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Identification of Potential Laundry Waste Generation in Yogyakarta, Solutions and Impacts

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ABSTRACT

Laundry businesses that are not legal entities are growing in Yogyakarta Province and dispose of waste into the environment without processing so that it can cause harm to environmental health and public health because it has high organic and hydraulic loads, process model of anoxic oxic phase and wetlands with bath neutralization is a high-efficiency anaerobic process that can operate at high organic loads. Processing with wetland as a follow-up treatment can reduce organic contamination levels further. Therefore, this study used a process model with the combination of an anoxic-oxic phase and a wetland with a straw bath neutralization (the soaking of the straw) as a pretreatment to treat the laundry waste. The purpose of this study was to examine the potential of the process model on the effluent quality, the potential and impact of effluents as fertilizers for agricultural crops, and the fate and translocation of pollutants in rice plants. This study compared the process model with and without the straw bath neutralization as a pretreatment method. Detail Engineering Design in this study was an influent debit (Q) of liquid waste of 50cc/minute, an average hydraulic residence time in anaerobic, anoxic, and aerobic (wetland) processes of < 12 hours, 0.5-5 days, and > 53 hours, respectively with detergent organic load in the range of 42.17 mg/L - 164.11 mg/L. The results of this study showed that the quality of the effluent increased as indicated by the reduction in pollutant parameters such as BOD, COD, TSS, TDS, detergent, and total phosphate in the range of 7.39-98.17% and 7.09-95.49% in the control group (without pretreatment) and the pretreatment group, respectively. The potential and impact of effluents as fertilizers for rice plants were that they can stimulate morphological growth and vegetative development of plants and generative quantity of rice plants by producing quantity and quality of rice plant products where the control group produced a rice grain weight of 155.80 grams/0.4 m^2, fate and translocation of hazardous materials of ABS surfactant (detergent) in rice grain with the content of 32.65 mg/kg, while the pretreatment group produced a rice grain weight of 75.79 grams/0.4 m^2 with the content of hazardous materials of ABS surfactant (detergent) of 24.80 mg/kg. The conclusion of this scientific study using the laundry waste treatment process model with the straw bath neutralization if it is scaled up and equipped with Detail Engineering Design can be used as a policy recommendation for water resource management by local regional policyholders. With the limitations of the work that has been done, the direction of future research is to try out the processing of laundry waste on a scale-up prototype or complete scale-up process model with Detail Engineering Design, to examine the hygienic effects of rice containing hazardous detergent ingredients in the process of cooking rice with water containing excessive doses of chlorine as well as to assess the Biological Exposure Index of detergents in humans.

1. INTRODUCTION

Until now, the City of Yogyakarta which is also often referred to as Yogya or Jogja is known as the City of Sultans. Another term such as the City of Gudeg is also often used to refer to this 32.5 square kilometers area. Besides being known as the City of Gudeg, Yogya is also often referred to as the City of Students. These predicates trigger the growth of the role of the business world in goods and services that meet the secondary needs of the student community and the general public and spur the productive economic activities to increase income, expand employment opportunities, diversify economic activities, increase investment and others that need to be optimized through the availability of accurate information. These are what trigger the growth of the laundry service business with various innovative services. In addition, the ease of licensing regulations that do not need to include the requirements of the Hinder Ordonantie (Nuisance Permit) causes the laundry business to grow rapidly in the City of Yogyakarta, even reaching the buffer zones such as Regencies of Bantul, Sleman, and Gunung Kidul. The number of laundry businesses in the City of Yogyakarta is much higher than that

in the buffer zones because many study centers have been located in the City of Yogyakarta. The laundry service industries have limitations on the environment related to social, economic, legal, information-communication, science and technology, and ecological aspects. Since the Sustainable Development Goals (SDGs) were proclaimed at the rural and urban levels, environmental issues have become the attention of all parties.

In the small and medium enterprise (SME) level service industries, with the easing of the regulations, the environmental impact analysis (EIA), and the construction of wastewater treatment plants (WWTP), wastewater from the home laundry service industry is not seen as a serious problem. On the other hand, the activities of laundry businesses in the hotels and hospitals have long been regulated by the regulations of the Indonesian Ministry of Environment and Forestry and the Indonesian Ministry of Health, which must have the EIA, the environmental management and monitoring plan (EMMP), as well as the WWTP. In the fact, the laundry waste has become a very complex problem because it causes water pollution and very serious environmental problems [1]. Therefore, efforts to recycle the laundry wastewater from home laundry business activities need to be done.

