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1st INTERNATIONAL JOINT CONFERENCE ON ADVANCED ENGINEERING

ICT Center - Diponegoro University
18-19 October, 2012

"REACH UP GREEN TECHNOLOGY"

Faculty of Engineering
Diponegoro University

in collaboration with

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The 1st International Joint Conference on Advanced Engineering

18-19 October 2012
ICT Center Diponegoro University
Semarang-Indonesia

Organized by:

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Proceeding of

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Welcome Message

By Ir. Bambang Pudjianto, MT- Dean of Faculty of Engineering Diponegoro University

Distinguished Professors, Ladies and Gentlemen

It is agreat honor to have opportunity to say a few words before starting the conference. First of all, on behalf of all members of Engineering Faculty, Diponegoro University, I would like to express our greatest pleasure in welcoming all of you and in hosting the 1st Joint Conference on Advanced Engineering (IJCAE) 2012.

I would like to express my thank to all committee members and other participants and partners who supports and make this conference possible and meaningful.

This conference planned to be held yearly with our sister university partners from 6 countries, Malaysia, Netherlands, Spain, Japan, South Korea and Australia. In my opinion, I have no doubt that the international dialogue and academic partnership in field of engineering will be further enhanced and intensified through the IJCAE 2012.

As we witness the fast-growing and the change of technical paradigms in many areas of engineering – civil, chemical, mechanical, electrical, naval architecture, industrial, environmental, architecture, computer system as well as geology and geodetic engineering. It is our genuine hope that we may be able to exchange and share experiences, new ideas through this conference, with the gathering of learned experts in the field of engineering.

I would like to appreciate to the invited plenary spakers, distinguished professors, participants from sister universities and authors who have contributed to the success of this conference.

Thank you very much for your attention and;

Have a nice conference

IJCAE 2012 Program

Wednesday October 17, 2012	Welcome Reception
18:30~20:00	Faculty of Engineering Building (3rd Floor)

Thursday October 18, 2012	Conference Day (ICT Center Building)		
	Plenary Hall		
08:00~08:30	Registration at ICT Center Building (4th Floor)		
08:30~08:40	Performing Gambang Semarang Traditional Dance		
08:40~09:10	**Opening Ceremony** ▪ Opening Address by Dr. Dipl. Ing. Berkah Fajar (Chair Person IJCAE 2012)		
	▪ Opening Address by Ir. Bambang Pudjianto, MT (Dean of Faculty of Engineering, Diponegoro University)		
	▪ Welcome Address by Prof. Sudharto P. Hadi, MES, Ph.D (Rector of Diponegoro University)		
09:10~09:40	Plenary Talk 1: Prof. Dr. Ir. Saparudin bin Arifin (UTHM-Malaysia)		
09:40~10:10	Plenary Talk 2: Prof. Sudharto P. Hadi (Diponegoro University -Indonesia)		
10:10~10:40	Plenary Talk 3: Dr. Ir. Gagoek Hardiman (Diponegoro University - Indonesia)		
10:40~11:30	Coffee Break and Poster Session		
11:30~12:00	Plenary Talk 4: Prof. Tetsuo Tezuka (Kyoto University-Japan)		
12:00~12:15	Take a group photo for all participants		
12:15~13:00	Lunch		
13:00~14.30	International Committee Meeting at Plenary Hall		
	Parallel Session		
13:00~17:00	Room A	Room B	Room C
	Mechanical Engineering, Energy, Chemical Engineering	Computer Science, Robotics, Electrical Engineering	Civil Engineering, Architecture and Environmental Engineering, Geology
17:00~17:30	Coffee Break and Closing		

Friday October 19, 2012	Cultural Tour
08:00~17:00	Dieng Plateau and Geothermal Power Plant

For further information please visit http://www.diengplateau.com/

Parallel Session Class

Room A : **Mechanical Engineering, Energy, Chemical Engineering**
Chairman : **1. Sulistyo, 2. Kwang-Hwan Choi**

