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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Department of Agroindustrial Technology
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 Margarette Gfrerer from Islamic State University of Jakarta, Indonesia; Dr Barry Elsey from University of Adelaide, Australia; Dr Gajendran Kandasamy from Melbourne University, Australia; 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 and Bioenergy Research Center; PT Bogor Life Science and Technology; Indonesian Ministry of Industry; PT Pachira Distirnusa; 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 (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.

Distinguished Guest, Ladies and Gentlemen,
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
COMMITTEE

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## AGENDA

<table>
<thead>
<tr>
<th>Time</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.00 - 09.00</td>
<td>Registration</td>
</tr>
<tr>
<td>09.00 - 10.00</td>
<td>Opening Ceremony</td>
</tr>
<tr>
<td></td>
<td>• Welcoming Address: Prof. Nastiti Siswi Indrasti (Head of DAT, Fateta, IPB)</td>
</tr>
<tr>
<td></td>
<td>• Welcoming Speech Head of Bogor Regency</td>
</tr>
<tr>
<td></td>
<td>• Conference Opening: Prof. Herry Suhardiyanto (Rector of IPB)</td>
</tr>
<tr>
<td></td>
<td>• Opening Speech and Conference Opening: Minister of Industry Indonesia *</td>
</tr>
<tr>
<td></td>
<td>• Launching Expose International program DAT</td>
</tr>
<tr>
<td>10.00 – 10.05</td>
<td>Photo Session</td>
</tr>
<tr>
<td>10.05 - 10.15</td>
<td>Coffee break</td>
</tr>
<tr>
<td>10.15 - 10.45</td>
<td>Keynote Speech:</td>
</tr>
<tr>
<td>10.45 - 11.30</td>
<td>1. Prof Irawadi (Bogor Agricultural University, Indonesia)</td>
</tr>
<tr>
<td></td>
<td>2. Prof. Kenneth De Jong (George Mason University, USA)</td>
</tr>
<tr>
<td>11.30 – 12.00</td>
<td>3. Dr. Yandra Arkeman (Bogor Agricultural University, Indonesia)</td>
</tr>
<tr>
<td>12.00 – 12.30</td>
<td>4. Dr. Guillermo Baigorria (University of Nebraska, Lincoln, USA)</td>
</tr>
<tr>
<td>12.30 – 13.30</td>
<td>Lunch break</td>
</tr>
<tr>
<td>13.30 – 13.50</td>
<td>Plenary Session 1:</td>
</tr>
<tr>
<td>13.50 – 14.10</td>
<td>Prof. Noel Lindsay (University of Adelaide, Australia)</td>
</tr>
<tr>
<td>14.10 – 14.30</td>
<td>Dr. Kiyotada Hayashi (National Agricultural Research Center, Tsukuba, Japan)</td>
</tr>
<tr>
<td>14.30 – 14.50</td>
<td>Prof. Margareth Gfrerer (Islamic State University of Jakarta, Indonesia)</td>
</tr>
<tr>
<td>14.50 – 15.10</td>
<td>Dr. Barry Elsey (University of Adelaide, Australia)</td>
</tr>
<tr>
<td>15.10 – 15.45</td>
<td>Ir. M. Novi Saputra (Marketing Director KML Food Group)</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
</tr>
<tr>
<td>15.30 – 15.45</td>
<td>Coffee break</td>
</tr>
<tr>
<td>15.45 – 18.00</td>
<td>Parallel session A, B and C</td>
</tr>
<tr>
<td>18.00 – 21.00</td>
<td>Welcome Dinner</td>
</tr>
<tr>
<td>Time</td>
<td>Activities</td>
</tr>
<tr>
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<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Tuesday, August 4\textsuperscript{rd} 2015</strong></td>
<td></td>
</tr>
<tr>
<td>08.30 – 09.00</td>
<td>Registration</td>
</tr>
<tr>
<td>09.00 – 09.20</td>
<td>Plenary Session 2: Dr. Gajendran Kandasamy (PhD in Physic, Melbourne University; PhD in Innovation Imperial Collage, London)</td>
</tr>
<tr>
<td>09.20 – 09.40</td>
<td>Prof. Allan O'Connor (University of Adelaide, Australia)</td>
</tr>
<tr>
<td>09.40 – 10.00</td>
<td>Dr. Eng. Wisnu Ananta Kusuma, ST, MT (Bogor Agricultural University, Indonesia)</td>
</tr>
<tr>
<td>10.00 – 10.20</td>
<td>Dr. Frank Neumann (University of Adelaide, Australia)</td>
</tr>
<tr>
<td>10.20 – 10.45</td>
<td>Discussion</td>
</tr>
<tr>
<td>10.45 – 13.00</td>
<td>Parallel Session A, B and C</td>
</tr>
<tr>
<td>13.00 – 14.00</td>
<td>Lunch break</td>
</tr>
<tr>
<td>14.00 – 15.30</td>
<td>Parallel Workshop</td>
</tr>
<tr>
<td></td>
<td>• Strategies for Agroindustry Development</td>
</tr>
<tr>
<td></td>
<td>• LCA for Agroindustry</td>
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<td></td>
<td>• Innovation and Technopreneurship for Agroindustry</td>
</tr>
<tr>
<td></td>
<td>• Agroindustrial Informatics</td>
</tr>
<tr>
<td>15.30 – 15.45</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>15.45 – 16.15</td>
<td>Closing remark</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS

Welcoming address from general chairs                               i
Welcoming address from head of Agroindustrial Technology Department ii
Bogor Agricultural University                                      iii
Committee                                                          iv
Agenda                                                             v
Table of Contents                                                   vii

Abstract of Invited Speakers
Noel Lindsay                                                        1
Kiyotada Hayashi                                                   2
Barry Elsey                                                        3
Frank Neumann                                                      4
Yandra Arkeman                                                     5
Wisnu Ananta Kusuma                                                6

Innovative Agroindustrial and Business System Engineering
The Feasibility Study of Establishment of Biodiesel And Paving Block Industry From Spent Bleaching Earth
Febriani Purba, Ani Suryani and Sukardi                            7
Green Supply Chain Management Innovation Diffusion in Crumb Rubber
Factories: Designing Strategies towards Implementation
Tri Susanto, Marimin Marimin and Suprihatin                         13
Mobile Business Analytics System for Service Level Analysis of Customer Relationship Decision
Taufik Dijna and Yudhistira Chandra Bayu                            19
Exploring an Innovative Approach to Address Non-Tariff Barriers
Experienced by Small to Medium Enterprises in Downstream Coffee Production in Indonesia
Andar Hermawan, Yandra Arkeman, Titi Candra Sunarti                 26
Innovation on Guardrail Press Tool with Simple Technology for Highway Road Business
Bambang Suhardi Waluyo and M.Syamsul Ma'Arif                      33
An Analysis of Innovation Network Performance on the Palm Oil Industry in North Sumatera
Danang Krisna Yudha, Aji Hermawan and Machfud                      34
Application of Nanotechnology to Improve Physical Properties of Red Fruit Emulsion in order to Increase Its Industrial Use
Murti Ningrum and Syamsul Maarif                                    41
Exploring the Internationalization Process Model of an Indonesian Product – Case study : Fruit Chips SME’s
Dickie Sulistya Apriliyanto, Hartrisari Hardjomidjojo, Titi C Sunarti Innovation Management in Indonesian Palm Oil Industry
Karim Abdullah, Aji Hermawan and Yandra Arkeman                     47
53
Innovation Design Process for Gayo’s Coffee Quality Improvement
Rahmat Pramulya, M Syamsul Ma’Arif and Tajuddin Bantacut
Technology Innovation Adoption to Improve the Performance of Dairy
Small-Medium Enterprises (SME): Case study in Pangalengan-Bandung
Regency, West Java, Indonesia
Nuni Novitasari, Titi Candra Sunarti and Nastiti Siwi Indrasti
Process Innovation for Producing Bioethanol from Oil Palm Empty Fruit
Bunches by Improving Fermentation Conditions
Fitriani Kasim, Novizar Nazir and Syamsul Ma'Arif
Managing Innovation through Knowledge Sharing in An Indonesia Coconut
SME
Muchammad Kodiyat P, Machfud, Nastiti S Indrasti
Increasing Added Value of Banana by Producing Synbiotic Banana “Sale”
Using Innovation & Technology Strategy Approach
Eka Ruriani
Innovation Palm Fronds Briquettes Through Noncarbonization Process
Petir Papilo, Syamsul Ma'Arif and Yandra Arkeman
Graphic Design Innovation As Brand Identity For “Mahlzeit N'Das Brot “
Bread Packaging
Zulkarnain, Deny Dwi Lestari and M. Syamsul Ma’Arif
An AHP Application for Selecting A Business Innovation Strategy of
Chocolate SMEs in East Java
Yani Kartika Pertwati, M. Syamsul Maarif and Machfud
Understanding local food consumers and their motivations: A case study in
Padang city
Poppy Arsil
Spatial Model Design for Competitive Improvement of Small Medium
Scales Enterprises (Case Study: Bogor City)
Hartrsari Hardjomidijojo, Harry Imantho and Armaiko Yusmur
System Analysis and Design for Selecting Chitin and Chitosan Industry
Location by Using Comparative Performance Index (CPI) Method
Dena Sisamaraini, Nastiti S. Indrasti and Taufik Djatna
Arduino-Based Temperature Monitoring Device for Cold Chain
Transportation
Delmar Zakaria Firdaus and Endang Warsiki
Development of Downstream Cocoa Industry: Exploring the Role of
Government and Small and Medium Industry in Partnership
Farda Eka Kusumawardana, Yandra Arkeman, Titi C Sunarti
The Role of Communication in the Technology Transfer (A Case Study at
the Center for Agro-based Industry)
Anindita Dibyono, Sukardi, Machfud
The Center for Pulp and Paper Appraising its Productivity in Generating
Industry-Applicable Research: A Best Practice Illustration
Ahmad Rudh Firdausi, Anas M Fauzi, Machfud