From an environmental point of view, the laundry waste causes odor pollution, reduces aesthetics, and reduces the value of the environmental medium that receives the waste [1]. Meanwhile, from a physical point of view, the laundry waste in the Province of Daerah Istimewa Yogyakarta (DIY) with a discharge of 8,304 m3 and a quality of 2,500 mg/L causes foam and odor in the rivers, thus affecting the designation of rivers as raw materials for drinking water. In several rivers, it is reported that the laundry waste triggers a blooming of aquatic biotas such as algae and water hyacinth [2].

The laundry waste has several potentials and aspects such as social, economic, legal, and information-communication, but there is not much justification in science, technology, and ecology of natural water resources. The Department of Environment and Forestry in the Province of Daerah Istimewa Yogyakarta (DIY) currently handles and monitors many industries, but the waste management and processing cannot be carried out optimally, so it can cause problems with the environmental carrying capacity of natural resources. This department already has a collection of web pages contained in a domain located on the World Wide Web (www) on the internet as an information media that is globally accessible, but the information displayed on the World Wide Web is still general and has not been able to describe in detail the potential generation of the laundry waste, the analysis of the benefits of the risk of laundry waste generation, the solutions based on the green technology, and its implications in the future. For this reason, a strategic plan is needed systematically by developing an effective managerial system, namely a Geographic Information System (GIS), which is a web-based mapping of the potential for laundry waste generation. This includes the proposed technology based on the green technology, the information on the academic studies on the use of the waste as fertilizer for agricultural crops and the direct consequences of findings resulting from a study, or the conclusions of findings from a study. It is hoped that users can access the web via the internet so that the dissemination of the information can extend to all areas in the DIY province. The laundry waste in the Regency or City of Yogyakarta has complex problems since the environmental carrying capacity conditions fluctuate in each region because it is influenced by differences in socio-cultural, ecology, science and technology, information-communication, and judicial institutions that can affect the performance of each economy and management of natural resources in the regency or city. Based on this, it can be concluded that the identification of the potential for the laundry waste generation in the DIY province can be used as a basis for developing the management of the city or regency's natural resources in the future. The identification of the potential waste generation is expected to be implemented in locations where the laundry services are located, based on solutions for implementing the green technology. Green Technology is a technology development concept that starts from the theory of designing or developing an operating system that integrates modern technology and environmental science to reduce the negative impact of human activities.

In the employee housing area in the Mutihan Village (District of Banguntapan, DIY province), the SME scale laundry industries discharge large amounts of untreated wastewater into the rice fields irrigation. Until now, in the dry season, the local farmers use the wastewater due to a lack of fresh water. Because of their ignorance about the content of laundry wastewater, the local farmers use the wastewater as a source of rice planting media [3]. Wastewater has certain advantages such as providing the essential nutrients and organic matter, saving the water and nutrients, and reducing the water pollution [4, 5]. The wastewater that is not treated properly can result in the accumulation of some heavy metals and eventually enter the food chain of agricultural crops. Therefore, this study aimed to inform the proposed solutions based on green technology. Green Technology in this study is a technology development concept that starts from the theories of designing or developing an operating system for activated sludge and wetland processes to treat phosphate from laundry waste with the 3R (Reuse, Reduce, Recycle) principles pretreatment using the soaking of the straw which are expected to have integration between the modern technology and the environmental science to reduce the negative impacts of human activities, where a previous study of Wahyudianto et al. [6] obtained the kinetics of phosphorus removal from laundry wastewater in an artificial wetland with the aquatic plant Equisetum hymale. Furthermore, another previous study, which reported on the soil irrigated with wastewater, focused on the content of several heavy metals in the soils without regard to plant species irrigated from sewerage systems which could reduce their impact on the environment [7]. Based on the literature study that has been carried out by the authors, the laundry waste has not only potential benefits but also many detrimental things. Therefore, the authors studied the treatment of laundry waste using the process model of anoxic-oxic phase and wetlands with straw bath neutralization (farmers have a habit of soaking straw in the water of rice fields). The purpose of this study was to examine the potential of the process model on effluent quality, the potential and impact of effluent as fertilizer for agricultural crops, fate and translocation of pollutants in rice plants.

