PROCEEDINGS

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 Margareth Gfrerer from Islamic State University of Jakarta, Indonesia; Dr Barry Elsey from University of Adelaide, Australia; Dr Gajendran Kandasamy from Melbourne University, Autralia; and Imperial College London-British, Prof Allan O'Connor from University of Adelaide, Australia; Dr Wisnu Ananta Kusuma from Bogor Agricultural University ,Indonesia; and Dr Frank Neumann from University of Adelaide, Australia, as invited speakers.

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

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

Sincerely,
Dr Yandra Arkeman
General Chairs, ICAIA 2015

WELCOMING ADDRESS

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

on

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

Bogor, August, 3 – 4, 2015

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

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

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

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

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

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

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

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

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

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

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

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

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

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AGENDA

Time	Activities
Monday, August 3rd 2015	
08.00 - 09.00	Registration
09.00 - 10.00	Opening Ceremony • Welcoming Address: Prof. Nastiti Siswi Indrasti (Head of DAT, Fateta, IPB) • Welcoming Speech Head of Bogor Regency • Conference Opening: Prof. Herry Suhardiyanto (Rector of IPB) • Opening Speech and Conference Opening : Minister of Industry Indonesia * • Launching Expose International program DAT
10.00 – 10.05	*Photo Session*
10.05 - 10.15	*Coffee break*
10.15 - 10.45 10. 45 - 11.30 11.30 – 12.00 12.00 – 12.30	Keynote Speech : 1. Prof Irawadi (Bogor Agricultural University, Indonesia) 2. Prof. Kenneth De Jong (George Mason University, USA) 3. Dr. Yandra Arkeman (Bogor Agricultural University, Indonesia) 4. Dr. Guillermo Baigorria (University of Nebraska, Lincoln, USA)
12.30 – 13.30	Lunch break
13.30 – 13.50 13.50 – 14.10 14.10 – 14.30 14.30 – 14.50 14.50 – 15.10 15.10 – 15.45	Plenary Session 1 : Prof. Noel Lindsay (University of Adelaide, Australia) Dr. Kiyotada Hayashi (National Agricultural Research Center, Tsukuba, Japan) Prof. Margareth Gfrerer (Islamic State University of Jakarta, Indonesia) Dr. Barry Elsey (University of Adelaide, Australia) Ir. M. Novi Saputra (Marketing Director KML Food Group) *Discussion*
15.30 – 15.45	*Coffee break*
15.45 – 18.00	Parallel session A, B and C
18.00 – 21.00	Welcome Dinner

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

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Pollution Reducing Opportunities for a Natural Rubber Processing Industry: A Case Study

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***Abstract*— One of the problems associated with natural rubber processing is the environmental problems created by the use of large amounts of water, together with energy and chemicals that pollute the environment. An environmental innovation is considered as a strategy to address the environmental impacts better than a conventional end-of-pipe treatment. This research aims to explore the opportunities of pollution prevention that have not been implemented yet in a natural rubber processing industry. This study used a Case Study approach on a small and exploratory scale, with data collected from interviews and observations. The results show that the environmental issues that are related to factory's daily operation that consists of water usage, accumulation of unprocessed material, the use of ammonia and the use of inorganic fertilizer. Some preventive strategies to overcome the environmental issues namely: reuse of the wastewater, efficiency of water usage, material substitution, and good housekeeping. The results of this study suggest the recommendation to overcome some specific environmental issues of a particular natural rubber industry that could be an appropriate template for broader study.**

I. Introduction

Indonesia is the second largest natural rubber producer in the world after Thailand [1] with approximately 26 % of the world's natural rubber needs is supplied by Indonesia [2]. The main types of natural rubber products in Indonesia are: crumb rubber, rubber sheet (Ribbed Smoked Sheet or RSS), concentrated latex, and crepe [3]. As one of the main commodities of the agricultural sector, Indonesia's natural rubber industries create attention with respect to the magnitude of potential wastewater, solid waste, as well as odor emissions resulting from the production processes chain [4].

