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Potential of Low Cost Sensor Usage for Waste Water IOT System

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1. Introduction

Water is the most important element on earth to support any living creatures on earth. Therefore, any contamination to natural water resources could lead to catastrophe [1]. Consequently, industrial waste must be prevented from polluting water resources. Usually, waste water from coal mining is settled in a pond and treated to balance the PH and reduce TSS (Total suspended solid) before being returned to water bodies. Wastewater treatment in coal mining industry is highly regulated by the government, due to the high usage of water and hazardous pollution. The Indonesian government through Minister of Environment and Forestry Regulation number P.93/MENLHK/SETJEN/KUM.1/8/2018 requires all coal mining companies to monitor water quality parameters namely pH, TSS, and water debit.

Therefore continuous pH and TSS measurement is required to ensure that the quality of water meets government regulations.

Industrial grade meters are costly, e.g. the price for a TSS portable meter is between USD 2,000 to 4,000. Therefore, a small-scale coal mining company would find the price too expensive. In addition, companies also feel that the monitoring task is too laborious. Not only the equipment is costly, to frequently measure and input the data manually is also time demanding. In addition to the meter investment cost, the company still has to assign a staff to manually measure the wastewater quality and enter the data to the system. Therefore, low cost solution to monitor water quality is a necessity to solve the problem. Shahanas and Shivakumar compiled various technologies and platform for 1 smart water management system (SMWS) and designed a framework for SMWS using raspberry pi [2]. Raspberry pi is a low cost CPU system with Wi-Fi capability. Therefore, the raspberry pi can function as a central controller for sensors. In this research, an IOT system based on raspberry pi was designed and developed for wastewater measurement equipment. The system has 3 sensors to measure temperature, pH, and turbidity each. pH and turbidity are used for wastewater quality monitoring. Figure 1 shows the system of waste water monitoring.

Nowadays, low cost sensors utilization for monitoring is increasingly popular because of their cheap price and availability in the market. The sensors can be easily purchased through online stores. Recently, the accuracy and reliability of low cost sensors are adequate for industrial purposes. Schmidt (2018) designed a low-cost monitoring buoy system for near-shore aquaculture and it performed satisfactorily [3]. While pH measurement can be directly obtained from pH sensor, TSS value cannot be directly obtained from the sensor. Therefore another sensor with a similar principle is used to estimate the value. Holliday et.al (2003) concluded that turbidity is able to estimate TSS [4]. Further, Daphne et al (2011) found that turbidity is the most economical solution to estimate suspended solid in the river [5]. Turbidity is a parameter to measure water clarity, therefore it is suitable as an estimator for TSS as both metrics are used to measure water clarity.

Figure 1. Waste water monitoring system

2. Material and Methods

The experiment utilized wastewater from a coal mining wastewater pond. However, the location of the pond cannot be disclosed due to confidentiality. The experiment steps are as follows:

1. The wastewater was mixed with pure water to create seven 500-ml wastewater samples to form gradually increasing TSS content.

2. The samples were then analyzed in an industrial laboratory to obtain pH and TSS values. A pH meter was used to measure the pH of the samples, while gravimetric analysis was used to measure TSS.
3. The voltage of turbidity and pH sensors from each solution samples were measured and plotted in the graph on X axis and the corresponding TSS values were also plotted in Y axis.
4. A model was to created to estimate TSS and pH value.

2.1. Gravimetric

Gravimetric is a method to measure TSS by weighing residue from a solution after filtering the solution using a 2-μm filter and drying the residue in the oven at 103-105°C for one hour. Gravimetric is the standard procedure to measure TSS.

2.2. Log linear regression

The log-linear model is a mathematical equation which is a function of logarithmic variables combination making it possible to create a linear regression. The equation is shown below

$$y = a \log x + c \quad (1)$$

Where:

- y is dependent variable
- x is independent variable
- a is constant
- c is constant

3. Results and Discussion

Among seven samples, three samples were omitted, one sample was omitted because the TSS values were similar to another sample, while two other samples were omitted due to sensor limitation. Therefore, only 4 samples are presented in Figure 2. Log-linear equation was applied to model the relationship between TSS values and turbidity voltages.

Figure

(a) Log

ry data

During implementation pond were different fr gravimetric method c as the sediments in the measurement through H meter were [3] used to measure the values. Waste water samples were taken from a pond where the equipment was installed to ensure that the sediment did not affect the value of the TSS. The sample was then [4] mixed with pure water to produce variation of TSS value. Moreover, following a discussion with the company's EHS staffs, the wastewater TSS value was rarely over 1000. Therefore the TSS values during implementation were below 1000. The results are shown in figure 2a illustrating turbidity vs TSS log linear graph and Figure 2b depicting the linear regression graph.

(a) (b)

Figure 3. Graph of Turbidity sensor voltage vs TSS during implementation

(a) Log-linear graph (b) Linear graph

Table 1. R2 Results

	Log linear R2	Linear regression R2
Laboratory data	0.993	0.7747
Implementation data	0.9941	0.9883

Table 1 shows that the log linear model has a coefficient of determination $R^2 = 0.993$ and 0.9941 for laboratory and implementation data respectively. Likewise, the linear regression model has a coefficient $R^2 = 0.7747$ and 0.9883 for laboratory and implementation data. The log-linear model fit the data satisfactorily for values more than 1000 compared to linear regression. For TSS values below 1000, the log linear and linear regression presented similar results, therefore both methods can be applied to model TSS value.

4. Conclusion

Log-linear equations were applied to model the relationship between turbidity sensor voltages and TSS values. Experiment results utilizing laboratory and implementation dataset confirmed that log- linear model fit the dataset satisfactorily. Therefore, turbidity sensor can be applied to estimate TSS values, particularly for TSS values that are more than 1000. However, the results are limited to coal mining wastewater. Future research should apply a varied wastewater dataset and utilization of spectrum sensor that would allow utilization of advanced modelling techniques such as neural networks, support vector models (SVM), particle swarm, etc.

Sources

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