2. MATERIALS AND METHODS

(1) Description of locations for the identification study

The subject of this study was GIS mapping the potential for laundry waste generation in four regencies and one city in the DIY province. This study was conducted in the DIY province

in four regencies and one city and several GPS locations for laundry services spread across various regions. The laundry services have been widely and illegally spreading massively in the DIY province. The laundry waste has been dumped into the environment and has been not treated properly yet. A large amount of untreated wastewater is currently being used by some local farmers under uncontrolled conditions. Zhang and Shen [8] reported that wastewater irrigation was widely applied in the past, present, and prospectively in the future.

Therefore, the laundry services need to be mapped to know the number and distribution in the DIY province, and then it can be studied the risk of pollution from unlicensed and irresponsible laundry service business behavior. The system to identify the potential laundry waste generation was built by making a map using ArcGIS Online (Web map).

(2) Water samples

Green Technology in this study is one of the solutions to answer and minimize the generation of laundry waste. This study was conducted in an area in Mutihan village, Banguntapan district, Bantul regency, DIY province. Home laundry service wastewater treatment was carried out during two periods of dry and rainy seasons on a pilot plant scale using an operating unit and activated sludge process and wetlands using 3R pretreatment with the soaking of the straw. Detail Engineering Design in this study was an influent debit (Q) of liquid waste of 50cc/minute, an average hydraulic residence time in anaerobic, anoxic, and aerobic (wetland) processes of < 12 hours, 0.5-5 days, and > 53 hours, respectively with detergent organic load in the range of 42.17 mg/L - 164.11 mg/L.

The independent variable in this study was pretreatment with the soaking of the straw. The laundry waste from home laundry services as much as 1 L was pretreated through the straw bath neutralization (the soaking of the straw) (3R principles), after that it proceeded in the activated sludge process, then the output from the activated sludge was used as a liquid fertilizer for rice plants in wetlands. The water samples were labeled and brought to the Indonesian Ministry of Health laboratory in an ice box and stored at cold temperatures. Water samples in the cases without pretreatment were also analyzed. Furthermore, the solid samples which were the whole grains of rice were dried under the sun and stored in a labeled plastic sample bag, and brought to the PPT FMIPA UGM laboratory [2].

3. RESULTS AND DISCUSSION

(1) Characteristics of the wastewater and the effluent of the treatment process

Figures 1 and 2 show the quality of laundry wastewater effluent, which was treated with a pilot plant unit operation and the green technology process, which utilized the effluent as fertilizer for rice plants in the study areas. In cases with pretreatment and without pretreatment, the wastewater with an acidic pH was dominated by the Pseudomonas bacteria, while that with an alkaline pH was dominated by the Kleibsella bacteria. The pH value was still within the limits of the Indonesian National Standard and the International Food and Agriculture Organization (6.5–8.5) for the use of wastewater as media for growing rice plants. The cases with and without pretreatment resulted in differences in the value of treatment efficiency, where the case without pretreatment resulted in the average processing efficiency of the biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), detergent and phosphate in the range of 7.39-98.17%, while the case with pretreatment only produced the average processing efficiency of 7.09-95.49%. In addition, the case without pretreatment had a positive effect on vegetative and generative development and growth of rice plants, in which it resulted in a higher amount of harvested production than the case with pretreatment, but in the case without pretreatment, the accumulation of detergent in the agricultural soil was higher and eventually entered the food chain through agricultural crops to the rice grains, which was a dangerous thing. These results were in line with another study [5]. The value of detergent content in the grain of rice in the case without pretreatment was greater than that in the case with pretreatment. Therefore, the green technology with the pretreatment (3R principle) successfully reduced the detergent content in the grain of rice. Figures 3 and 4 show that the unit operation and green technology process for treating the laundry waste with initial detergent content of 42.17 mg/L with pretreatment in an acidic pH condition resulted in a greater detergent reduction efficiency of 99.59% compared to that value in an alkaline pH which was only 70.70%. In this study, it was obtained how much potential laundry waste was used as the liquid fertilizer from the effluent unit operation and process (UOP) green technology which had differences in the growth and development of the rice plants as well as the contribution of micronutrient absorption and the production of rice yields. Specifically, technically in one part of the unit operation and green technology process, there was a surfactant transformation process into the form of abundant poly phosphate bonding compounds where this mineral was needed for the generative and vegetative development and the growth of rice [9]. Some other information was that the potential for laundry waste with the application of green technology with pretreatment occurs when the surfactant was transformed into a nonylphenol polyphosphate form and a persistent toxic ethoxylate bond that can reduce the Calcium and Magnesium ions in the form of sludge as an indicator of hitherto unknown pollution problems [1, 10]. In addition, acidic pH indicated the dominance of certain microbial populations such as Pseudomonas whose performance could increase the value of TDS as an important macronutrient element that increased the average number of leaves of rice plants and reduced the levels of Alkyl Benzyn Sulfonate (ABS) surfactants in rice grains [10].