Compliance with environmental laws in a country is one of the factors driving innovation opportunities within a company. It is intended to encourage the company and all its elements to use the technology, materials and processes that are more environmentally friendly [5]. Therefore, it is necessary to improve the environmental management performance through an innovation [6]. Innovation that aims to reduce environmental impacts is called environmental innovation [7]. The innovation could be on the process, product, marketing or organization [7]. While based on the approaches are used, the environmental innovation can be distinguished into two types i.e. reactive and preventive strategies [8]. Even though an end-of pipe treatment facility is able to comply with the effluent standards, the type of environmental strategy is seen as an uneconomic treatment and cannot anticipate changes in environmental issues in the future [9]. Therefore, it is necessary for industry to start looking for proactive strategies replacing the conventional waste management with the pollution prevention efforts at the sources.

Given the situation, the purpose of this study is to explore the opportunities for pollution prevention practices in a natural rubber company. Therefore, the research question that posed in this study is:

"What are the pollution prevention strategies to innovate the existing environmental practices?"

This question intends to explore the opportunities for environmental practices improvement based on the identified environmental impacts and company's situation.

II. Pollution Control for Natural Rubber Industries

Some characteristics of the waste or pollution associated with the processing of the intermediate

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products of natural rubber are: 1) high concentration of biochemical oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids (SS) in the wastewater, 2) acidic effluent, 3) high concentration of ammonia and nitrogen compounds, 4) high level sulphate, and 5) high level of odor [10]. The untreated wastewater from natural rubber production can contaminate ground water and surface water [11]. In addition to water pollution, environmental impact is also caused by air pollution, for the example, odor and smoke particles from the production process of the RSS rubber [12]. In addition to air pollution from the production process, air pollution also comes from anaerobic wastewater treatment system due to the release of methane as a greenhouse gas [13]. With the strict environmental requirements and sanctions system from the Ministry of Environment, some medium and big business implement waste management systems. The wastewater that is discharged from the treatment facility must meet the quality of Ministry of Environment's Decree No. 51 Year 1995 [14]. To comply with the regulation, the company must provide a sewage treatment unit to meet the required standard [15]. However, majority rubber industries in Indonesia are using conventional lagoons system to treat their wastewater, that requires long retention times and large area [16].

III. Pollution Prevention

Some environmental approaches to deal with environmental pollution in industries include: (1) the end-of-pipe approach, (2) pollution prevention or total quality management (TQM), (3) product stewardship, and (4) sustainable development [17], [18]. A company is said to be environmentally innovative if they meet one of the several criteria such as the integration of environmental criteria into the design process or product, improvements in waste management and recycling process for either internal or external [19]. The shifting from reactive into pollution prevention strategy show higher level of proactivity in terms of environmental management strategy in a company. This includes an environmental innovation in process [20]. Pollution prevention is reduction or elimination of pollutants creation at the sources, not when the waste is already formed [21], [22]. Some activities that are categorized as pollution prevention include the substitution of raw materials, spill and leak prevention, modification processes and equipment, modification of products, and so forth [23].

IV. Data and Methodology

A. Conceptual framework and case study

In seeking the innovative environmental strategies, it is necessary to conduct the identification and prioritization of key environmental issues for the determination of the resources and actions required [24]. After that, a more detailed examination of the status and performance of environmental management are required. Thus, to determine the areas and corrective actions, it is necessary to review the existing environmental management system in the company. This review may consist of the amount of natural resources used during production processes, and the amount of waste that is formed along with the potential environmental impacts that may result.

Hence, research on innovative strategies and opportunities for environmental improvement will be done in a natural sheet rubber processing factory using the fumigation method. A case study approach was used to understand the findings [25], [26]. This approach also was taken due to the specific conditions of a company that leads to difference environmental impacts, environmental management [27] and relationship with the local environmental institution. The stages in this study consist of identification the source of pollution and practices that are not environmentally friendly, obstacles to pollution prevention efforts, and possible environmental innovations in achieving environmental improvements in the plant. This research was in a rubber processing company in Central Java Province, Indonesia which is called company X. The company manufactures quality rubber products such as RSS (ribbed smoked sheet) and cutting (pieces of rubber from the sorting process). This company employs 1,447 employees. Ribbed smoked sheet (RSS) is one of the processed products made from rubber plantations in Indonesia that occupies the second largest rubber products after crumb rubber or SIR (Standard Indonesian Rubber). The process of RSS rubber through smoking is more complicated than the manufacturing of crumb rubber that consist of nine stages [28].The stages in the RSS production from field latex are: raw materials handling before arrive at factory, reception of latex in the factory, dilution latex, coagulation, milling, draining, drying with fumigation, sorting, and packaging.

