THE 5TH
ENVIRONMENTAL TECHNOLOGY AND MANAGEMENT CONFERENCE

NOVEMBER 23RD - 24TH 2015
BANDUNG, INDONESIA

EDITOR IN CHIEF
Prof. Dr. Ir. Enri Damanhuri

PROCEEDINGS BOOK

FACULTY OF CIVIL AND
ENVIRONMENTAL ENGINEERING
INSTITUT TEKNOLOGI BANDUNG

ISBN 978-979-98278-5-2

Proceedings

The 5th Environmental Technology and Management Conference

Green Technology towards Sustainable Environment

23 - 24 November 2015, Bandung, Indonesia

Editor in Chief

Prof. Dr. Ir. Enri Damanhuri

Published by

Faculty of Civil and Enviromental Engineering

Institut Teknologi Bandung – Indonesia

ISBN 978-979-98278-5-2

9 789799 827852

Proceedings

The 5th Environmental Technology and Management Conference

Green Technology towards Sustainable Environment

ISBN: 978-979-98278-5-2

Cover Design:

Sandy Indriana

Publisher:

Faculty of Civil and Environmental Engineering
Institut Teknologi Bandung
Jl. Ganesha 10 Bandung 40132
Telp. 022 2504952
Fax. 022 2516586
Email: kantor@ftsl.itb.ac.id
Website: www.ftsl.itb.ac.id

PREFACE

Green Technology that provides the basic needs of society in sustainable environment is essential for the survival, health and well-being of a society in developing countries. The engineers, scientists, policy makers, academics, environmental consultants, environmental contractors, industrial practitioners, businessmen, politicians, NGOs are at the epicenter in seeking means to enhance human life through modernization of technology and infrastructure. The current rate of urbanization, industrialization and environment mismanagement rise environmental issues. The problems are further aggravated with environmental degradation such as soil erosion, depletion of water resources, climate changes, and others. In order to seek answers for these multifaceted challenges, proper planning, implementation and verification exercises are required, via an integrated, multidisciplinary and holistic approach especially in the area of green infrastructure and green cities, development of eco-industry, environmental health and risk assessment, air quality, advanced technology, natural resources and mitigation of climate change. This international conference shall become a momentum for development of sustainable environment through green technology.

The 5th Environmental Technology and Management Conference (ETMC) was held on 23-24th November 2015, at *Sasana Budaya Ganesha, Institut Teknologi Bandung* (ITB). The ITB is located in Bandung, West Java. Bandung is the center of Sundanese culture and volcanoes surrounds city which make Bandung to be a delightful place to host this conference. More than 300 scientific participants (researcher, students, government officers and industries) had many fruitful discussions and exchange ideas that contribute to the success of the conference. Participants of the conference are coming from US, Australia, Nederland, Japan, Malaysia, Singapore and Indonesia, made the conference truly worthwhile globally. There are 4 speakers in plenary sessions covering different areas, and all the keynote speakers are well known and competent speakers; They are Ir. Mochamad Basoeki Hadimoeljono, M.Sc., Ph.D (Ministry of Public Works and Housing, Republic of Indonesia), Prof. Dr. AJM Smits (Director of Institute for Science, Innovation & Society, Radboud University Nijmegen), Albert Simanjuntak (President Director of Chevron Pacific Indonesia) and Ir. Edwan Kardena, PhD (Environmental Engineering, Institut Teknologi Bandung). There were also 5 parallel sessions with eight invited speakers : Prof. Satoshi Okabe; Prof. Ir. Mindriany Syafila, MS; Prof. Ir. Iwan Kridasantausa Hadihardaja, MSc, PhD; Prof. Dr. Takeshi Fujiwara; Rene van Berkel, PhD; Prof. dr. A.M.J. Ragas; Dr. Budi Haryanto, SKM, MKM, MSc; Dr. rer.nat Armi Susandi,MT.

This volume of proceedings from the conference provides an opportunity for readers to engage with a selection of refereed papers that were presented during the conference. These proceedings divided into 6 sections of 110 abstracts as oral presentation and 23 abstracts as poster session with such topics as follows: Air Quality & Climate Change, Green Cities & Infrastructures, Eco-Industries, Appropriate & Advanced Environmental Technology, Natural Resource Management, and Environmental Health and Risk Assessment. Selected papers will be republished in the special issues of Journal of Technological and Engineering Sciences.

Generous support for the conference was provided by Chevron Pacific Indonesia, JICA, BNI, Vale, Sari Husada, Indocement, Holcim, Sabuga and Faculty of Civil and Environmental Engineering, ITB. The funds were sizeable, timely, and greatly appreciated, and allowed us to support a significant number of young scientists (students) and delegates from developing countries.

Finally, the 5th ETMC was a very successful conference. The plenary lectures, parallels session and special reports bridged the gap between the different fields of green technology, making it possible for non-experts in a given area to gain insight into new areas. Also, included among the speakers were several young scientists and students, who brought new perspectives to their fields. Given the rapid advancement of science in all areas that covered by ETMC, we expect that this ETMC was as stimulating as the previous one, as indicated by the papers contributions presented in this proceeding volume.

Bandung, 24 November 2015

Ir Agus Jatnika Effendi, PhD

LIST OF COMMITTEE

STERRING COMMITTEE

Chairman : Prof. Dr. Ir. Mindriany Syafila, MS

1. Prof. Dr. Ir. Wisjnuprapto
2. Prof. Dr. Ir. Enri Damanhuri
3. Prof Ir Suprihanto N, Ph.D
4. Prof. Dr. Ing. Ir. Prayatni Soewondo, MS
5. Prof. Dr. Ir. Arwin Sabar, MS
6. Prof. Dr. Ir Tjandra Setiadi, M.Sc
7. Dr. Ir. Dwina Roosmini, MS
8. Dr. Ir. Edwan Kardena
9. Ir. R. Driejana, MSCE, Ph.D
10. Dr. Herto Dwi Ariesyadi,ST,MT
11. Dr. Rofiq Iqbal, ST,MSc

ORGANIZING COMMITTEE

Chairman	: Ir.Agus Jatnika Effendi, PhD
Secretary	: Emenda Sembiring, ST,MT, MEngSc, PhD
Treasurer	: Dr. Ing Marisa Handajani, ST,MT
Sponsorship coordinator	: Ir. Puji Lestari, PhD
	Ir. Edwan Kardena, PhD
	Dr. Sukandar, SSi,MT
	Dr. Asep Sofyan, ST, MT
Publication	: Dr Mont Kania Dewi ST, MT
	Ir. Indah Rahmatiah, MSc, PhD (proceeding)
	Haryo Satriyo Tomo, ST, MT (internet media)
	Ir. James Nobelia I, MT

Logistic coordinator : Dr. Ahmad Soleh, ST, MT
Dr. Helmy, ST,MT
Drs Daddy Surachman, MS
Ir. Hardjono
Drs. Moh. Irsyad, M.Si

Program Coordinator : Suharyanto, ST,MSc, PhD
Ir Yuniati, MSc, PhD
Dr. Opy K, ST., MT
Dr. Ir. Tri Padmi D

Welcome Dinner coordinator : Dr. Katharina Oginawati

Exhibition/Poster coordinator : Dr. I.M.Wahyu W, ST,MT
Dr. Mochammad Chaerul, ST, MT