Room B : Computer Science, Robotics. Electrical Engineering
Chairman : 1. Wahyul Amien Syafei, 2. *Sang-Bong Kim*

Room C : Civil Engineering, Architecture and Environmental Engineering, Geology
Chairman : 1. Bagus Hario S, 2. M. Arief Budihardjo

Potential of Microalgae Biomass from Wastewater Agroindustry for Bioenergy Feedstock in Indonesia (an overview)

Hadiyanto[1] and Muhamad Maulana Azimatun Nur[1]

[1] Center of Biomass and Renewable Energy, Chemical Engineering, Diponegoro University, Semarang, 50275 Indonesia

ABSTRACT

Currently, Indonesia is leading in agroindustry production in the world. In other hand, waste water product also increase along with the main production. It is predicted that waste water will threat the environment due to high COD and BOD content. Second problem in Indonesia is Energy crysis, due to petroleum depletion, and energy demand. It is needed to solve the two problems in a feasible technology. Almost of agroindustry waste water contains nitrogen, phosphorus, and several micronutrient. It is potential medium for microalgae growth. Due to tropical climate, light, and several factor, it is predicted that microalgae cultivated in waste water agroindustry could be a potential biomass for bioenergy feedstock and a good phycoremediator to lower toxic matter in waste water.

1. INTRODUCTION

Currently, Indonesia is one of leading agroindustry producer in the world. The major food crops, ranked by area harvested, are rice, corn, cassava, soybeans and peanuts. Indonesia is also one of the world's largest producers and exporters of tree crops such as palm oil, rubber, copra, palm kernels, coffee, cocoa and spices [1]. This product are potential to generate waste water polutant and green house gases.

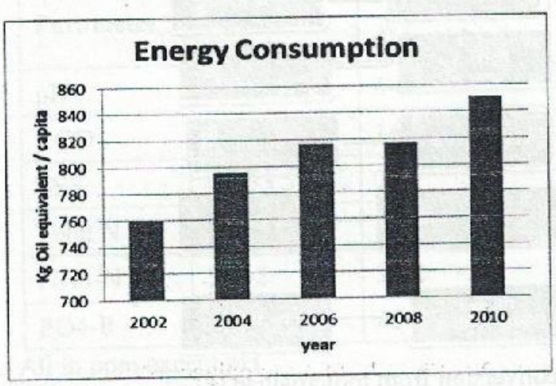

Fig 1. Indonesia Energy Consumption equivalent per capita [2]

In other hand, Indonesia is in energy crysis. A demand of energy always increasing through years. Decreasing of new fossil fuel source, few of renewable energy feedstock, and increasing in human population are main problems that affecting the crysis.

One of most promising technologies to be implemented in Indonesia is microalgae technology based biofuel. Indonesia is a tropical archipelago, it is potential to produce microalgae in a blooming biomass. However, several microalgae can produce biofuel, and it could utilize agroindustry wastewater [3]. Finally, the COD and BOD, and several polluting content will be removed, and the biomass product from microalgae is used as feedstock of bioenergy.

2. MICROALGAE AS BIOFUEL FEEDSTOCK

Researchers are interested to microalgae as biofuel feedstock due to high production in all year round and season, it has a rapid productivity, it can remove nutrient and heavy metal from waste water, and utilize CO_2 in a large amount [3].

Microalgae appear to represent the only current renewable way to generate biofuels [4]. Microalgae biofuels are also likely to have a much lower impact on the environment and on the world's food supply than conventional biofuel-producing crops. When Compared with plants biofuel, microalgal biomass has a high caloric value, low viscosity and low density, properties that make microalgae more suitable for biofuel than lignocellulosic materials [5].

2.1. Biomass Conversion

Related biomass conversion from microalgae not only for biodiesel based, but also in bioethanol, biohydrogen, methane, even for electricity production [6]. A schematic microalgae biomass conversion is listed in fig 2.