B. Data Collection

- *Literature Study*

By studying data from books, journals, research report, publications and documents that are relevant for this study. The documents that were studied include environmental regulations, the company's monthly production reports, and job training reports.

- *Interview*

The interview aims at generating primary data from source persons, who were selected through purposive method sampling [29]. The interviewees were selected based on their expertise in the rubber industry and

environmental management. Therefore the total participants are 11 that consist of:

1) Two representatives from Ministry of Industry who handle agricultural industry and green industry policy.
2) Two representatives from environmental agency at the provincial level
3) Two representatives from R & D Agency pollution prevention
4) Two representatives from R & D Agency of natural rubber
5) Three representatives from the selected factory (includes director, technical manager, and employee)

The interview is a semi-structured interview, in which the main research questions were explored and combined with derivative questions from primary research questions, following the context of this study and the roles of the participants. The interviews with experts were held for thirty to sixty minutes which then recorded and transcribed.

- *Observation*

This stage focused on the performance of existing environmental management, to identify sources of pollution and their causes. Direct observation was performed at every stage of the production process to identify the practices that are inefficient and potentially cause environmental impacts in the company. At this stage a checklist was used during the observation process, which consists of the data about raw material consumptions; production process, numbers of employees, waste management system; and additional qualitative information as needed.

C. Data analysis

To support reliability of data, this study used a triangulation method from multiple sources that contributes to the confirm-ability of research findings [26], [30]. The key interviews and sections of interviews were transcribed and categorized [31]. Then the data analysis used explanatory approach with supporting literature and evidence [32].

V. Results and Discussions

A. Identification of potential environmental impacts

From the processing of smoked rubber products (RSS) and by-products (brown crepe rubber) in the company, the wastes that were generated are wastewater and solid waste. The liquid wastes are generated from water residue and washing equipment. While the solid waste consist of solid rubber and wood chips.

The environmental review aimed to take into the environmental effects associated with firm's activities in order to identify the most significant ones [33]. Data of the materials used for production are shown in the Table 1.

The potential environmental effects that can be identified in this rubber company namely:

1) Pollution by wastewater resulting from the production process that uses large amounts of water. The effluent of rubber wastewaters have negative impacts on the sediments, water body receiver and macroinvertebrate due to the content of pollutants such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), heavy metals and conductivity [34].
2) Air pollution that comes from burning wood to the rubber latex curing process. Burning the rubber firewood can cause smoke particles pollution if there are no proper ventilation systems [12]. It also has effect to the local residents. However, this concern is not significant because from the air monitoring results, it shows that the air quality still meet the regulatory standards.
3) Bad smell due to the accumulation of raw material that has not been processed yet in the secondary product unit. The odor is usually caused by organic matter in the raw materials and the amount of water that causes the decay process. As for odor control in factory environments can be performed by using liquid smoke, but it is still less optimal because it has not eliminated the source of the smell.
4) The use of ammonia. Ammonia is used to prevent coagulation latex at the time of collecting the latex, and prevent contamination of the latex [35]. Ammonia has a pungent odor, toxic, and corrosive to some materials [36]. With these characteristics, ammonia will impact on the health of the respiratory system of workers [12].
5) The use of inorganic fertilizers contributes to greenhouse gases. This is due to two reasons: 1). the process of making artificial fertilizers which is energy intensive; and 2) the application of fertilizer will release the gas N_2O [13].

