Design and Development of a Website-based Palm Oil Industry Liquid Waste Monitoring System

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Abstract. Liquid waste produced by palm oil mills needs to be monitored regularly to avoid pollution and negative impacts of waste before being discharged into rivers. Monitoring of pollution levels of palm oil effluent is carried out in wastewater disposal ponds. In this study, a website-based prototype of a palm oil effluent monitoring system was designed and built. This prototype monitors the level of pollution of liquid waste in the liquid waste disposal pond. Monitoring the level of pollution of this liquid waste takes a sample of waste at one of the palm oil mills located in Kuantan Singingi, Riau. This research uses a pH sensor and a water turbidity sensor. Provision of calcium oxide is carried out if the level of acidity of the liquid waste and the level of turbidity of the liquid waste is in poor condition. The measurement results are then displayed directly on the website that was built. From the results of field tests, it was found that the liquid waste is very acidic, so it is necessary to add calcium oxide to reduce the acid content.

1. Introduction

Riau is one of the largest palm oil-producing provinces in Indonesia with an area of 3.4 million hectares and an average production of 8 million tons. One of the negative impacts of the existence of this mill is often not accompanied by good handling of the waste. Generally, the pollution produced by palm oil mills is water pollution, as a result of waste that is not managed properly which can cause damage to natural resources and decrease the quality of the water environment because it’s dirty and polluted. The negative impact of liquid waste is often called Palm Oil Mill Effluent (POME). POME is an oily liquid waste derived from condensate decomposition, water hydro cyclones, and mud separators. Though non-toxic, POME that is not maintained properly will cause unpleasant odors around the plant. Then, the liquid waste seepage will cause water and soil contamination around the factory area and release large amounts of methane gas and other hazardous gases, leading to greenhouse gas emissions [1]. Decree of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning Quality Standards for Palm Oil Liquid Waste, has determined the type of hazardous pollutant load contained in waste from oil palm plantation activities for parameters pH 6 to 9 and Nephelometric Turbidity Unit (NTU) value less than 100. Therefore, liquid waste must meet the specified levels before being channeled into the river [2]. Domestic industry and other business/household activities have the potential to have a negative impact on organisms that depend on...
water resources. Therefore, it is necessary to manage and protect quality water resources. Control of pollution caused by integrated liquid waste needs serious attention to be studied and investigated in order to meet environmental quality standards set by the government. The handling does not only involve the government but also the community and industry. In addition, wastewater treatment technology is also needed to reduce the level of pollutants contained in the waste [3]. In studies conducted by researchers [4-5], calcium oxide (CaO) based catalysts have been used to remove pollutants in wastewater due to their high mechanical stability and low cost. In this paper, the provision of CaO is also carried out in artificial ponds where the pollutant conditions of the liquid waste exceed the predetermined threshold.

The results of the monitoring test for the provision of CaO in this artificial pond are expected to provide information on the right amount of CaO to be applied to the liquid waste disposal pond so that it returns to its normal state.

2. Methodology

Three main tools need to be implemented to monitor palm oil effluent. The first piece of equipment is Arduino Uno as a control and instrumentation system, the second tool is a pH analog and a turbidity sensor to measure pH and turbidity levels of waste, the last important device is the MCU esp8266 node as a module that sends data obtained by sensors to the website. The block diagram monitoring tool system is shown in Figure 1.

![Block Diagram Monitoring Tool System](image)

**Figure 1.** Block Diagram Monitoring Tool System

2.1 Sensor Monitoring

The major sensors needed in monitoring palm oil effluent are pH and turbidity sensors. The measuring pH sensor operates on a supply voltage of 3.3-5V and is easy to interact with the Arduino. The pH sensor has a range from 0 to 14. The turbidity sensor operates at a voltage of 5V (DC) and a current of 40mA (max). Response time for this sensor is less than 500 milliseconds. The operating temperature ranges from 5ºC to 90ºC. It provides output in the form of analog voltages ranging from 0-4.5V. There is a relationship between turbidity and stress given in the graph plotted by the manufacturer [6]. Figure 2 shows the circuit on the pH and turbidity sensor module.
Figure 2. Module pH Sensor and Turbidity Sensor

2.2 NodeMCU ESP8266

NodeMCU is an open-source firmware and development kit that helps to build Internet of Things (IoT) products. NodeMCU is developed to make it easier to use advanced Application Programming Interface (API) for hardware Input-Output (IO). The API can reduce redundant work for configuring and manipulating hardware. NodeMCU is designed like Arduino hardware Input-Output (IO). NodeMCU uses the lowest cost Wi-Fi MCU that is ESP 8266. To provide an IoT system, this module uses wireless communication. Wi-Fi 802.11 b/g/n is chosen for the communication. NodeMCU already built-in Wi-Fi module. Many devices like laptop, smartphone, and the computer can access NodeMCU using Wi-Fi [7].