(2) Characteristics of the solid samples in the form of rice grains

Analysis of the rice grain samples from the wetlands in partial operating units and green technology processes that were irrigated with laundry wastewater showed that a higher value of detergent content in rice grains and a higher total grain weight (g) per wetland area (m^2) was obtained in the case of without pretreatment, with values of detergent content of 32.65 mg/kg and the rice grain yield of 155.80 g/0.4 m^2. Meanwhile, the case with pretreatment produced the rice grain with a detergent content of 24.80 mg/kg and the rice grain yield only reached half of the case without pretreatment, which was 75.79 g/0.4 m^2.

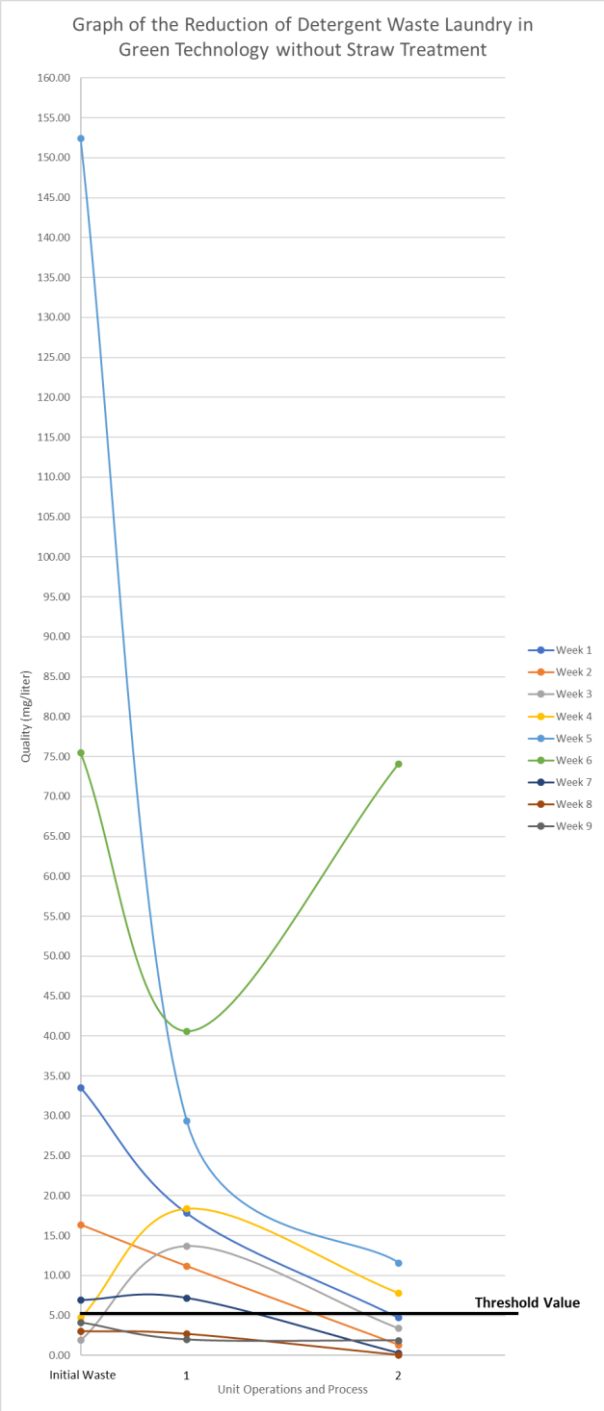

Figure 1. Reduction of detergent and other parameters of laundry waste in green technology without pretreatment of the soaking of the straw

It can be explained that the application of green technology with pretreatment by the soaking of the straw caused the pH to become acidic and was dominated by the Pseudomonas bacteria population converting the surfactants to become the persistent toxic ethoxylate bonds in the form of sludge which was a pollution problem whose effects are not yet known [2].