TABLE I
LIST OF MATERIAL USAGE

No.	Material	Application	Unit	Volume
1	An organic fertilizer	Plantation	Liter	140
2	Water	Plant irrigation, production processes (dilution, coagulation, equipment washing)	m^3	69,546
3	Ammonia	Latex preservation and anti-precoagulation	Liter	475
4	Formic acid	Coagulation of latex	Liter	700
5	Rubber firewood	Smoking process	m^3	3,047
6	Electricity	Machines and equipment	kWH	53,173

B. Pollution prevention opportunities

From the identification of the existing processes and the interviews result, the improvements that are

required namely on the production process, handling of raw material and waste management systems. Therefore some solutions that can be proposed to prevent environmental pollution can be seen in the table 2.

Reuse of wastewater

With the quality of treated wastewater effluent that meets the Quality Standard according to the Ministry of Environment's Decree No. 51/1995 [14], there is the opportunity to use it for irrigation or secondary purposes. The end output of the wastewater treatment unit of processing of natural rubber in Thailand was reused for irrigation purposes in various rubber plantations and rice plantations through several experiments [37]. Some of these experiments used to test the impact on vegetables, rubber trees, as well as rice. They also suggest the feasibility of re-using wastewater for irrigation of cash crops plantation with the consideration of the economic value and organic nutrients contained in the effluent. However, in the context of Indonesia, the output of effluent reuse for irrigation must meet certain statutory requirements as stipulated in Government Regulation No. 82/2001 [38] on Water Management and Water Pollution Control. So, prior to its implementation, it is necessary for testing of the control plants for a year. In addition, as the company is big enough and has implemented an environmental management system, company X must consider the quality of effluent that still meets with the requirements for irrigation water quality standards issued by the Ministry of Environment.

Efficiency in water usage

Because to the large amount of water used, the company should conduct efficiency for water use. In this case it does not mean reducing the amount of water usage, but examining the efficiency of its use. This is in line with the manager's technique which is for example to warn employees to turn off the water taps when not needed. Although the boss is still a very necessary role in the supervision of its implementation, the employees show a cooperative attitude to implement management directives.

Raw material substitution

According to the engineering manager that one of the main pollutant of concern is the use of ammonia. Ammonia is used to freeze the latex. Liquid smoke is an alternative as a latex coagulant to replace ammonia. Liquid smoke is considered more environmentally friendly because it is made from a biomass through a pyrolysis process. The company has such resources given they own the rubber plantation and can utilize parts of rubber trees that have not grown to make liquid smoke. In addition, to reduce the emissions due to fertilizer, the use of organic fertilizer such as animal manure would be to replace synthetic fertilizer [13].

Good housekeeping

According to [22], good housekeeping is considered as a cost effective way to reduce pollution. Its implementation requires commitment and active participation of managers and employees. The practices consist of awareness of employees to use water, chemicals and fertilizer efficiently and carefully.

TABLE 2
POLLUTION PREVENTION OPPORTUNITIES

	Previous action and result	Change that less pollute
1	The use of chemicals such as ammonia and formic acid for latex coagulation.	Substitution of the chemicals with organic coagulant, for example with the use of liquid smoke from biomass that is more environmentally friendly.
2	Uncontrolled use of water when washing the latex freezing equipment.	The response of employees to close the water taps when not in use so as to prevent water wastage.
3	Treated wastewater flowed through the drain pipe end.	Study to reuse wastewater for secondary purposes.
4	The accumulation of unprocessed raw material in the unit byproducts causes bad smell.	Add more partitions in the fumigation chamber, to increase the capacity of curing and accelerating curing time, thereby reducing the accumulation of unprocessed material.
5	Rubber sheet drying time is for 21 days in the fumigation chamber.	Addition of drying time optimization rubber partition in the fumigation chamber, so that the drying time is faster and more products are produced.
6	The use of synthetic fertilizers in rubber plantations contributes to greenhouse gas emissions.	Cooperate with a rubber research center which has been producing organic fertilizer and fungicide.
7	The use of fertilizers in general.	Efficiency in the use of fertilizer by proper time and frequency fertilization, as well as the prevention of shedding of the fertilizer.