Frontier Approaches in Process and Bioprocess Engineering
Identification of Flavor Compounds In Cemcem (Spondiazpinata (L.F)
Kurz) Leaf Extra
Luh Putu Wrasati, Ni Made Wartini and Ni Putu Eny Sulistyadewi
Synthesis and Characterization of Nanosilica from Boiler Ash with Co-
Precipitation Method

Wahyu Kamal Setiawan, Nastiti Siswiliandra and Suprihatin
The Comparison Of Media on the Microalgae *Nannochloropsis* sp. Culture
Anak Agung Made Dewi Anggreni, I Wayan Arnata and I B Wayan
Gunam

Identification of Media and Indicator Liquid as A Recorder Smart Label
Endang Warsiki and Riris Octaviasari

The Effect of Concentration of Mes Surfactant From Palm Oil and
Consentrasion of Inorganic Salt to Interfacial Tension Value
Rista Fitria, Ani Suryani, Mira Rivai and Ari Imam

Effect of Nano Zinc Oxide On Bionanocomposite
Siti Agustina, Nastiti Siswi Indrasti, Suprihatin and Nurul Taufiku
Rohman

The Effects of Molar Ratio Between 80% Glycerol And Palm Oil Oleic
Acid on the Synthesis Process of Ester Glycerol
Mira Rivai, Erliza Hambali, Giovanni Nurpratiwi Putri, Ani Suryani,
Pudji Permadi, Bonar T.H Marbun and Ari Imam Sutanto

Selecting Part of Natural Fiber EFB which has Best Mechanical Strength
through Tensile Test Analysis for Composite Reinforced Material
Farkhan, Yohanes Aris Purwanto, Erliza Hambali and Wawan
Hermawan

Effect Of Ethyl Methane Sulfonate (EMS) On Growth Rate, Cell Size, Fatty
Acid Content And Antioxidant Activities Of *Dunaliella* sp.
Mujizat Kawaroe and Amelia Gustini

Identification of phenol red as Staphylococcus aureus indicator label
Dunaliella sp.
Melati Pratama, Endang Warsiki and Liesbetini Hartoto