SCIENTIFIC COMMITTEE

Chairman : Prof. Dr. Ir. Enri Damanhuri

Secretary : Prof. Dr. Ing. Ir. Prayatni Soewondo, MS

1. Prof. Dr. Ir. Arwin Sabar, MS
2. Prof. Ir. Suprihanto N, Ph.D
3. Prof. Dr. Ir. Mindriany Syafila, MS
4. Dr. Ir. Tri Padmi Damanhuri
5. Dr. Ir. Tresna Dermawan Kunaefi
6. Dr. Ir. Benno R, MT
7. Ir. Pudji Lestari, Ph.D
8. Dr. Ir. Priana Sudjono, MS, Dipl.Eng
9. Ir. Idris Maxdoni Kamil, M.Sc, Ph.D
10. Dra. Barti Setiani Muntalif, Ph.D
11. Dr. Ir. Indah Rahmatiah SS, MSc
12. Ir Arief Sudrajat, MSc,PhD

KEYNOTE SPEAKERS

KEYNOTE SPEAKERS

NAME	THEME
Ir. Mochamad Basoeki Hadimoeljono, M.Sc., Ph.D (Ministry of Public Work and Housing of Indonesia)	Green Infrastructure Research and Development in Indonesia
Prof dr A.J.M. Smits Radboud University Nijmegen	Water, Health, and Sustainability
Albert Simanjuntak, Chevron Pacific Indonesia	Eco Energy Research and Development in Oil and Gas Industry
Dr. Ir. Edwan Kardena, ITB	Microbial Application for Enviromental Pollution Control: “From Laboratorium into The Field”

INVITE SPEAKERS

INVITE SPEAKERS

NAME	TITLE
Prof. Satoshi Okabe	Advance In Biological Nitrogen Removal Process – Anamox – Based Process
Prof. Dr. Ir. Mindriany Syafila,MS	Advance Oxidation Processes (AOPs) For Wastewater Treatment Application
Prof. Ir. Iwan Krisdasantausa Hadihardaja, MSc, PhD	River Regime Change and the Basin Land Use Development Regarding To Healthy River Performance
Prof. Dr. Takeshi Fujiwara	Study On Impact Analysis Of Recycling – Based Municipal Solid Waste Management On Recycling Business Of Informal Sector In Bandung
Rene van Berkel, PhD	Competitive Advantage Through Industrial Resource Efficiency : Pathway Towards Inclusive and Sustainable Industrialization
Prof. dr. A.M.J. Ragas	Modelling Human and Ecological Risks Of Chemicals
Dr. Budi Haryanto, SKM, MKM, MSc	Blood Lead Levels For Human Health Risk Assessment: A Case Of Used Battery Recycling In Indonesia
Dr. rer.nat Armi Susandi, MT	Impact Of International Climate Policy On Air Pollution In Indonesia

CONTENTS

ORAL PRESENTATION

APPROPRIATE AND ADVANCED ENVIRONMENTAL TECHNOLOGY

AGUS JATNIKA EFFENDI PRAYATNI SOEWONDO DAMIR BRDJANOVIC TJANDRA SETIADI	To Support The Development Of Emergency Sanitation Products	
EDWAN KARDENA LUHUR AKBAR DEVIANTO KURNIASIH HERTO DWI ARIESYADY AMINUDIN SULAEMAN	Biosorption And Desorption Of Chromium From Immobilized Microalgae Biosorbent	OP/AE/016
HERLIAN ERISKA PUTRA KANIA DEWI ARI DARMAWAN PASEK ENRI DAMANHURI	Hydrochar Production From Municipal Solid Waste By Hydrothermal Carbonization Under Low Temperature Condition	OP/AE/020
VERA BARLIANTI EKA TRIWAHYUNI JOKO WALUYO AJENG ARUM SARI	Decolorization Of Black Liquor From Bioethanol G2 Production Using Iron Oxide Coating Sands	OP/AE/022
NOPA DWI MAULIDIANY PRAYATNI SOEWONDO	Kinetic Study of COD Removal From Bandung Municipal Wastewater in Continue Moving Bed Biofilm Reactor System	OP/AE/023
TITIK ISTIROKHATUN MUAMMAR FIKRI ZAMANI SUDARNO HERU SUSANTO	Treatment of Landfill Leachate by Using Nanofiltration Membranes	OP/AE/025
DYAH WULANDARI PUTRI DEWI FITRIA MARLISA DIAN ARDINA KUSUMANINGAYU PRAYATNI SOEWONDO AGUS JATNIKA EFFENDI TJANDRA SETIADI	Organic Substance Removal Using Modified Tripikon-S System	OP/AE/026
EDY WIYONO SITI SYAMSIAH SARTO HARWIN SAPTOADI	Combustion of Municipal Solid Wastes by Using Self Burning Incinerator	OP/AE/030

HANA PUSPITASARI NURINA FITRIANI NIEKE KARNANINGROEM	Test in Using Animal Bones as Natural Coagulant for River Water Treatment	OP/AE/032
ANNISA ATHIFAH INDAH RACHMATIAH SITI SALAMI	Quality Improvement Evaluation Of Textile Waste Water Bodies Receiver With Simple Filtration Process (Case Study: Cikakembang River)	OP/AE/033
HERMAWATI WIDYAPRATAMI MINDRIANY SYAFILA	Chemical Oxygen Demand (COD) Kinetics and Removal Efficiency of Biologically Treated Landfill Leachate Bantargebang Landfill with Advanced Oxidation Process of Ozone and Hydrogen Peroxide	OP/AE/035
RISYANA SUKARMA	Pressurized Ceramic Filter And Its Impact In Filtrating Effectiveness	OP/AE/037
AMRINI AMALIA SHAFDAR HERTO DWI ARIESYADY	The Optimization Of Active Cultivated Bacterial Consortium Application In The Activated Sludge Process Of Painting Wastewater Treatment	OP/AE/039
LITA DARMAYANTI EDY SAPUTRA SUPRIHANTO NOTODARMODJO ENRI DAMANHURI ADE ANGGRIAWAN	Kaolin-Based Geopolymeric Adsorbent For Fe And Mn Removal From Peat Water (Research Ongoing)	OP/AE/040
ANDRI GUMILAR MARISA HANDAJANI MINDRIANY SYAFILA	Influence Of N2 Flushing For The Ethanol Production From High Concentration Of Organic Waste	OP/AE/041
HIDAYATUL MUSTAFIDAH BIEBY VOIJANT TANGAHU	Growth Rate Of Scirpus Grossus Egeria Densa And Salvinia Molesta For Wastewater Treatment Of Soil Washing Oil Contaminated	OP/AE/050