In the international market, the most technically feasible and commercialised alternative renewable fuel sources are biodiesel and bioethanol.[7]

Direct transesterification (in situ) leads to one most promising technology due to lower energy consumption to produce biodiesel from microalgae [8].

Several factor are also considered affecting lipid in microalgae. Widjaja et al. conclused several factor increasing lipid in *Chlorella vulgaris* such CO_2 concentration, nitrogen depletion, harvesting time, and extract method [9].

However a strain inoculum also play important role to produce high microalgae by biofuel. the process to push cost value and meet the reasonable price. Several factor affecting are biorefinery integrating system, advanced photobioreactor design, and conversion technology system.

Microalgae not only produce biofuel but also it can serves bioprotein and several valuable product. The economical feasibility of microalgal biofuel production should be significantly enhanced by a high-value co-product strategy[10].

Photobioreactor is important factor in microalgae cultivation. Several method that meets the cost and production also have to be considered. A few authors discussed a difference between open and closed system [11][12]. A Hybrid system is a new alternative for cultivating microalgae [7]. A combination of both systems are probably the most logical choice for cost effective cultivation of high yielding strains for biofuels.

Conversion system of biomass also influence in cost efficiencies of product. Traditional method of microalgae technology is harvesting, extracting, and converting to biofuel. In situ transesterification, direct biomass combustion, direct fermentation is an alternative method to lower downstream cost processing.

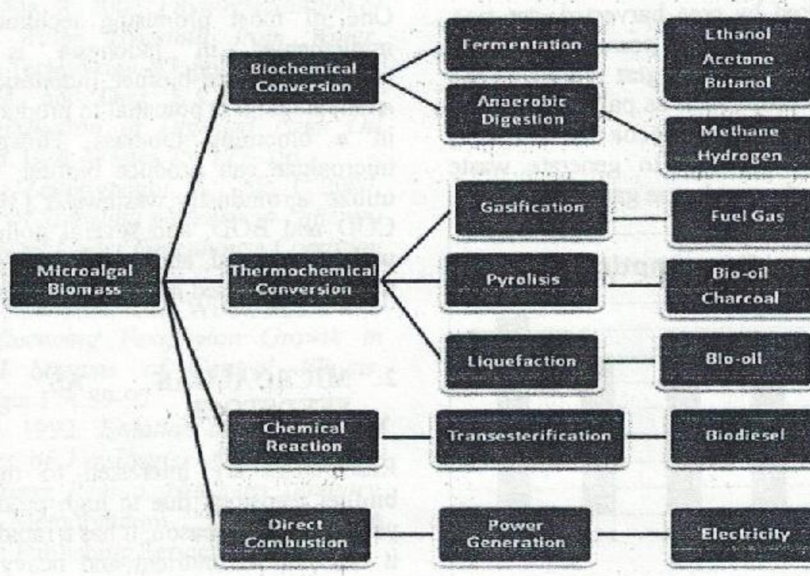

Fig 2. Schematic Biomass conversion from moicroalgae [6]

2.2.Enhancement Economic Feasibility Production Biofuel from Microalgae

A feasibility and sustainability production of biomass from microalgae have to be placed in

3. INDONESIA AGROINDUSTRY

Indonesia is an agricultural country which leading in several agroproducet export shared to world demand. Three major export agroindustry product are derivated palm, rubber and cacao.

3.1.Crude Palm Oil

Palm is a leading favourite crops product in Indonesia. A last ten years, CPO production inrease significantly up to 13.4% [13]. Indonesia and Malaysia shared almost 80% of total CPO demand in the world.

Table 1. CPO Market share (In 2010) [13]

No	Country	Production (Ton)	Market share
1	Indonesia	23.2	43.60%
2	Malaysia	19.3	36.20%
3	Other Country	10.7	20.20%

However, along with CPO production, several waste pollution generated from the process are increased.