Enhancing Ethanol Tolerant of *Escherichia coli* Recombinant by Glutamate
Addition under Aerobic Conditions
Indra Kurniawan Saputra, Prayoga Suryadarma and Ari Permana
Putra

In Vitro Potentifal of Antibacterial Marine Microalgae Extract
*Chaetoceros gracilis* Toward *Staphylococcus epidermidis* Bacteria
Ardhi Novrialdi Ginting, Liesbetini Haditjaroko and Iriani
Setyaningsih

The Potential Applications of Modified Nagarja Bean Flour through
Fermentation for Innovation of High Protein Analog Rice
Susi, Lya Agustina and Chondro Wibowo

Studies on the Characteristics of Pasayu (Pasta of Waste-Cassava)
Fortification as a New Product Development
Marleen Sunyoto, Roni Kastaman, Tati Nurmalia and Dedi Muhtadi

Optical And Particle Size Properties Of *Sargassum* Sp Chlorophyll As Dye-
Sensitized Solar Cell (DSSC)
Makkulawu Andi Ridwan and Erliza Noor

Alkaline Pre-Treatment of *Gelidium latifolium* and *Caulerpa racemosa* for
Bioethanol Production
Dwi Setyaningsih, Neli Muna, Elisabeth Yan Vivi Aryanti and Anastasya Hidayat

New Trends in Industrial Environmental Engineering & Management
Formulating a Long Term Strategy for Sustainable Palm Oil Biodiesel Development In Indonesia: Learning From the Stakeholder Perspective
Beny Adi Purwanto, Erliza Hambali and Yandra Arkeman
Quality Improvement of Polluted River Water Used as Raw Water in Clean Water Supply by Using Biofiltration
Suprihatin, Muhammad Romli and Mohamad Yani
An Empirical Investigation of the Barriers to Green Practices in Yogyakarta Leather Tanning SMEs
Dwi Ningsih, Ono Suparno, Suprihatin and Noel Lindsay
Preliminary Study For CO2 Monitoring System
Farhan Syakir, Rindra Wiska, Irvi Firqotul Aini, Wisnu Jatmiko and Ari Wibisono
Designing a Collaboration Form to Overcome Innovation Resistance in Waste Management Practices in Lampung Tapioca Industry
Nur Aini Adinda, Suprihatin, Nastiti Siswi Indrasti
Pollution Reducing Opportunities for a Natural Rubber Processing Industry: A Case Study
Syarifa Arum Kusumastuti, Suprihatin and Nastiti Siswi Indrasti
Creating the Standard for Specific Energy Consumption at Palm Oil Industry
Alfa Firdaus and M Syamsul Ma'Arif
Effects of Palm-Dea Non-Ionic Surfactant as an Additive in Buprofezin Insecticide on the Efficacy of it in Controlling Brown Planthopper Rice Pest Fifin Nisya, Rahmini, Mira Rivai, Nobel Cristian Siregar, Ari Imam Sutanto and Ainun Nurkania

Intelligent Information & Communication Technology for Adaptive Agroindustry of the Future
Design of Web-Based Information System With Green House Gas Analysis for Palm Oil Biodiesel Agroindustry
Yandra Arkeman, Hafizd Adityo Utomo and Dhani S. Wibawa
Sequential Patterns for Hotspots Occurrence Based Weather Data using Clospan algorithm
Tricia Agustina and Imas S. Sitanggang
How to Deal with Diversity in Cultivation Practices using Scenario Generation Techniques: Lessons from the Asian rice LCI Initiative Kiyotada Hayashi, Yandra Arkeman, Elmer Bautista, Marlia Mohd Hanafiah, Jong Sik Lee, Masanori Saito, Dhani Satria, Koichi Shobatake, Suprihatin, Tien Tran Minh and Van Vu
Development of Life Cycle Inventories for Palm Oil in North Sumatra: Modelling Site-Specific Activities and Conditions
Vita D Lelyana, Erwinsyah and Kiyotada Hayashi
Sequential Pattern Mining on Hotspot Data using PrefixSpan Algorithm
Nida Zakiya Nurulhaq and Imas S. Sitanggang

x
An Intelligent Optimization Model Analysis and Design of Bio-filtration in Raw Water Quality Improvement
Ramiza Lauda and Taufik Djatna