TIKA KUMALA SARI ALIA DAMAYANTI	Filtration Laundry Waste Water Using Zeolite Nanofiltration Membrane To Remove Turbidity And Phosphate	OP/AE/053
IPUNG FITRI PURWANTI SITI ZULAIKAH DIDIK BAMBANG SUPRIYADI SETYO BUDI KURNIAWAN	Minimum Inhibitory Consentration of Chromium (III) By Bacteria as Preliminary Test of Chromium Biosorption	OP/AE/055
YUNIATI ZEVI REFNILDA FADHILAH	Heavy Metals Removal From Urban Stormwater Runoff Using Lab-Scale Biofiltration Systems: Influence Of Filter Media Combination	OP/AE/059
QOMARUDIN HELMY MUSFIANDINI ZAHRA SUPRIHANTO NOTODARMOJO	A Small-Scale, Low-Technology Water Treatment Plant: The Treatment Of Raw Water With High Suspended Clay, Iron, And Manganese	OP/AE/060
AINI ZAHRA MARISA HANDAJANI	Water Flow Characterization In Longitudinal Section Of Oxidation Ditch Reactor Using Cfd Simulation	OP/GC/003
SINARDI PRAYATNI SOEWONDO SUPRIHANTO NOTODARMOJO CYNTHIA RADIMAN	Chitosan from *Mytilus virdis linneaus* Shell as a Natural Coagulant	OP/GC/004
ENDAH WAHYUNI BUDI SUSWANTO INDRA KOMARA	Effects Of Angle Of Inclination Cables On The Performance Of Submerged Floating Tunnel Under Hydrodynamic Load	OP/GC/015
AINI ZAHRA MARISA HANDAJANI	Nitrification Kinetics In Aquaculture Wastewater Treatment Using Batch Reactor	OP/GC/025

AIR QUALITY AND CLIMATE CHANGE

ECO-INDUSTRIES

AYU NINDYAPUSPA MASRULLITA YULINAH TRIHADININGRUM	Stabilization/Solidification Of Waste Containing Heavy Metals And Hydrocarbon Using Portland Cement And Bentonit	OP/EI/002
ELZAVIRA FELAZA CINDY RIANTI PRIADI	Implementation Of Cleaner Production In A Natural Dye Batik Industry Sme: A Way To Enhance Biodegradability Of Batik Wastewater?	OP/EI/003
SRI GUSTIANI QOMARUDIN HELMY SUPRIHANTO NOTODARMOJO	Treatment Of Textile Wastewater By Uv/Zno Nanoparticle As An Advanced Oxidation Process	OP/AE/058
R.FATKHURRAHMAN ERLANGGA SYAIFFUL AMRI KEMALA OKTAVIANI YOHAN	A New Prospective Soil Remediation Contamined By Mercury From Artisanal Gold Mining Using Natural Zeolite As A Microtechnology	OP/NR/022
YUYUN ISMAWATI LELITASARI SARAH E. ROTHENBERG SONIA BUFTHEIM	Gold Production In Rural Areas Of Bogor Regency And Its Hidden Hazards Implication	OP/NR/042
DEWI PERMATA IFADIANA JULI SOEMIRAT	An Analysis of the Effect of the Implementation of an Integrated Management System (IMS) on Work Ergonomics in O&M Power Plant Company	OP/OS/001
BIEBY VOIJANT TANGAHU ARSETYO YEKTI BAGASTYO ELSITA OCTARINA NAREGA HERMANIAR HIDAYATUL MUSTAFIDAH	Batik Industry Wastewater Preliminary Toxicity Test Against of Aquatic Plants	OP/AE/043

GREEN CITIES & INFRASTRUCTURES

ANNI ROCHAENI ENRI DAMANHURI MOCHAMMAD CHAERUL TRI PADMI	Factor Analysis Of Solid Waste Collecting System In Bandung City	OP/GC/001
HAFNIDAR A. RANI SUPRIATNA	Green Infrastructure Innovation Towards Sustainable Environment In Aceh	OP/GC/007
WARMADEWANTHI WILUJENG S. PANDEBESIE E. HERUMURTI W. TRIHADININGRUM Y	The Analysis of Household and Commercial Waste Reduction in Surabaya (Case study : Gudeng, Simokerto, and Wonokromo District)	OP/GC/009
MOHD. SYARIF HIDAYAT	Ecological Evaluation Of The Several Urban Green Spaces In Jakarta	OP/GC/014
JUN SAKAMOTO KAZUKATA KUBOTA SHOTARO YADA	Time Series Analysis on Mass Media Report and Utilization on Social Media - Case Of Local Railway	OP/GC/018
FRANSISCA A.D ANGGRAENI NURINA FITRIANI EDDY S. SOEDJONO	Study Of Successful To Stop Open Defecation Free (Odf) In Tutur Subdistrict And Duplication Of Successful In Pandaan Subdistrict, Pasuruan District, Indonesia	OP/GC/019
IENDRA SOFYAN PRAYATNI SOEWONDO TRESNA DARMAWAN KUNAEFI MARISA HANDAJANI	A Review Of Waste Water Treatment Management In Slum Area (Case Study: Greater Bandung Area)	OP/GC/022
DONNY DHONANTO TRIANA SHARLY PERMAISURI ARIFIN CITRA ANGGITA	Master Plan Road Network In The Border Region Of Malinau Regency Of The North Kalimantan Province	OP/GC/026
HERU PURBOYO HIDAYAT PUTRO NUR IDA FITRIANTI	The Role Of Public Participation In Improving Bike Lanes In Taman Ayodya And Banjir Kanal Timur In Jakarta, Indonesia	OP/GC/027
AYU LISTIANI EMENDA SEMBIRING	Evaluation Of Expanded Polystyrene (Eps) Plastic Waste Utilization As An	OP/AE/029

HARMEIN RAHMAN	Asphalt Substitution Material In Asphalt Concrete-Wearing Course Layer	
NIEKE KARNANINGROEM NURINA FITRIANI YULIA PUSPA RACHMANIATI	The Assessment Of River Capacity And Capability In Surabaya City As Basic Determination Of Typical On Site Infiltration System	OP/AE/034
DIEN F. AWALIYAH MARISA HANDAJANI	The Effectivity Of Biopore Infiltration Hole Applications To Increase Water Infiltration Rate In Soil	OP/AE/036
ELVITA SARI SARAGI ARSETO YEKTI BAGASTYO	Reduction Of Organic Solid Waste By Black Soldier Fly (Hermetia Illucens) Larvae	OP/AE/044
SITI BOEDI DARMA	Appropriate Waste Water Infrastructure For Sustainable Informal Housing Settlement In Bandung	OP/AE/048
WILMA NURRUL ADZILLAH EMENDA SEMBIRING MARISA HANDAJANI	Alternative Selection Of Waste Water Treatment In Depok City Using Dependence And Driving Power Analysis (DDPA) And Analytic Network Process (ANP) Method	OP/NR/011
WONG LI HUN FAUZIAH SHAHUL HAMID	Municipal Sanitary Landfill Leachate Characterization And Its Acute And Chronic Effects On Survival, Development And Growth Of Larval Dark-Sided Chorus Frog, Microhyla Heymonsi	OP/NR/016
SRI MARYATI AN NISAA' SITI HUMAIRA	Co-Benefits Of Community Based Water Supply Management	OP/NR/018
KIYOSHI WADA YUKIO OTA	Development Of The Siphon System Pipe-Type Fishway And Monitoring Of Fish Migration	OP/NR/019