Testing of the two sensors was carried out using a sample of liquid waste from one of the palm oil mills in Kuantan Singingi, Riau, the liquid waste sample was placed into an artificial pond that was available then the prototype of the monitoring system that had been made was placed on top of the liquid waste. Measurements of pH and turbidity are carried out directly at the factory waste disposal
pond. Then the test results obtained will be analyzed and used to determine the right amount of CaO levels to be applied. The purpose of giving this CaO is to neutralize the acid content in the waste so that it becomes neutral and according to the standards set by the government.

3. Results and Discussion

Figure 3 is a prototype that has been built and used in testing and monitoring the condition of palm oil mill effluent.

![Figure 3. Prototype System Monitoring](image)

This research focuses on pond 1 and pond 2 waste. The measurement results obtained from the sewage disposal pond are shown in Table 1. The measurement has been done in 5 days. The data was recorded every 30 minutes.

|                | pH (V) | pH level | Turbidity (V) | NTU  |
|----------------|--------|----------|---------------|------|
| Pond 1         | 3.22   | 2.62     | 2.69          | 274.7|
| Pond 2         | 3.22   | 2.62     | 2.98          | 271.7|

From Table 1, both ponds have pH levels and waste turbidity almost equal to or less than the established waste quality standards. The results of the measurement data for palm oil waste ponds are sent by the node MCU module to the website. Figure 4 shown the display website monitoring pH level and turbidity.
After measuring the pH and turbidity of the wastewater in the pond, the next step is to apply calcium oxide (CaO) to a pond that has a high acid content with a ratio of 1: 1,000,000 in the original pond. In this study, four artificial ponds were made to observe the application of this CaO as shown in Figure 5. Pool 1 is a sample of liquid waste taken in the field with high acid content. Pool 2 is stirring. On pool 2 is what will be given the CaO. After giving the right amount of CaO, the waste resulting from mixing with CaO flows into Pool 3. Pool 3 is a pond where the liquid waste is in accordance with the established standards by silica sand added. This pool is the last pool to be connected with the river in its original condition in the field. Pool 4 is river water as a comparison.

*Figure 4. Display Website Monitoring*
Giving CaO with doses of 0 g, 0.1 g, 0.2 g, 0.3 g, and 0.4 g into the prototype pond that already contains palm oil waste. The stirring process is then carried out until the CaO is well mixed and then the readings of the two sensors are carried out and observed. The addition of CaO levels was carried out until both sensor readings were at a predetermined standard, namely pH 6-9 with turbidity less than 200 NTU. The results of pH measurements when giving CaO can be seen in Table 2.

| Cao(g) | Time | Pond 2 |     |     |
|-------|------|--------|-----|-----|
|       |      | Volt   | pH  | Volt | NTU |
| 0     | 21.10| 3.24   | 2.88| 2.64 | 265 |
| 0.1   | 21.40| 3.08   | 4.1 | 2.64 | 262 |
| 0.2   | 22.10| 2.77   | 5.34| 2.64 | 263 |
| 0.3   | 22.40| 2.69   | 6.55| 2.64 | 264 |

It can be seen in Table 2, that the addition of CaO affects the voltage change on the pH sensor which will cause an increase in the pH value. The addition of the amount of CaO to 0.3g was carried out to obtain a pH value above 6, although the turbidity value was still above the specified threshold. Then the mixed waste is distributed to pool 3 which has been given silica sand. Tests showed that in pool 3 there was a decrease in the value of NTU and also an increase in pH due to mixing with silica sand. The results showed a pH of 6.62 with a turbidity value of 185 NTU. The results obtained have met the established quality standards. then the waste is channeled into pond 4 which is river water. This mixing causes a decrease in the turbidity value to 86 NTU. from the test data, by giving 0.1 grams of CaO, the pH value in the drained pond will increase by 1.22. And the above data can be used as a reference for the provision of CaO with real conditions. With a ratio of 1: 1,000,000, then 0.1 grams of CaO in the prototype pond will be equivalent to 120 kg of CaO for an actual pond with a pool area of 600 m3.

4. Conclusion
The website-based liquid waste monitoring system has been successfully designed and built. The test results in the palm oil waste pond obtained the value of the pH level and the level of turbidity in very acidic conditions. Thus, it is necessary to give calcium oxide (CaO) to neutralize the pH in a ratio of 0.1 grams with an increase in the pH value of 1.22. The level of turbidity can be reduced by adding
silica sand to the third pond. The addition of CaO and silica sand has reduced the pH and turbidity of the waste so that it is in accordance with the quality standards set by the government.

Acknowledgment
This research work was financially supported by LPPM Universitas Riau under a community service grant. The authors also thank the Village Head and his staff for the good cooperation and facilities provided while the research team was in the village.

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