Development Of People Food Consumtion Patterns Information System Based On Webmobile Application.
Fadly Maulana Shiddieq, Roni Kastaman and Irfan Ardiansah

Association Rules Mining on Forest Fires Data using FP-Growth and ECLAT Algorithm
Nuke Arincky and Imas S. Sitanggang

Development Of Expert System For Selecting Tomato (Solanum Lycopersicon) Varieties
Erлин Cahya Rizki Amanda, Kudang Boro Seminar, Muhamad Syukur and Noguchi Ryozo

Developing Life Cycle Inventories for Rice Production Systems in Philippines: How to Establish Site-specific Data within the General Framework
Elmer Bautista, Kiyotada Hayashi and Masanori Saito

Construction of Site-specific Life Cycle Inventories for Rice Production Systems in Vietnam
Tran Minh Tien, Bui Hai An, Vu ThiKhanh Van and Kiyotada Hayashi

Study on Life Cycle Benefit Assessment as a tool for promoting the solution of Environmental Problems
Tetsuo Nishi

Real Time Monitoring Glycerol Esterification Process with Mid IR Sensors using Support Vector Machine Classification
Iwan Aang Soenandi, Taufik Djatna, Irzaman Husein and Ani Suryani

Extraction of Multi-Dimensional Research Knowledge Model from Scientific Articles for Technology Monitoring
Arif R. Hakim and Taufik Djatna

Performance of Artificial Lighting Using Genetics Algorithms
Limbran Sampebatu

The Application of Fuzzy-Neuro Approach for ERP System Selection: Case Study on an Agro-industrial Enterprise
Joko Raton, Kudang Boro Seminar, Yandra Arkeman and Arif Imam Suroso
Quality Improvement of Polluted River Water Used as Raw Water in Clean Water Supply by Using Biofiltration

Suprihatin1,2, Muhammad Romli1, Mohamad Yani1
1Department of Agro-Industrial Technology, Bogor Agricultural University (IPB), Bogor, Indonesia
2Corresponding E-mail: suprihatin@indo.net.id

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

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 (CHCl₃) 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 MDGs (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
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 Oz/H2O2, Oz/UV, UV/H2O2, TiO2/UV, H2O2/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 Chedeung 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 1 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>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Rainy condition</th>
<th>No rain condition (bright)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>148</td>
<td>39</td>
</tr>
<tr>
<td>Turbidity</td>
<td>FTU</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>Color</td>
<td>PtCo</td>
<td>550</td>
<td>283</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>4.5</td>
<td>6.9</td>
</tr>
</tbody>
</table>

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 testing 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 (NH₄⁺) 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.

![Graph](image-url)

(a) "Bee Nest" matrix

![Graph](image-url)

(b) Quartz sand matrix

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.

![Graph showing TSS vs. Hydraulic Retention Time](image)

(a) "Bee Nest" matrix

![Graph showing TSS vs. Reactor Biofilter](image)

(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.

![Graph showing ammonium vs. Reactor Biofilter](image)

(b) Quartz sand matrix

Table II.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Plastic type &quot;Bee Nest&quot;</th>
<th>Quartz sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS</td>
<td>70</td>
<td>90</td>
</tr>
<tr>
<td>Turbidity</td>
<td>65</td>
<td>80</td>
</tr>
<tr>
<td>COD</td>
<td>65</td>
<td>75</td>
</tr>
<tr>
<td>Ammonium</td>
<td>75</td>
<td>55</td>
</tr>
</tbody>
</table>

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.

![Graph showing TSS vs. Color](image)

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

\[
\text{NH}_4^+ + \text{Cl}_2 + 2\text{HOCI} \rightarrow \text{NCl}_3 + 2\text{H}^+ + \text{Cl}^- + 2\text{H}_2\text{O}
\]

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.

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**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.
The point of Innovation

**Coagulant** (Alum/PAC) **Flocculants** (optional)

Polluted River Water

Air

Rapid mixing

Flocculator

**Sedimentation Tank**

Filter

Clean Water

Activated Carbon (optional)

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.

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REFERENCES