ANNISA NUR SABRINA INDAH RACHMATIAH S. S.	Evaluation Of Raw Water Quality In Pdam Bandung (Study Area : Dago Bengkok, Bantar Awi, Dan Cikalong	OP/NR/023
LAURENTIA MUTIARA SANI WIDYAWATI HERTO DWI ARIESYADY MOCHAMMAD CHAERUL	Seasonal Variation Impact of Leachate Contamination to Shallow Groundwater in Burangkeng, Bekasi District, West Java, Indonesia	OP/NR/027
PUTRI CHISSY RAEZA RIANTI HERTO DWI ARIESYADY SISKA WIDYA DEWI KUSUMAH	Study On Bacterial Contamination And Its Dispersion In Groundwater Of Burangkeng Landfill Site, Bekasi Regency, West Java, Indonesia	OP/NR/028
I M A K SALAIN I K SUDARSANA W MUSTIKA	Mechanical Properties Of Concrete Using Nickel Slag As Coarse Aggregate	OP/NR/039
YOSHITAKA EBIE KEIZOU NIKI HIROSHI YAMAZAKI	Japanese Decentralized Domestic Wastewater Treatment System And Its Resilience To Natural Disaster	OP/NR/040
DEWI SARTIKA	Safety Study Of Using Salmonella Phage As A Natural Anti Microbe To Decrease Salmonella Contaminant On Food And Environmental	OP/OS/005
MUHAMMAD IQBAL ANINDYA NASTITI BARTI SETIANI MUNTALIF	Improved But Not Always Safe: A Microbial Water Quality Analysis In Bandung Peri-Urban Households	OP/OS/009

NATURAL RESOURCES

JEFRI FERLIANDE IDRIS MAXDONI KAMIL AKHMAD RIQQI	Application of Ordinary Kriging And Idw For Predicting Soil Contaminants Distribution in Industrial Area, Case Study: Rancaekek – Indonesia	OP/NR/001
MARIANA MARSELINA ARWIN SABAR INDAH RACHMATIAH SITI SALAMI	Optimization Management Of Hydroelectric Energetic Exploitation Saguling Reservoir In Upper Citarum Cascade	OP/NR/002

DESSAEDA ADILLA IDRIS MAXDONI KAMIL	Economic Valuation Of Perum Perhutani's Community Based Forest Management (Cbfm) And Its Application As Riparian Buffer Zone Of Cipanji-Cisondari River In Bandung Regional	OP/NR/013
EVY HENDRIARIANTI NIEKE KARNANINGROEM	Rate Of Nitrification-Denitrification Brantas River In The City Of Malang	OP/NR/014
EKA WARDHANI SUPRIHANTO NOTODARMOJO	Assessment Of Heavy Metal Contamination In Surface Water And Sediments: A Case Study From Saguling Lake, West Java	OP/NR/015
ANDRI WARSA KADARWAN SOEWARDI	Estimation Of Phosphorus Loading And Its Impact On Eutrophication At Jatigede Reservoir, Sumedang-West Java, Indonesia	OP/NR/020
HERTO DWI ARIESYADY AMALIA RIZKA RAHMANI	The Diversity Of Nitrogen Cycling Bacteria As A Bioindicator Of Domestic And Industrial Wastewater Pollution In The Sediment Of Upper Citarum River, West Java, Indonesia	OP/NR/030
LUFIANDI GERTJAN GEERLING AGUS JATNIKA EFFENDI DWINA ROOSMINI	Water Quality Management And Water Pollution Control Under Decentralization In Indonesia: The Case Of Upper Citarum River Basin	OP/NR/032
RATIH PRATIWI INDAH RACHMATIAH SS	Combination Of Eichhornia Crassipes, Pistia Stratiotes, And Salvinia Molesta To Improve Water Quality Of Upstream Citarum River	OP/NR/038
KANIA DEWI YUYUN ISMAWATI	Inventory of Mercury Releases In Indonesia	OP/NR/041
YUNIATI ZEVI DEIFY NOVANDY MINDRIANY SYAFILA	Removal Of Iron And Manganese Ions From Groundwater By Sukabumi Greenstone: The Role Of Natural And Activated Modernite	OP/NR/043

GARY WOLINSKY TRI WISONO JAMAR SYAKIR	Net Environmental Benefit Analysis (NEBA) To Minimze Impacts On Communities And The Environment : Concept, Application And Case Studies	OP/NR/049
SARA McMILLEN TRI WISONO	Risk Based Screening Levels For Remediation Sites In Sumatera, Indonesia	OP/NR/050
DENI RUSMAYA FADJARI LUCIA NUGROHO YONIK M. YUSTIANI FAJAR IBNIL HAFIZ RUNIE B.T. PUTRI	Improving Artificial River Water Quality Using Mudballs Made From EM4, Rice Bran And Clay Soil	OP/AE/002
AMANDA LARASATI SUPRIHANTO NOTODARMOJO	Equilibrium and Kinetics of Orthophosphate Adsorption onto Indonesian Tropical Soils	OP/AE/011
NURUL CHAZANAH BARTI SETIANI MUNTALIF GEDE SUANTIKA PRIANA SUDJONO	Determination River Water Quality With Bioassessment Using Benthic Macroinvertebrates (Case Study : Citarum Upstream, West Java, Indonesia)	OP/AE/021
BIEBY VOIJANT TANGAHU ROCHMA SEPTI VYATRAWAN PRESTIANI PUTRI	The Effectivity of Adding Aeration Against Bioremediation Oil-Contaminated Soil	OP/AE/042
PLATO MARTUANI SIREGAR RUSMAWAN KARIN NADIRA DAUWANI	Standardized Precipitation Index Analysis For Drought Study Case At The Indramayu Region Crop Area West Java	OP/AQ/009
REGINAWATI HNDERSAH MARTHIN KALAY SONDI KUSWARYAN WAWAN HERMAWAN	Application Of Biofertilizer To Decrease Inorganic Fertilizer Dosage In Leafy Vegetables Production In Ambon, Mollucas	OP/GC/006
REO AUDI \	Eco Innovation On Marine Litter Prevention : Case Studies Around The World	OP/GC/012
TAKAHIRO SHIMIZU	An Importance of Past Disaster Records – A Case Study of its Application After the Noubi Earthquake in Gifu –	OP/GC/017

EDDY SETIADY SOEDJONO NURINA FITRIANI AULIA RAMADANO	Study of the Involvement Financier in MDGs Sustainability in 2015 and Accelerate Achievement of the National Medium Development Plan in 2019 at Mojokerto	OP/GC/020
AFIF FAIQ MUHAMMAD SUSI. A. WILUJENG IDAA WARMADEWANTHI WELLY HERUMURTI ELLINA S. PANDEBESIE YULINAH TRIHADININGRUM	Evaluation of Non- Residential Solid Waste Collection In Simokerto District, Central Surabaya	OP/GC/021
YULIANA SURYANI ALIA DAMAYANTI EDDY SETIADY SOEDJONO ZULKIFLI YUSOP EIICHI NAKAKITA SUNMIN KIM	Flood Handling of Madiun River as a part of Bengawan Solo Waterhed by Utilizing the Capacity of Environment in Madiun City	OP/GC/029