VI. Conclusion and Recommendation

This study examines the current situation of environmental management in a natural rubber processing company to explore the pollution prevention practices opportunities.

The prevention at the source consists of efficiency in water usage, raw material substitution, good housekeeping, and increasing production capacity.

These environmental improvement strategies cannot be generalized beyond the company where the conditions and characteristics differ by region. However, this design is an appropriate template for a broader based study. In addition, future research also needed to evaluate the effectiveness if the application of these strategies is implemented by the organization. The results of this research highlight the practical implications by optimizing employees' participation for environmental friendly practices. As the strategic implications, this research also assists the company's management in environmental decision making by conducting a feasibility study on an environmental project towards implementation. These results also suggest policy makers to assist industries in the environmental management and provide the industries with technical guide. Finally, the success of efforts to implement the pollution prevention practices requires active participation from all involved parties in the company, as well as optimization of the roles of relevant experts.

References

[1] (2013, April 4). *Natural rubber, production quantity (tons) - for all countries*. Available: http://www.factfish.com/statistic/natural%20rubber,%20production%20quantity

[2] S. Damanik. (2012, June 2012) Pengembangan Karet (Havea brasiliensis) berkelanjutan di Indonesia. *Perpektif*. 12. Available: http://perkebunan.litbang.pertanian.go.id/wp-content/uploads/2013/06/perkebunan_perspektif112-2012-N-3-_damanik.pdf

[3] M. A. Darmawan, M. P. I. F. Putra, and B. Wiguna, "Value chain analysis for green productivity improvement in the natural rubber supply chain: a case study," *Journal of Cleaner Production*, vol. 85, pp. 201-211, 2014.

[4] S. Hasibuan, "Pengembangan sistem penunjang manajemen audit produksi bersih pada agroindustri karet remah," Graduate School Disertation, Agroindustrial Technology, Bogor Agricultural University, Bogor, 2012.

[5] R. Nidumolu, C. K. Prahalad, and M. Rangaswami, "Why sustainability is now the key driver of innovation," *Harvard business review*, vol. 87, pp. 56-64, 2009.

[6] A. Warhurst and G. Bridge, "Improving environmental performance through innovation: recent trends in the mining industry," *Minerals Engineering*, vol. 9, pp. 907-921, 1996.

[7] J. Horbach, C. Rammer, and K. Rennings, "Determinants of eco-innovations by type of environmental impact—The role of regulatory push/pull, technology push and market pull," *Ecological Economics*, vol. 78, pp. 112-122, 2012.

[8] J. Lam, P. Hills, and R. Welford, "Ecological modernisation, environmental innovation and competitiveness: the case of public transport in Hong Kong," *International Journal of Innovation and Sustainable Development*, vol. 1, pp. 103-126, 2005.

[9] R. Welford, and A. Gouldson, *Environmental management and business strategy*. 2002, London: Pitman.

[10] H. N. T. Van, D. T. T. Duong, N. T. M. Thanh, T. H. T. T. Trang, I. Dinuriah, S. Sharmin, *et al.*, "Waste Abatement and Management in Natural Rubber Processing Sector," unpublished|.

[11] K. Girish, "Effect of Carbon Sources on the Biomass Build-Up and Degradation of Rubber Processing Industry Effluent," *International Journal of Applied Sciences and Biotechnology*, vol. 2, pp. 579-584, 2014.

[12] P. Tekasakul and S. Tekasakul, "Environmental problems related to natural rubber production in Thailand," *Journal of Aerosol Research*, vol. 21, pp. 122-129, 2006.

[13] W. Jawjit, C. Kroeze, and S. Rattanapan, "Greenhouse gas emissions from rubber industry in Thailand," *Journal of Cleaner Production*, vol. 18, pp. 403-411, 2010.

[14] *Ministry of Environment's Decree on The Effluent Quality Standard for Industrial Activity No. 51 Year 1995*, M. o. Environment, *1995*.

[15] D. Esty and A. Winston, *Green to gold: How smart companies use environmental strategy to innovate, create value, and build competitive advantage*: John Wiley & Sons, 2009. p.32-76.