The results of this study showed that the unit operation and green technology process reduced several pollutant parameters such as BOD, COD, TSS, TDS, detergent, and total phosphate as well as affected the pollutant removal efficiency, the growth rate of rice plants, the vegetative and generative development of rice plants, the harvested products per unit area of wetlands and the detergent level translocation significantly. Generally, previous studies aimed to examine the application of conventional technology that is oriented toward the effluent in meeting and complying with the Indonesian National Standard for Environmental Quality such as in the studies of Artiyani and Firmansyah [11], Astuti and Sinaga [12], Nascimento et al. [13], Zulkarnain et al. [14], Wahyudianto et al. [6]. However, the previous studies rarely or even completely examine the opinion of Abu-Elela et al. [4] in which on the other hand, many environmental, sanitation and health risks are also associated with the use of wastewater as non-agricultural plant growing media due to the presence of toxic contaminants and microbes. The same thing was also reported by Scott et al. [15]. Among the green technology process operation units, the highest form of the process performance and products that were beneficial to the environment, sanitation, and health could be measured from the green technology for treating laundry waste without pretreatment. Meanwhile, the lowest form of the process performance and products that were beneficial to the environment, sanitation, and health could be measured from the green technology for treating laundry waste with pretreatment. Almost similar results have been reported by Nawaz et al. [5]. Accumulation of heavy metals or pollutants occurred in rice plants irrigated with wastewater.

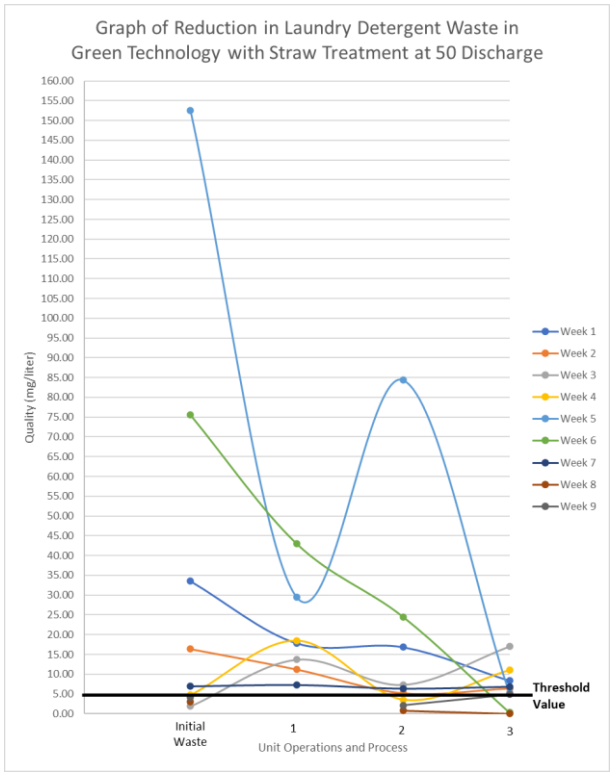

Figure 2. Reduction of detergent and other parameters of laundry waste in green technology with pretreatment of the soaking of the straw

The results of this study are the forms of advice and concrete academic solutions to the generation of laundry waste. The proposed application of green technology-based processing in a pilot plant has been investigated, in the future, the laundry waste treatment technology can be scaled up into a model with a variable ratio of area and proportion of waste generation, meanwhile the fermentative capacity of the soaking of the straw as a pretreatment method in the form of Detail Engineering Design (DED) as a WWTP plant for treating the

laundry waste. Future implications as the conclusion of the findings of this study which is the potency of the process model on the effluent quality are the benefits of reducing the pollutant concentrations in laundry waste according to the permitted quality standards. This study found that the effluent has the potential as fertilizer for agricultural crops in the case without pretreatment. The impact of utilization of the effluent (in the case without pretreatment) as fertilizer is that it results in bigger vegetative and generative growth but it results in fate and translocation of pollutants in rice plants so increasing the level of detergent in rice grains, which is dangerous compounds.