OCCUPATIONAL SAFETY AND HEALTH

LEE VOTH-GAEDDERT IDRIS MAXADONI KAMIL DWINA ROOSMINI DANIEL OERTHER	Identifying The Long Term And Short Term Feedback Loops Impacting National Child Health Levels In Guatemala; An Application Of System Dynamics Modeling	OP/OS/006
DINA LUSIANA NUR ROHMAH	Safe Behavior on Workers Division of MSD in PT XYZ Kalimantan East Kalimantan	OP/OS/008
SYAHBANIATI PUTRI ANINDRYA NASTITI BARTI SETIANI MUNTALIF	Applying Quantitative Microbial Risk Assessment in Household Drinking Water Sources: A Case Study of Ujungberung Subdistrict, Bandung	OP/OS/010
ANINDRYA NASTITI BARTI SETIANI MUNTALIF ARIEF SUDRADJAT DWINA ROOSMINI	Water Monitoring Beyond MDGs: A Case Study of Peri-Urban Bandung, Indonesia	OP/OS/011

A.J.M. SMITS S.V. MEIJERINK		
FAIRUZ ZAHARANI INDAH RACHMATIAH SITI SALAMI	Urine and Hair Mercury Levels as Indicator Mercury Exposure in Artisanal Gold Miner in Desa Pasar Terusan Kecamatan Muara Bulian Kabupaten Batanghari-Jambi	OP/AE/051
SUDARNO PERTIWI ANDARANI M. AGUNG WIBOWO ASHANTHA GOONETILLEKA	Evaluation of Factors That Influence Performance of the Decentralized Wastewater Treatment System 'Sanimas'	OP/GC/013

POSTER PRESENTATION

APPROPRIATE & ADVANCED ENVIRONMENTAL TECHNOLOGY

IMAN DIMASSETYA YANUAR YUSUF SAHAT RICKY PRANATA OMPUSUNGGU ARSETO YEKTI BAGASTYO	Salt Recovery from Reverse Osmosis Concentrate Using Electrodialysis	PP/AE/002
YULINAH TRIHADININGRUM RHENY RATNAWATI INTAN DWI WAHYU SETYO RINI ARYA GHALI ARUDAM IDAA WARMADEWANTHI SRI RACHMANIA JULIASTUTI	Composting Process of Slaughterhouse Solid Waste Using Aerobic System	PP/AE/004
VERA BARLIANTI EKA TRIWAHYUNI DIAN BURHANI NURHASNI YANNI SUDIYANI	Xylitol Production from Residual Fermentation Broth of Bioethanol G2 Using Apergillus Niger	PP/AE/005
MURYANTO AJENG ARUM SARI	Degradation of Black Liquor Wastewater from Bioethanol Process Using	PP/AE/006

HAZNAN ABIMANYU	Coagulation and Fenton Methods	
HITOE HABUCHI SHIORI FUJITA HIROFUMI TAKIKAWA	Photosensitivity of Graphitic Carbon Nitride Films Obtained by Evaporation	PP/AE/009
YULINAH TRIHADININGRUM RHENY RATNAWATI RIMA AULIYATI WULANDARI DEQI RIZKIVIA RADITA SRI RACHMANIA JULIASTUTI	Comparison of Slaughterhouse Solid Waste Treatment Using Anaerobic-Anoxic-Oxic and Aerobic Composting Methods	PP/AE/010
MUCHLIS MUNAWAR RITA ANGGRAINI	Synthesis of Lauryl Alcohol (Dodecanol) from Methyl-Laurate Ester using Zinc-Borohydride in Combination with Zinc-granular and Molecular Hydrogen (H2, gas) in Mild Condition	PP/AE/011
WILDA CHARISMA YUNAZ ARSETO YEKTI BAGASTYO	Subsequent Fenton Process and Neutralization for Wastewater Treatment of Textile Home Industry	PP/AE/013
FERI ARIYANTO ELLINA S.PANDEBESIE	A Mixture of Coconut Husk Waste and Water Hyacinth as a Medium of Oyster Mushroom Growth	PP/GC/004
DITA YUSTINE WINDANINGRUM TRIMURTI HESTI WARDINI	The Effect of Sarimukti Compost to Marginal Soil Quality and the Growth and Productivity of Capsicum Frutescens L.	PP/NR/007

GREEN CITIES & INFRASTRUCTURES

MUHAMMAD SAFRI LUBIS EMENDA SEMBIRING	Using GIS Web-Based To Show Environmental Status: A Case Study At Medan Environmental Bureau (BLH)	PP/AE/015
KOJI TAJIMA SHINYA NAKAMURA	A Prototype of Location Information Infrastructure using iBeacon for the	PP/GC/001

TADAHIKO SATO SHIGERU KOBAYASHI	Bicycle Touring	
NURHAWA ABDUK RASHID AGAMUTHU P. FAUZIAH S.H.	Zinc Flow in A Municipal Solid Waste Landfill in Malaysia	PP/NR/004
ANNA FADLIAH RUSYDI JANUARI RIDWAN	Groundwater Quality in Coastal Aquifers	PP/NR/005
M.C. TRI ATMODJO	The Environmentally Friendly Slow Release Nitrogen Fertilizer Applied in Sugarcane (*Saccharum officinarum)*	PP/NR/008
SYARIFAH MELLY MAULINA EMENDA SEMBIRING	An Analyzing of Community's Ability and Willingness to Pay For Drinking Water Supply at Coastal Area (A Case Study at Telok Batang District, Kayong Utara Regency, West Borneo Province)	PP/NR/009
YUYUN ISMAWATI KRISHNA ZAKI SONIA BUFTHEIM ARWIN SABAR PRAYATNI SOEWONDO YADI SURYADI	Mercury Vapour In 3 ASGM Hotspots In Indonesia: Bombana, Sekotong, and Cisitu	PP/OS/002

AIR QUALITY & CLIMATE CHANGE

HAFIDAWATI PUJI LESTARI ASEP SOFYAN	Investigation of $PM_{2.5}$ and Black Carbon Concentration From Rice Straw Open Field Burning in District Cianjur, West Java	PP/AQ/002
YENY DHOKHIKAH YULINAH TRIHADININGRUM ELLINA SITEPU PANDEBESIE SONY SUNARYO	Estimation of GHGs Emission From Household Solid Waste Reduction in Sukolilo District, Eastern Subaya, Indonesia	PP/AQ/005

NATURAL RESOURCE MANAGEMENT

ENVIRONMENTAL HEALTH AND RISK ASSESSMENT

The 5th Environmental Technology and Management Conference "Green Technology towards Sustainable Environment" November 23 - 24, 2015, Bandung, Indonesia.

