The recommended setup of water treatment facility equipped with biofiltration unit

Results of the experiments shown in this preliminary study concluded that this technology has potential technical and financial benefits in the overall water treatment system. This technology will have a significant contribution in the context of ever increasing intensity of river water pollution and the high variation of pollution load. However, further thorough investigation on the applicability of the pre-treatment of raw water is still needed at a larger scale and longer period of time. Comprehensive studies are currently taking place in our laboratory. The studies are focused on the further development of biofiltration for the treatment of polluted river water as raw water in water supply in order to exploit these advantages optimally, includes aspects of the degradation characteristics of various types of pollutants (including non-conventional pollutants and new / emerging pollutants), such as trace elements from pesticides, herbicides, medicines, cosmetics, shampoo, soap, heavy metals, and detergent, testing the stability of the system against shock loads, mode of operation (upflow, downflow), process optimization, and determination of design and operating parameter values of the biofiltration system with various types of filter media, as well as a comprehensive analysis of techno-economic aspects.

IV. CONCLUSIONS

Biofiltration systems can remove various pollutants in raw water significantly, such as organic substances (COD), turbidity, color, TSS and ammonium. The increased raw water quality can reduce water treatment cost and the risk to public health. The biofiltration systems as pre-treatment unit also function as equalizer to the high variation in organic pollutant load of influent. Besides the technical benefits, use of biofiltrations has been shown to result in cost saving due to reduced consumption of coagulant and chlorine. Further development of biofiltration for the treatment of polluted river water as raw water in water supply is still needed in order to exploit these advantages optimally, includes aspects of the degradation characteristics of various types of pollutants (including non-conventional pollutants and new / emerging pollutants), testing the stability of the system against shock loads, mode of operation (upflow, downflow), process optimization, and determination of design and operating parameter values of the biofiltration system with various types of filter media, as well as a comprehensive analysis of techno-economic aspects.

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