Prototype of Methyl Mercury Contamination Monitoring System based on Internet of Things in the Jambi Batanghari River

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Keywords: Batanghari river, contamination monitoring, internet of things, *methyl mercury*, raspberry pi.

Abstract: The parameters used to monitor and determine river water quality are divided into physical, chemical, and microbiological parameters. Specific on chemical parameters, especially dissolved metals, there is also Methyl Mercury / Hg, which is very dangerous. Even water that is exposed to mercury cannot be purified in any way. Research on water quality by the Jambi Regional Environment Agency at 16 points found that the Batanghari river category is now heavily polluted (Class D), allegedly due to wastewater from Gold Mining Without Permits (PETI). The need for raw water for residents throughout the Batanghari River area is urgent always to maintain its quality. To find out the development of water quality, especially in the dissolved metal content, which is dangerous and is the primary pollutant of illegal gold mining activities such as Methyl Mercury / Hg, effective and efficient technology is needed so that it is expected to be able to read the level in real-time. Contamination of water. The purpose of monitoring water quality is to match whether the quality of water monitoring results is following the standard of use/consumption. The internet of things technology is applied using a raspberry pi with several sensors, including a pH sensor, water electrolyzer, and colour sensor, as well as a TDS (Total Dissolved Solids) analogue gravity sensor, as well as a mobile web-based application that is used to monitor real-time data. The mercury contamination monitoring tool will produce data output in a summary of the mercury contamination category, pH, and water turbidity level. Then the output generated in real-time is sent via the Module Shield SIM800L GSM component to the server and can be monitored through the Methyl Mercury Contamination Monitoring Application.

1 INTRODUCTION

Based on the Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning Management of Water Quality and Water Pollution, the parameters used to monitor and determine river water quality are divided into physical, chemical, and microbiological parameters. Physical parameters consist of turbidity, colour, taste, smell, temperature, and Total Dissolve Solid (TDS) (Republic of Indonesia Government Regulation Number 82 of 2001). While the chemical parameters consist of pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Nitrite, Sulfate, hardness, and dissolved metals. Meanwhile, the biological parameters consist of Total coliform and Escherichia coli. In chemical parameters, especially dissolved metals, mercury (Methyl Mercury / Hg) is very dangerous.

Even water that is exposed to mercury cannot be purified in any way. Based on Government Regulation Number 82 of 2001 regarding raw materials for drinking water, the safe limit for mercury is 0.001 mg / l, arsenic is 0.005 mg / l, and iron is 0.3 mg / l. Reporting from the results published on the Kompas website, the level of mercury in the surface water of the Tembesi River, which is the water source for PDAM Tirta Sako Batuah, Sarolangun City, is right at the critical line. In the PDAM intake channel, the levels of heavy metals reached 0.001 mg / l, iron 1.39 mg / l, and arsenic 0.001 mg / l. Mercury levels in the intake sample of PDAM Merangin, whose water comes from the Merangin River, is the same as the Mesumai River (0.0008 mg / l), arsenic is 0.002 mg / l, but the iron content is four times above the safe limit (1.31 mg / l). The three rivers empty into Batanghari. As a result, the water quality of the Batanghari River continues to deteriorate. Last April, research on water quality by

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the Jambi Regional Environment Agency found that the Batanghari category was now heavily polluted (Class D), allegedly due to wastewater from unlicensed gold mining (PETI). Also, based on the data listed in the Decree of the Minister of Public Works Number 51 / KPTS / M / 2012 concerning the Management Pattern of Water Resources in the Batanghari River Basin, it is projected that the population around the Batanghari River area continues to increase every year, for example, Jambi City to In 2028 it is projected that a total of 715,525 people depend on the Batanghari River with water needs increasing to 104.46 m3/s (Decree of the Minister of Public Works Number 51 / KPTS / M / 2012).

2 MANUSCRIPT PREPARATION

2.1 Place and Time of Research

This research was carried out in the Laboratory of Computer Science, Faculty of Computer Science, Universitas Nurdin Hamzah, and Laboratorium of Sumatra River Basin VI in May to October 2020.

2.2 Materials

The research was carried out in the Batanghari Jambi river water bodies. Water sampling is carried out in the Aurduri Bridge area 1. Development of the device uses several components, including Raspberry Pi 4 Model B, SIM800L V.2 V2 5V Upgrade GSM GPRS Quad-Band with Antenna, PH Meter 0-14 Detector Sensor Probe Module, Measuring Tool Water Quality TDS Electrolyzer, TCS3200 Color Sensor Board Module Color, DFRobot Gravity Analog TDS Sensor / Meter. The methyl mercury pollution monitoring application was developed using one of the PHP programming frameworks, namely Laravel 7 and the MySQL database.