ISBN : 978-979-98278-5-2

LIFE CYCLE ASSESSMENT OF INTEGRATED PALM OIL INDUSTRY WITH SCENARIOS OF LIQUID AND SOLID WASTES UTILIZATION AND INTEGRATION WITH CATTLE FARM

Suprihatin [a,*,†], *Email: suprihatin167@gmail.com*

Andre Wahyu Nugroho[a], *Email: andrew0189@gmail.com*

Ono Suparno [a], *Email: ono.suparno@gmail.com*

Sarono [b], *Email: saronotipipb@yahoo.com*

[a] *Department of Agro-Industrial Technology, Institut Pertanian Bogor, Indonesia*

[b] *Agricultural Technology Study Program, State Polytechnic of Lampung, Rajabasa-Bandar Lampung, Indonesia*

** Presenter; † Corresponding author.*

Abstract: *This research work used Life Cycle Assessment (LCA) as a tool for identification possibilities for improvement of crude palm oil (CPO) production, focusing on energy efficiency and greenhouse gas emission aspects. The research was conducted with two cases of palm oil mill (POM). Results showed that energy consumption for production of one ton CPO was 6313 MJ in POM 1, with a Net Energy Ratio (NER) of 6.2 and a Net Energy Value (NEV) of 33.03 GJ/ton CPO, while energy consumption in POM 2 was 7270 MJ/ton CPO with NER of 5.4 and NEV of 32.08 GJ/ton CPO. The GHG emmisions in the case POM 1 and the case POM 2 were 1463 and 624 kg* CO_2 *–eq/ton CPO, respectively. The identified most potential opportunity to improve energy efficiency and reduce emission is the utilization of biogas from anaerobic decomposition process of wastewater as an energy source of power plant. The scenario can reduce emission of approx. 970 kg* CO_2*–eq/ton CPO (POM 2) resulting in NER and NEV increases of up to 5.7 and NEV of up to 33.83 GJ/ton CPO. A further significant improvement of CPO production process can be achieved through the integration of the oil palm plantation with cattle farm and the utilization of solid waste as an organic fertilizer.*

Keywords: Crude palm oil, greenhouse gas emission, integrated oil palm plantation, Life Cycle Assessment, net energy efficiency

1. Introduction

Indonesia is the biggest Crude Palm Oil POM 1(CPO) producer in the world with a production of 27 million tons CPO in 2013 (Ditjenbun 2014). The development of palm oil industry will increase further as the Government of Indonesia targeted to produce 40 million tons CPO per year by 2020. To support the achieving of the target, the government will allocate some forest area for oil palm plantation in according to the National Forestry Plan 2011-2030 (Kemenhut 2011).

The rapid growth of the oil palm industry had caused the environmental impacts. Palm oil industry activities from nursery, planting, fertilizing, energy use, and management of the wastes are considered as sources of greenhouse gas (GHG) emission. The GHGs absorb and reflect infrared radiation resulting in an increase in temperature of the earth (Cicerone 1987). The environmental issues are becoming more serious attentions from international communities leading to the decrease of the competitiveness of Indonesian CPO in the international market.

In order to improve the international competitiveness of Indonesian oil palm products, the government of Indonesia implements regulations arranged in the Indonesian Sustainable Palm Oil (ISPO) consisting of seven principles: licensing system and plantation management, application of technical guidelines for the cultivation and processing of palm oil, environmental management, responsibility to workers, social responsibility, empowerment of economic activities, and increased efforts for sustainability. According to the criteria, the corporate environmental management needs to identify and manage the source of GHG emissions (Ditjenbun 2014). Life cycle assessment (LCA) can be applied to in-depth environmental evaluation process of CPO production. The methodology enables a holistic life cycle thinking, comprehensive identification of potentials and opportunities for improvement of the CPO production process.

This research work aimed to develop an inventory of environmental burdens by identifying and quantifying energy and materials used and wastes released by palm oil production process. The results are expected to provide can benchmark for assessment and improvement of CPO production processes covering resource use, energy efficiency, and the impact on the environment.

2. Research Methodology

The LCA is realized by the quantitative identification of all material and energy input-output flow at the CPO production system, with attention focused on the energy efficiency and the environmental impact. The analysis of environmental impact of CPO production process is given at all stages of its life cycle, starting from the nursery, oil palm plantation, FFB transportation, and FFB processing (or CPO extraction), including scenarios of the capturing and utilization of methane from anaerobic degradation of wastewater, integration of oil palm plantation with cattle farm, and utilization of solid waste as an organic fertilizer.

This study was conducted with two cases, namely palm oil mill (POM) 1 (case 1) and POM 2 (case 2). The POMs are owned by the State-Owned Enterprises. The POMs are different in many aspects; including distance between plantation area and POM, POM production capacity, type of product, ISPO certification, and biogas electric generation plant (Table 1).

Tabel 1 Characteristics of POM 1 dan POM 2

	POM 1 (Case 1)	**POM 2 (Case 2)**
Plantation area	5870 ha	7667 ha
Production capacity	40 ton FFB/h	40 ton FFB/h
Main product	CPO & PKO	CPO & PKO
ISPO certification	No	Yes
Biogas electric generation	No	Yes

Inventory analysis was undertaken by analyzing the mass and energy flows at the CPO production process life cycle. The materials and energy flows are standardized in the unit per ton CPO produced. Inventory data are collected from field observation, in-depth interviews, corporate documents, and relevant scientific publications. The impacts of the CPO production are evaluated based on the results of the inventory analysis referring to the net energy and the GHG emissions in the CPO production process.

The CO_2 emission (E) per ton CPO is estimated by referring to the equation in the IPCC (2006):

$$E = A.EF \quad (1)$$

where A is inventory volume, and EF is emission factor (kg $CO_{2\ -eq}$/A).

Energy consumption is converted in a standardized energy unit (Joule) to estimate the net energy ratio (NER) and the net energy value (NEV). The energy consumption (E_n) for production of one ton CPO is estimated by using Eq. 2:

$$E_n = n.CV \quad (2)$$

where n is inventory volume, CV is calorific value of each inventory.

Energy efficiency is expressed in NER and NEV that are calculated by using Eq. 3 and 4, respectively:

$$NEV = \sum En_o - \sum En_i \quad (3)$$
$$NER = \sum En_o / \sum En_i \quad (4)$$

where NEV is net energy value, NER is net energy ratio, $\sum En_o$ is total energy earned, and $\sum En_i$ is total energy used.

The net energy is used as indicator of the process performance. For a good process performance, NEV should be positive and NER should be more than 1. The higher the value of NER and NEV, the better is the performance of the CPO production process, in the context of energy consumption and energy recovery

3. Results and Discussion

3.1 Inventory of CPO Production

CPO production process life cycle is started with nursery and plantation. At these stages, impacts on the environment are caused by the use of synthetic fertilizers, pesticides, herbicides, and diesel (RSPO 2012). Fertilizer is one of the major emitters in agriculture, so that its use should receive special attention (Vijaya *et al* 2008b).

Both synthetic and organic fertilizers can be applied in palm oil plantations. The synthetic fertilizers include urea, NPK fertilizer, Kieserite, MOP (Muriate of Potash), dolomite, and TSP/RP. The application of the fertilizers causes emission from the fertilizer production itself (use of fossil energy during the production production), transportation, direct emissions from the field both physically and biologically by soil microbes, and indirect emissions due to re-deposition (RSPO 2012). The oil palm plantations also use organic fertilizers derived from solid wastes such as empty fruit bunches and wastewater sludge, but the applied organic fertilizers are still relatively small in quantity, so that the emissions by organic fertilizer are not taken into account in the emission calculation.

Pesticides and herbicides also have an impact on the environment because it can produce emissions. Pesticides and herbicides have substantial emissions as stated by ISCC (2011). The pesticides are applied only if the plantation is attacked by pests such as caterpillars and beetle horns. Herbicides are used to control weeds around the oil palm trees.