3.1.1 POME

Palm oil mill effluent (POME) is wastewater generated from CPO processing. It contains rich of nutrient, a dark colour, and acid pH.
Indriyati [14] reported that a processing fruit fresh bunch (FFB) of palm produces waste water pollutan up to 66%. This waste water called as palm oil mill effluent or POME.

Table 2. POME Characteristic [15][16]

Parameter*	POME	POME digested
pH	3.91-4.9	4-6
COD	83356	1400
TSS	49233.57	700
Total N	1494.66	456
NH3-N	50.42	34.2
PO4-P	315.36	68.4

All in ppm except pH.

Releasing un-treated POME directly to the surrounding will caused serious pollution problem towards the environment due to high COD and BOD content and could produce green house gases.
Instead, POME can be treated efficiently using available wastewater treatment technologies in order to meet the standard discharge regulation for wastewater [7].

3.1.2. POME as Microalgae Medium

Several researcher investigated a potential POME as microlgae medium. A characterization of POME is high in COD, BOD, low pH, dark, contains tannic acid but also rich in nutrient. Habib et al [15], reported that POME is a potential medium for microalgae growth. Meanwhile Putri et al. recorded several biofuel microalgae are able to be cultivated in diluted POME (250ppm COD) [17]. Among of them, *Chlorella sorokiniana* was the highest in terms of specific growth rate and biomass productivity, when compared to the other species.

Table 3. Microalgae in POME Medium [17]

Microalgae Strain	Biomass Productivity (mg/l/day)	Percentage of Lipid (%)
Chlorella vulgaris	5.9	21.34
Chlorella pyrenoidosa	2.9	21.51
Chlorella sorokiniana	8.0	28.27
Botryococcus sudeticus	5.3	30.83
Tetraselmis sp	4.0	25.69

Hadiyanto and Nur [18] also reported preliminary investigation of *Chlorella* sp in 50% v/v digested POME by modify carbon, nitrogen, and phosphorus ratio. A result shown that 50% digested POME and 1gr/l urea addition gave biomass of *Chlorella* sp. up to 58.4mg/l n 16 days cultivation.
A problem of POME as medium for microalgae is high COD content, dark colour of tannic acid, and high impurity. This problem could be solved by using integrated process of POME to generate methane and CO_2, meanwhile the effluent could be used as medium for microalgae. Habib et al. also reported that *Chlorella vulgaris* cultivated in 10% digested-POME contains 18.3% crude lipid, meanwhile the lipid decrease when cultivated in 20% digested-POME up to 16.8%. However, COD and related content of digested POME has changed afer used as medium for *Chlorella vulgaris*. [16]

Table 4. POME digested before and afer used as medium [16]

Parameter*	Before	After**
pH	6.8	7.2
Dis O_2	3.6	3.5
COD	4245.5	220
TS	1926	115.4
TSS	959.7	42.5
T.Nitrogen	228	17.6
Orthophosphate	34.2	2.8

*all parameter in ppm except pH
*experiment in aerated medium

Microalgae grew slowly in higher concentration of digested POME due to inadequate light. A specific growth rate affecting COD and BOD removal as low as in POME medium.

3.2. Rubber

Rubber is the second large agroindustry product in Indonesia, and also ranked as 2nd largest producer in the world in 2010 with market shared up to 28%. In 2009, Indonesia produces 2.4 million tons of rubber, Thailand 3.1 million tons, and Malaysia 951 thousand tons [13]. However, indonesia has the largest area of rubber plantation in the world, recorded up to 3.40 million ha, followed by Thailand and Malaysia.

During rubber production, 25% v/w waste water pollutant was generated as rubber mill effluent [19]. The effluent usually treated by traditional anerobic-anaerobic facultative method. However this method only remove carbon content [20].

3.2.1. Rubber Mill Effluent

Rubber Mill effluent (RME) consists of latex washings and a serum containing proteins, sugars and lipids as well as inorganic and organic salts. The high level of ammonium and other plant nutrients makes it a good medium for algal growth[].