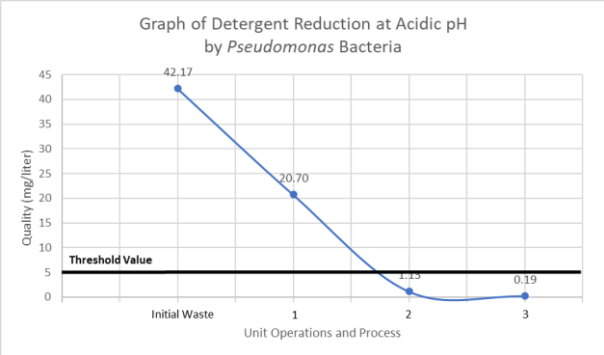

Figure 3. Detergent reduction at acidic pH by the Pseudomonas bacteria

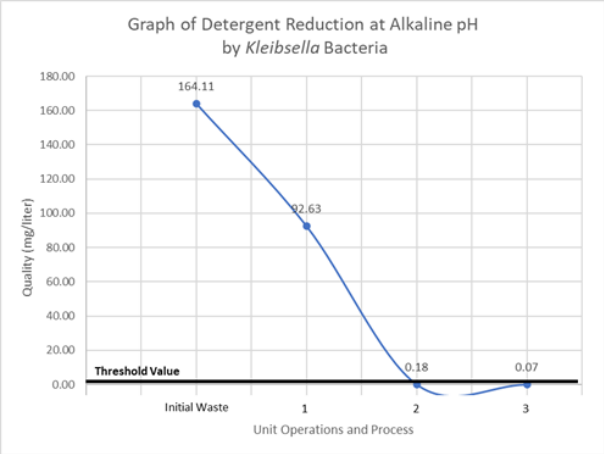

Figure 4. Detergent reduction at alkaline pH by the Kleibsella bacteria

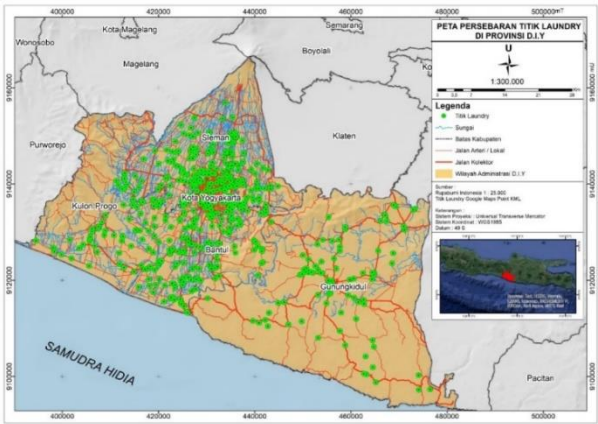

Figure 5. Potential for laundry waste generation in the DIY province

The conclusion of this scientific study using the laundry waste treatment process model with the straw bath neutralization if it is scaled up and equipped with Detail Engineering Design can be used as a recommendation for water resource management policies by local regional policyholders. Following are the results of the mapping of the potential laundry waste generation in four regencies and one city in the DIY province. The map was created using the ArcGIS Online (Web map) with the study locations being carried out in the DIY province in four regencies and one city and several GPS locations for laundry services that were spread out as shown in Figure 5.

Figure 5 shows a map of the results of the identification of potential laundry waste generation where it is known that the laundry services are widespread and unlicensed, which are spread massively in the DIY province. The laundry waste has been dumped into the environment and is not being treated properly. A large amount of untreated and/or inadequately treated wastewater is currently being used by some farmers in uncontrolled conditions. This mapping provides information on the number of laundry services and their distribution in the DIY province and further studies can be done to analyze the risk of pollution from the unlicensed and irresponsible laundry service business behavior [16].

4. CONCLUSION

This study identified the potency of the process model with anaerobic, anoxic, and aerobic reactors as well as wetlands in treating the laundry waste with Detail Engineering Design of an influent debit (Q) of liquid waste of 50cc/minute, an average hydraulic residence time in anaerobic, anoxic, and aerobic (wetland) processes of <12 hours, 0.5-5 days, and >53 hours, respectively with detergent organic load in the range of 42.17 mg/L - 164.11 mg/L. The conclusion of the findings of this study which was the potency of the process model on the effluent quality was the benefits of reducing the pollutant concentrations in laundry waste according to the permitted quality standards. This study found that the effluent has the potential as fertilizer for agricultural crops in the case without pretreatment. The impact of utilization of the effluent (in the case without pretreatment) as fertilizer was that it resulted in bigger vegetative and generative growth but it resulted in fate and translocation of pollutants in rice plants so increasing the level of detergent in rice grains, which is a dangerous thing. The conclusion of this scientific study using the laundry waste treatment model with the straw bath neutralization if it is scaled up and equipped with Detail Engineering Design can be used as a recommendation for water resource management policies by local regional policyholders.