The next inventory analysis is the transportation of FFB from the field to the palm oil mills. FFB transportation is done by using diesel-fueled trucks. Diesel consumption is taken into account in the analysis of usage due to the use of direct impact on the environment (IPCC 2006). FFB is transported from the field to the POMs by using trucks with an average capacity of 9 tons. Diesel consumption for the transportation is estimated based on consumption of diesel trucks per km distance. Empty trucks require diesel of 0.25 liters / km, while loaded trucks (10 ton FFB/truck) require diesel of 0.49 liters / km (ISCC 2011). The map of plantation area is used to estimate the distance of FFB transportation.

The final stage of the oil palm life cycle is the FFB processing to extract CPO. FFB is going through a series of processes: weighing, sorting, boiling, pressing, and oil refining. Inventory at the FFB processing consist of the utilization of electric, diesel and steam (ISCC 2011, RSPO 2012). Electricity from steam turbine is used to run various processing machines. Diesel is used as fuel for electric generator when the electricity from boiler have not been adequat for covering the electricity demand. Steam obtained from the boiler is used in the boiling FFB process.

Table 2 shows the results of the analysis of inventory based on operation data of the studied POMs during 2013. Energy consumption and earning, as well as GHG emissions at every stage of the life cycle are also presented in Table 2, which will be discussed later in the sub-chapter 3.2.

The use of the inventory at the nursery and plantations stages for POM 2 is greater than it is for POM 1. This is because of the lower crop productivity for POM 2 in the time. Palm oil plantation of POM 2 experienced rejuvenation of plantation crops and many plantation areas did not produce FFB optimally yet, while utilities such as fertilizers were needed for the young crops. The differences in inventory of both cases as presented in Table 2 are caused mainly by the condition of the plantation (crop productivity), distance of plantation and POM location, the capacity of POM, and operational practices in both plantation and the palm oil mills.

3.2 Energy Efficiency and GHG Emission

Each identified inventory has a specific calorific value as presented in Table 3, representing the energy value of each inventory volume. Results of energy calculations according to the Eq. 2 are presented in Table 2. Table 4 shows the NEV and NER calculated using the Eq. 3 and 4. The specific energy consumptions for CPO production are 6330 MJ for POM 1 and 7270 MJ for POM 2. Differences in energy efficiency represented by NER and NEV are resulted from differences in conditions of the oil palm plantation (crop productivity), the distance between the plantation and POM location, the use of agricultural inputs (fertilizers, pesticides, and herbicides), the capacity and efficiency of the FFB processing mills. The most important factor of the CPO proses performance is the efficiency of palm oil extraction. The CPO yields were 23.46% (1 ton CPO/4.26 ton FFB) for POM 2 and 20.71% (1 ton CPO/4.83 ton FFB) for POM 1.

Utilization of the methane gas from the anaerobic decomposition of wastewater as an energy source for electricity generation will improve energy efficiency that is indicated by the increase of the NER and NEV. The generated methane gas is about 12.36 kg CH_4 / ton palm oil mill effluent (Yacob *et al* 2006). One kg of methane gas is equivalent to 45.1 MJ (JRC 2011). POM 2 has been equipped with the installation of a biogas power plant that generates electrical energy of 1750 MJ/ton CPO. By taking into account of the generated as the energy output in the life cycle assessment, the NER and NEV in POM 2 will increase to 5.7 and 33.83 GJ/ton CPO, respectively.

Tabel 2 Inventories, energy consumption, and GHG emission of POM 1 and POM 2

Stage of the life cycle, and the inventories	**Unit**	Quantity (per ton CPO)		Energy (MJ/ton CPO)		Emission (kg CO_2 –eq/ ton CPO)	
		Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
Nursery and Plantation:							
FFB	ton	4.83	4.26				
N Fertilizer	kg	2.57	0.33	360.86	1086.72	15.11	1.92
P Fertilizer	kg	4.80	10.71	51.79	115.57	4.85	10.82
K Fertilizer	kg	8.96	31.47	44.80	157.34	5.11	17.94
Urea	kg	11.29	23.04			37.35	76.28
Kieserit	kg	0.26	0.66			0.05	0.13
Dolomit	kg	26.29	28.03			3.42	3.64
Herbicides	liter	0.05	0.27			0.54	2.93
Pesticides	liter	0.02	-			0.16	0.00
FFB Transportation							
Diesel	liter	3.25	3.76	116.86	135.32	8.67	10.04
FFB Processing:							
Electricity	kWh	58.35	67.60	210.06	243.35	52.51	60.84
Diesel	liter	0.79	0.91	28.31	32.60	2.1	2.42
Stream	kg	2360.49	2360.01	5499.94	5498.83	437.39	437.31

Stage of the life cycle, and the inventories	Unit	Quantity (per ton CPO)		Energy (MJ/ton CPO)		Emission (kg CO_2 –eq/ ton CPO)	
		Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
Water	m^3	2.19	4.96				
Products:							
CPO	ton	1.00	1.00				
Palm kernel oil	ton	0.27	0.24				
Mesocarp Fiber	ton	0.65	0.59				
Shell	ton	0.32	0.36				
Empty fruits bunchs (EFB)	ton	0.95	1.26				
Wastewater	m^3	2.90	3.14			895.38	-
Total						1462.65	624.26

Table 3 Energy inventory conversion factor

	Conversion factor	Unit	Reference
N Fertilizer	46.5	MJ/ kg	Dai *et al* (2006)
P Fertilizer	10.79	MJ/ kg	Dai *et al* (2006)
K Fertilizer	5	MJ/ kg	Dai *et al* (2006)
Herbicides	262.11	MJ/ liter	Dai *et al* (2006)
Pesticides	310.35	MJ/ liter	Sheehan *et al (*1998)
Electricity	3.6	MJ/ kWh	-
Diesel	35.99	MJ/ liter	IPCC (2006)
Steam	2.33	MJ/ kg	Horsono 2012
CPO	39.36	MJ/ kg	Van Zutphen and Wijbrans (2011)
Methane gas (CH_4)	45.1	MJ/ kg	JRC 2011

Tabel 4 Total energy consumption, energy earning, NER and NEV of CPO production

	Unit	POM 1 (Case 1)	POM 2 (Case 2)
Energy consumption	MJ/ton CPO	6313	7270
Energy earning	MJ/ton CPO	39,360	39,360
NER (-)	-	6.2	5.4 →5.7*
NEV	GJ/ton CPO	33.03	32.08 →33.83*

*With capture and utilization of wastewater biogas

The GHG emissions are affected by the materials and energy uses in the life cycle. The GHG emissions from production processes of 1 ton CPO at each stages of life cycle was calculated using Eq. 1 are presented in Table 2. The greatest GHG emissions is identified came from the CPO extraction. Total emissions released from two cases differ greatly, where case 1 and case 2 emit 1463 and 624 CO_{2-eq}/ton CPO, respectively. The great difference is mainly due to the emission from wastewater. POM 2 applied methane capture and utilization technology resulting in energy substitution and GHG emission reduction. In opposite, POM 1 treated the wastewater without methane emission control. Methane is 25 times harmful than carbon dioxide in term of the GHG effect (IPCC 2007). During the year 2013, POM 1 produced around 157 thousand m^3 of wastewater which is equivalent to 895 kg of $CO_{2\ \text{-eq}}$ / ton CPO.