Table 5. RME Characteristic from *Ribbed Smoked Sheed* [20]

Parameter	Means Value
pH	5±1
COD	4000±1000
BOD	2500±200
Total Nitrogen	300±100
NH_3-N	200±100
NO_3-N	6±2
PO_4-P	30±10

All parameter in ppm except pH

3.2.2. RME as Microalgae Medium

There is few report about microalgae cultivated in RME as biofuel feedstock but several researcher were done investigating microalgae (i.e. *Spirulina platensis, Chlorella vulgaris,* and several cyanobacteria) in RME and it is a potential medium for microalgae.

Tri-panji and Suharyanto [21] investigated growth and carotenoid production of *Spirulina platensis* cultivated in medium enriched latex concentrate rubber effluent (LCRE) and concluded that the cost of synthetic medium could be lowered by adding the LCRE 5% v/v.

Senthil, et al. reported that rubber mill effluent significantly influencing the biochemical constituents of cyanobacteria by both qualitatively and quantitatively, but increasing report in amino acid and unsaturated fatty acid should to be investigated for further research [22].

Habib et al. also recorded an increasing of biomass, protein and lipid from tropical green algae, *Ankistrodesmus convolutus*, cultivated in diluted latex concentrate rubber effluent (LCRE), and in a standard rubber mill effluent (RME). lipid was recorded significantly higher than in control medium, 15.75% and 15.15%, respectively. [23]

3.3. Cocoa

Cocoa is third leading potential agroindustry product from Indonesia. In 2009, Indonesia ranked for 2nd in the world market demand, followed by Ghana. An increasing production is up to 7.60% (2000-2010) [13]. A first largest cocoa producer is Cote d'Ivoire with 1.27 million ton, meanwhile Indonesia produces 830,790 ton in 2009.

A fine cocoa product is processed by fermenting method to lower tannic acid. Along with demand of fermented cacao, a waste water pollutant generated from fermenting process is also increased.

3.3.1. Fermented Cocoa Bean Mill Effluent

During process of cocoa bean sweating, 10% v/w waste water was generated [24]. A fermented cocoa bean mill effluent, or also called as cocoa sweating effluent (CSE), contains several sugar residue and micro nutrient. It is still low investigation of the effluent in Indonesia unless the fermented cocoa bean processing was still developed. Several research was done by utilize the effluent as medium for nata de cocoa [25], and ethanol production [26][27].

Table 6. Characteristic of cocoa sweating effluent [26]

Parameter	Value
TSS	2,844
VSS	2,610
pH	4.41
BOD	19,100
COD	109,190.4
Glucose	17,510

All in ppm except pH

medium for microalgae based by biofuel. However it is potential medium for microalgae due to glucose value and several nutrient.

A heterotrophic microalgae cultivation is interested method to increase lipid accumulation in biomass production. It utilize organic carbon source, (i.e. glucose, sucrose) without using photosynthetic reaction [28]. However, a combination in mixotrophic condition also influences several microalgae to form higher lipid. When microalgae grow in mixotrophic condition, it utilizes glucose and uses light in photosynthetic reaction to form biomass [29].