Conclusions of this scientific research in addition to answering the objectives were also to obtain the process models that can reduce pollutant concentrations in the waste, the information about the potential and impact of liquid waste as fertilizer for agricultural crops, the information about the fate and translocation of pollutants in rice plants. This study used the process models in treating the laundry waste with or without pretreatment using the wet rice fields irrigated for 14 weeks with long-term laundry waste generation. The technology significantly affected the reduction efficiency of the pollutant parameters such as BOD, COD, TSS, TDS, detergent, and total phosphate where the average reduction efficiency of 7.39-98.17% was obtained without pretreatment

and that of 7.09-95.49% was obtained with pretreatment. This study also examined the physical appearance of morphological growth, vegetative and generative development of rice plants, quantity and quality of harvested products, and the ABS surfactant translocation in rice harvested grains.

The quality of the effluent from the green technology, which resulted in high processing efficiency, met the requirements of the Indonesian National Standard for Environmental Quality. The laundry waste was very potential as a trigger for the growth and development of vegetative and generative agricultural water plants and had the potential to increase the quantity and quality of rice crop products, whereas in the case without pretreatment it produced a rice grain weight of 155.80 g/0.4 m^2 with ABS surfactant content in the grain of 32.65 mg/kg, while in the case with pretreatment it only produced a rice grain weight of 75.79 g/0.4 m^2 with ABS surfactant content of 24.80 mg/kg.

This conclusion included the main conclusions of this author's research with an easy-to-understand explanation, such as obtaining the potential of the model process on the effluent quality, the potential and impact of effluent as fertilizer for agricultural crops, the fate and translocation of pollutants in rice straw.

In this study, 3 variables are thought to be related to the concentration of detergent, phosphate and effluent quality and product quantity, namely quality variable (chemical content of laundry waste), quantity variable (ratio of waste to rice area) and capacity variable (addition of rice straw fermented liquid). To obtain an answer to which factors have variable synergism, a multivariate analysis was carried out through some stages including candidate variable selection, modeling, and interaction analysis. From the analysis of the selection of candidate variables, it turned out that there were two variables with p-value (sig) < 0.05, namely the quantity variable (the ratio of waste to the rice area) and the capacity variable (addition of rice straw fermented liquid). While one variable which was the quality variable (chemical content of laundry waste) had p-value (sig) > 0.05, so this variable did not enter the multivariate model. From the results of the multivariate logistic regression analysis, it can be seen that the quantity variable (ratio of waste to rice land area) and the capacity variable (addition of rice straw fermentation liquid) had p-value (sig) below 0.05, meaning that both variables were significantly related to detergent levels, phosphate and effluent quality, and product quantity. Factors that had a high influence on system performance were the addition of rice straw fermented liquid and the proportion of waste/discharge ratio, in other words, had a positive synergy while the chemical content of laundry waste and the flow of effluent into the wetlands had negative antagonism because the 3 dependent variables between factors were low, namely discharge of waste streams to the wetlands. From the whole analysis process that has been carried out, it can be concluded that from the three independent variables that are thought to be related to detergent, phosphate and effluent quality and product quantity, there are only two variables, namely quantity variables (ratio of waste ratio to rice area) and capacity variable (addition of rice straw fermented liquid) correlated after controlling for the confounding variable which is quality variable (chemical content of laundry waste). Furthermore, it can be concluded that between the two variables, the quality variable (chemical content of laundry waste) is more dominantly related to the levels of detergent, phosphate, and effluent quality and the quantity of the resulting product.

The conclusion of this scientific study using the laundry waste treatment process model with the straw bath neutralization if it is scaled up and equipped with Detail Engineering Design can be used as a recommendation for water resource management policies by local regional policyholders.

With the limitations of the work that has been done, the direction of future research is to try out the processing of laundry waste on a scale-up prototype or complete scale-up process model with Detail Engineering Design, to examine the hygienic effects of rice containing hazardous detergent ingredients in the process of cooking rice with water containing excessive doses of chlorine as well as to assess the Biological Exposure Index of detergents in humans.

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