According to Hutzler (2004), one kg COD (chemical oxygen demand) in wastewater can be converted to 0.6 m^3 of biogas. The calorific value of biogas is approx. 6 kWh/m^3, which is equivalent to 0.5 liter of diesel. Each kg of CH_4 produced is equivalent to 45.1 MJ (JRC 2011). POM 2 has a biogas power plant with a capacity of 1 MWh. The electricity generated is used for the purposes of the plant (in this case, used for PKO production process). The average electricity generated is 900 kWh which is equivalent to about 70 liters of diesel per hour. With the methane capture and utilization as electric generation, POM 2 can reduce CO_2 emissions by 970 kg $CO_{2\text{–eq}}$/ton CPO or approximately 60%.

3.3 Other Potential Opportunities

Some oil palm plantations have been implementing the integration of the management of oil palm plantation with cattle business. As the form of integration, cattle obtains feed in the form of the stem of oil palm tree, grass, and POM solid waste. One adult cattle produces about 4 ton dung per year that can be used as compost or additional substrate for biogas production. Furthermore, the utilization of forage growth among the oil palm trees as cattle feed will reduce the use of herbicides as a weed killer. Thus, the integration of cattle farm into the management of oil palm will be able to save both the use of inorganic fertilizers and herbicides. Research of the Animal Husbandry Office of Jambi Province (2003) showed that a hectare of oil palm plantations could meet about 80% of the one cattle feed.

The palm oil industry generates solid waste such as empty fruit bunches (EFB), stem, shell, and fibers. Management of the solid wastes is until now still not optimum yet. So far, the wastes are just burned and a part is scattered on the field as mulch. In other side, the solid waste is potentially a source of nutrients that can replace synthetic fertilizers (Urea, TSP, etc.). EFB contains nutrients such as N, P, K and Mg; 1 ton EFB is equivalent to 3 kg of urea; 0.6 kg CIRP (P= 30-35%); 12 kg MOP; and 2 kg Kieserite (Lubis and Tobing, 1989). About 5 thousand tons EFB is produced in POM 1 and POM 2 in 2013. If all the generated EFB is used as organic fertilizer, organic fertilizer it will produce fertilizers that are equivalent to 15 ton urea, 3 ton CIRP, 60 ton MOP, and 10 ton Kieserite. The use of organic fertilizer will reduce the use of synthetic fertilizers that result in reduction of CO_2 emissions. Based on the equivalence of each fertilizer, the use of organic fertilizer as substitution of synthetic fertilizer would reduce emissions by 75 tons of $CO_{2\ \text{-eq}}$ / year, or about 1.5 kg $CO_{2\ \text{-eq}}$ / ton CPO.

4. Conclusions

The amount of resources (inventories) to produce CPO is influenced by various factors at each stage of the life cycle, covering the FFB production activities in the plantation, FFB transportation and CPO extraction. The energy consumption for production of 1 ton CPO is 6313 MJ for POM 1 and 7270 MJ for POM 2, respectively. The most energy consumption is for the extraction of palm oil, which is about 80-90 percent. With NER of 5.4-6.2 and NEV of 32-34 GJ/ton CPO, energy earning through the production of CPO is relatively high. The GHG emission from CPO production is estimated around 1,500 $CO_{2\text{-eq}}$ / ton CPO, where the greatest emission is coming from wastewater treatment and disposal. With the application of technology for methane capture and utilization of methane from anaerobic decomposition process of wastewater as renewable energy source for generating electricity, for example in the case of POM 2, NER and NEV value can be increased, respectively from 5.4 to 5.7 and from 32 to almost 34 GJ/ton CPO, and GHG emission reduction can be up to 970 kg CO_{2-eq}/ton CPO. A further significant improvement of CPO production process performance can be achieved through the integration of the oil palm plantation with cattle farm and the utilization of solid waste as an organic fertilizer.

References

[1] [Ditjenbun] Direktorat Jendral Perkebunan. 2014. *"Peran Strategis ISPO Dalam Bisnis Produk Kelapa Sawit*". http://ditjenbun.pertanian.go.id. [Accessed on April 20, 2014]
[2] [IPCC] Intergovernmental Panel on Climate Change. 2006. *IPCC Guidelines for National Greenhouse Gas Inventories Volume 2: Energy*. www.ipcc.ch. [Accessed on March 23, 2014]
[3] [ISCC] International Sustainabilityaccessed on and Carbon Certification. 2011. *GHG Emissions Calculation Methodology and GHG Audit.* www.iscc-system.org [Accessed on April 20, 2014]
[4] [JRC] Joint Research Center of the EU Commission, [EUCAR] European Council for Automotive Research and Development, [CONCAWE] Oil companies' European association for environment, health and safety in refining and distribution. 2011. *Well-to-wheels analysis of future automotive fuels and powertrains in the European context.* http://ies.jrc.ec.europa.eu/WTW
[4] [Kemenhut] Kementerian Kehutanan Republik Indonesia. 2011. *Rencana Kehutanan Tingkat Nasional (RKTN) 2011-2030.* http://www.dephut.go.id. [Accessed on 20 April 2014]
[5] [RSPO] Roundtable on Sustainable Palm Oil. 2012. *A Greenhouse Gas Accounting Tool for Palm Products*. Malaysia. www.rspo.org [Accessed on April 20, 2014]
[6] Cicerone R.J. 1987. *Changes in Stratospheric Ozone*. J. Science 237, p. 35-42.
[7] Dai, D., Hu, Z., Pu, G., Li, H., Wang, C. 2006. *Energy efficiency and potentials of cassava fuel ethanol in Guangxi region of China.* Energy Conversion and Management 47 , p. 1686–1699.
[8] Honsono N. 2012. *Analisis Life Cycle Bioetanol Berbasis Singkong Dan Tandan Kosong Kelapa Sawit di Indonesia.* Skripsi. Fakultas Teknik. Universitas Indonesia
[9] Hutzler N. 2004. Solid Waste Management. Lecture Note online. www.cee.mtu.edu/~hutzler/ce3503/ Solid Waste Managementnjh.ppt. [Accessed on 22 April 2014]
[10] Lubis dan Tobing. 1994. *Penggunaan Betagen-Rispa Untuk Pengendalian Limbah Kelapa Sawit*. Berita PPKS 2 (3), p. 221-230
[11] Sheehan J, Camobreco J, Duffield M, Graboski dan Shapouri. 1998. *Life Cycle Inventory Of Biodiesel And Petroleum Diesel For Use In An Urban Bus. NREL/SR-580-24089 Golden, Colo.: National Renewable Energy Laboratory*
[12] Van Zutphen JM, R.A. Wijbrans RA. 2011. *LCA GHG emissions in production and combustion of Malaysian palm oil biodiesel*. Journal of Oil Palm & The Environment 2, p. 86-92.
[13] Vijaya S.A., Ma A.N., Choo Y.M., Nik Meriam N.S. 2008. *Life cycle inventory of the production of crude palm oil - A gate to gate case study of 12 palm oil mills*. Journal Of Oil Palm 30 Research 20, p. 484-494.
[14] Yacob S., Hassan M.A, Shirai Y., Wakisaka M., Subash S. 2006. *Baseline Study of Methane Emission from Anaerobic Ponds of Palm Oil Mill Effluent Treatment*. Science of the Total Environment 366, p. 187-196