2.3 Research Methods

The monitoring system that is designed consists of three main parts, namely the pH probe sensor as input, the Raspberry Pi as a server computer (web server and database server), and SIM800L V.2 V2 5V GSM upgrade as a network device. The following in Figure 1 is a system design block diagram:

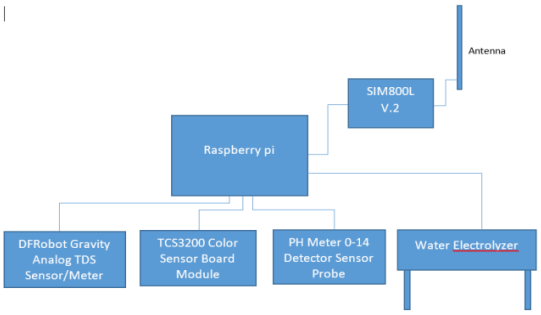

Figure 1. Block System Design Diagram

The pH probe sensor used in the design of this monitoring device is a glass electrode that functions as a pH sensor connected to the pH circuit using a BNC connector. Electrolyzer water quality measurement tool for detecting mercury (methyl mercury) contamination, pH circuit and Gravity Analog TDS (Total Dissolved Solids) connected to the Raspberry Pi with serial communication on the Raspberry Pi GPIO pin, namely the RX pin on the pH circuit connected to the TXD pin on the Raspberry Pi, the TX pin is connected to the RDX pin. When the Electrolyzer, pH probe sensor, and TDS analogue gravity sensor receive a reference voltage in the form of an analogue signal from each sensor, the Electrolyzer results will be sent to the TCS3200 Color sensor. The pH circuit and Gravity Analog TDS will process the output voltage passed by the pH and TDS sensors into data in the form of values of mercury (methyl mercury), pH, and TDS.

2.4 Implementation of Research

2.4.1 Raspberry Pi

According to Natarajan (Natarajan, 2014), the Raspberry Pi is a mini-computer that is the same size as a credit card that can be used for many things as a computer can do, such as spreadsheets, word processing, games, and programming.

Raspberry Pi can also be used for controlling more than one device, both short and long distances. Unlike the microcontroller, the Raspberry Pi can control more than 1 unit of the device you want to control. For controlling the unit device, the Raspberry Pi uses the Python language as its programming language. Raspberry Pi has several features, namely Micro SD, which functions as a hard drive, USB port, Ethernet port, audio-video output, HDMI Video, 400-700 MHz CPU, and most importantly, the Raspberry Pi has a GPIO pin that functions to interface with various devices electronic.

2.4.2 Methyl Mercury

Methylmercury is a hazardous substance of interest concerning environmental health. Inorganic mercury circulating in the general environment is dissolved into freshwater and seawater, condensed through the food chain, ingested by humans, and consequently affects human health. Recently, there has been much interest and discussion regarding the toxicity of methylmercury, the correlation with fish and shellfish intake, and long-term management methods of the human health effects of methylmercury. What effects chronic exposure to a low concentration of methylmercury has on human health remains controversial. Although the possibility of methylmercury poisoning the heart and blood vessel system, the reproductive system, and the immune system is continuously raised and discussed, and the carcinogenicity of methylmercury is also under discussion, a clear conclusion regarding the human health effects according to exposure level has not yet been drawn (Young, et al., 2012).

2.4.3 The Batanghari River

The Batanghari River is one of the rivers in Indonesia, which has its head in the West Sumatra Province with its water source from Mount Rasan, flowing downstream in the Jambi Province. This river passes through several districts in the two provinces (Ratnaningsih, et al., 2019).

2.4.4 Internet of Things

In the past decade, all humans' life changed because of the internet. The internet of things has been heralded as one of the significant developments in the internet portfolio of technologies. The Internet of Things (IoT) is concerned with interconnecting communicating objects that are installed at different locations that are possibly distant from each other. Internet of Things represents a concept in which network devices can collect and sense data from the world and then share that data across the internet, where that data can be utilized and processed for various purposes (Kalpana, 2016).

2.4.5 Sample Analysis

Raspberry Pi functions as a server computer (web server and database server). The Raspberry Pi will receive a pH value which is the output of the pH circuit. Readings of the pH value received will be directed to a database table on MySQL periodically to be stored and displayed using a graph on the monitoring web page; besides that, the monitoring web page also displays the pH value is measured directly or live. SIM800L V.2 V2 5V GSM upgrade functions as a network device on the connected Raspberry Pi. Internet or GSM access is required so that the local web server that has been designed on the Raspberry Pi can be widely accessed by the client using the internet network via the tunnelling method or via short message when the internet signal is inadequate.

The power supply in this design functions as a source of electrical energy required by the main components of the monitoring system. The power supply circuit in the design of this monitoring device uses a DC to DC converter whose output voltage can be adjusted. This circuit has an energy source, namely from the battery as the main power. As for the series of monitoring device construction as shown in the figure 2.