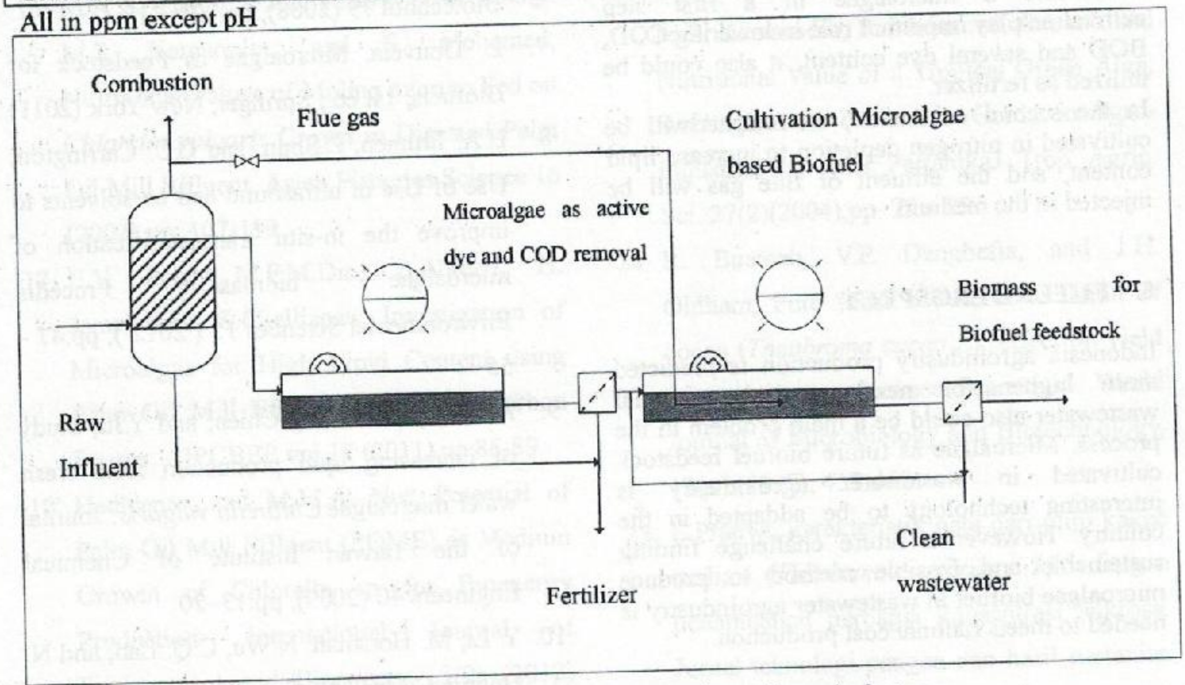

Fig 3. Schematic Process Integration of agroindustry wastewater treatment for biofuel production

Table 7. Chemical component Cacao pulp from PTPN XII [27]

Component	Concentration (%)
Water	79.61
Sugar	15.50
Nitrogen	0.63
Ash	0.50
Other component	4.26

3.3.2. Potential of CSE as Medium of Microalgae

Few researcher are interested in utilizing CSE as

CSE characteristic is similar to POME medium, the colour tend to dark due to tannic and another chemical compound, it also has acid pH.

4. INTEGRATING PROCESS IN AGROINDUSTRY WASTEWATER FOR BIOGAS AND BIOMASS PRODUCTION.

Almost of agroindustry effluent contain high COD and BOD content. It is a potential to generate green house gases that harness the environment. However microalgae could grow in a maximum specific growth rate and utilize the agroindustry waste water by removing nitrogen and micronutrient in low COD and BOD condition.

However, COD and BOD content could be lowered by using anaerobic digesting method. This process generate methane gas, carbon dioxide and other content.

Wastewater influent will be processed in digested reactor to produce biogas. A biogas then combusted to generate electricity, and the effluent, flue gas, is utilized as feedstock of microalgae cultivation. The effluent of biodigester could be used as fertilizer, meanwhile a microalgae in a first step cultivation play important role in lowering COD, BOD and several dye content, it also could be utilized as fertilizer.

In the second cultivation, microalgae will be cultivated in nitrogen depletion to increase lipid content, and the effluent of flue gas will be injected to the medium.

5. FUTURE PROSPECT

Indonesia agroindustry production is predicted more higher for next year. A potential wastewater also could be a main problem in the process. Microalgae as future biofuel feedstock cultivated in wastewater agroindustry is interesting technology to be addapted in the country. However a future challenge finding sustainable and feasible method to produce microalgae biofuel in wastewater agroindustry is needed to meets rational cost production.

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