[16] D. Tanikawa, T. Yamashita, M. Hatamoto, M. Fukuda, M. Takahashi, K. Syutsubo, *et al.*, "Development of an Appropriate Treatment Process for Wastewater from a Natural Rubber Processing Factory," *Transactions on GIGAKU*, vol. 1, pp. 1-8, 2012.

[17] K. Buysse and A. Verbeke, "Proactive environmental strategies: a stakeholder management perspective," *Strategic management journal*, vol. 24, pp. 453-470, 2003.

[18] S. L. Hart, "A natural-resource-based view of the firm," *Academy of management review*, vol. 20, pp. 986-1014, 1995.

[19] T. Cleff and K. Rennings, "Determinants of environmental product and process innovation," *European Environment*, vol. 9, pp. 191-201, 1999.

[20] A. Subramanian and S. Nilakanta, "Organizational innovativeness: exploring the relationship between organizational determinants of innovation, types of innovations, and measures of organizational performance," *Omega*, vol. 24, pp. 631-647, 1996.

[21] R. van Berkel, "Eco-efficiency in primary metals production: Context, perspectives and methods," *Resources, Conservation and recycling*, vol. 51, pp. 511-540, 2007.

[22] M. K. Hill, *Understanding environmental pollution*: Cambridge University Press, 2010. p.56

[23] D. R. Harrington, "Two-stage adoption of different types of pollution prevention (P2) activities," *Resource and Energy Economics*, vol. 34, pp. 349-373, 2012.

[24] A. Rickmann, "Developing environmental management strategies," *European Environment*, vol. 2, pp. 15-18, 1992.

[25] R. Yin, "Case study research: Design and methods. Beverly Hills," ed: CA: Sage publishing, 1994. p.44.

[26] B. A. Bossink, "The interorganizational innovation processes of sustainable building: a Dutch case of joint building innovation in sustainability," *Building and Environment*, vol. 42, pp. 4086-4092, 2007.

[27] S. Banerjee, "Corporate environmental strategies and actions," *Management Decision*, vol. 39, pp. 36-44, 2001.

[28] T. P. Utomo, U. Hasanudin, and E. Suroso, *Agroindustri karet Indonesia: Petani karet dan kelembagaan, proses pengolahan dan kinerjanya, dan selayang pandang karet sintetis*, 1 ed. Bandung: Sarana Tutorial Nurani Sejahtera, 2012.

[29] T. Palys, "Purposive sampling," *The Sage encyclopedia of qualitative research methods*, vol. 2, pp. 697-698, 2008.

[30] J. Rowley, "Using case studies in research," *Management research news*, vol. 25, pp. 16-27, 2002.

[31] K. Fischer and J. Schot, "Environmental strategies for industry; international perspectives on research needs and policy implications," 1993.

[32] C. Elman, "Explanatory typologies in qualitative studies of international politics," *International organization*, vol. 59, pp. 293-326, 2005.
[33] R. Hillary, "Environmental management systems and cleaner production," 1997. p. 46
[34] F. O. Arimoro, "Impact of rubber effluent discharges on the water quality and macroinvertebrate community assemblages in a forest stream in the Niger Delta," *Chemosphere*, vol. 77, pp. 440-449, 2009.
[35] S. Afreen, K. Haque, and M. Huda, "Troubleshooting for the observed problems in processing latex concentrate from natural resource," in *IOP Conference Series: Earth and Environmental Science*, 2013, p. 012007.
[36] D. Pahlevi, "Penghilangan Emisi Gas Bau Dari Tempat Penumpukan Leum Industri Karet Remah Dengan Menggunakan Teknik Biofilter," 2007.
[37] S. Chaiprapat and S. Sdoodee, "Effects of wastewater recycling from natural rubber smoked sheet production on economic crops in southern Thailand," *Resources, conservation and recycling*, vol. 51, pp. 577-590, 2007.
[38] *Goverment of Republic of Indonesia's Regulation No. 82 Year 2001 on The Management of Water Quality and Water Pollution Control*, G. o. R. o. Indonesia, 2001.