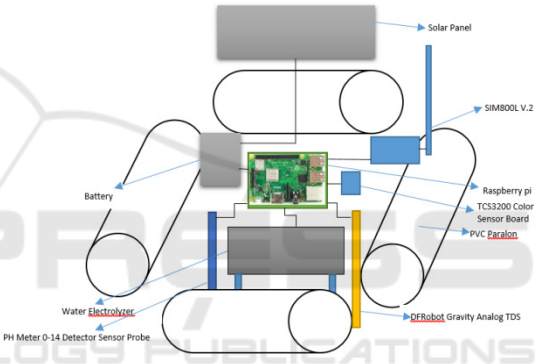

Figure 2. Construction Monitoring Device

Figure 2 is the design of water pollution monitoring devices based on the internet of things. The monitoring device is designed as light as possible to float on the water in the position of the sensor below to touch the water directly and the position of the solar panel above so that it is easy to get solar radiation.

3 RESULTS AND DISCUSSION

The need for raw water for residents throughout the Batanghari River area is urgent always to maintain its quality. To determine the development of water quality, especially in the dissolved metal content, which is dangerous and is the primary pollutant of illegal gold mining activities such as methyl mercury / Hg, effective and efficient technology is needed so that it is expected to be able to read the level of contamination in water in real-time. Water quality monitoring aims to match whether the water quality

monitoring results are following the standard of use/consumption. In addition to assisting the Sumatra VI River Basin in monitoring water quality, the designed technology is expected to assist several tasks, including a) Helping to collect water quality data, identifying potential sources of pollution and pollution load; b) Maintain long records of water quality, which can be read in real-time. As for the technology built in this study, monitoring methyl mercury / Hg contamination can be done by mobile using a web-based application. The Mercury Contamination Monitoring Application interface development results are as shown in figure 3 and so on.

Figure 3. Login page of the Batanghari River Mercury Contamination Monitoring Application

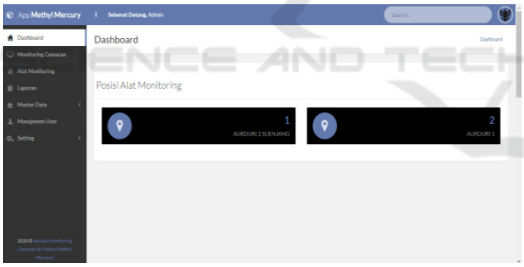

Figure 4. Dashboard page of the Batanghari River Mercury Contamination Monitoring Application

Figure 5. Mercury Contamination Monitoring Page, pH, and Turbidity of Batanghari River Water

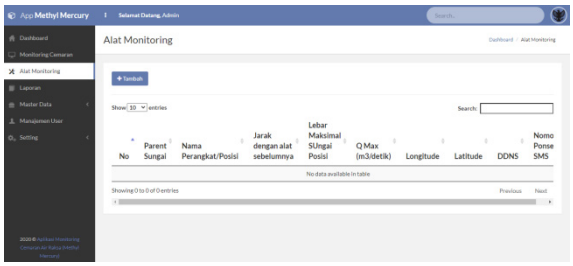

Figure 6. List of Placement of Mercury Contamination Monitoring Tool in Batanghari River

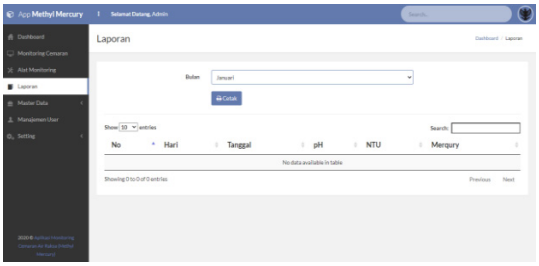

Figure 7. Report page of the Batanghari River Mercury Contamination Monitoring Application

4 CONCLUSIONS

Methyl mercury / Hg contamination monitoring system based on the Internet of Things (IoT) using the Raspberry Pi 4 Model B accompanied by a Water Electrode, pH Electrode Sensor, and a Gravity Analog TDS Sensor. The choice of electrolysis-based methyl mercury module is due to the availability of sophisticated sensors to read accurately digital data on mercury content which is very expensive and not marketed freely, based on previous research conducted by Maulana (Maulana, 2017) regarding the Design of Drinking Water Quality Detection Devices Using Electrolysis and Conductivity, The electrolysis method used as a whole work well. However, there are still errors with an average value of 2.32%. The mercury contamination monitoring tool will produce data output in a summary of the mercury contamination category, pH, and water turbidity level. Then the output generated in real-time is sent via the Module Shield Sim800 GSM component to a server computer and can be monitored through the Methyl Mercury / Hg Contamination Monitoring Application.

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