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Manufacturing of IOT-Based Industrial Wastewater pH and TSS Monitoring Instruments Using RUT 955

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ABSTRACT

According to data from the Environment Ministry of the Republic of Indonesia, 59 percent of Indonesian rivers are severely Polluted. The pollutant is due to many people's and industry's behavior of discharging waste directly into the river. This liquid waste contains solids and chemical compounds that affect river water's acidity (pH). Their pollutant does not meet the Government Regulation of the Republic of Indonesia Number 101/2014. Research has been carried out to manufacture an IoT-based sparing monitoring system device using RUT955 to measure the pH and TSS of industrial wastewater in remote areas. This sparring system uses two sources of electric current: PLN and the sun. Solar electricity stored in the battery is used to overcome the problem of breaking the electricity supply from PLN. The device made has been successfully connected to the internet using the webhook.site platform. Acquisition data storage is carried out using the google spreadsheet platform. The pH and TSS data measured by the sensor sent by RUT955 can be received and displayed on the internet platform. The measurement results that the sensor has carried out need to be calibrated so that the data sent is accurate.

Keywords: *Pollutant, Waste water, Monitoring system, RUT955, IOT.*

1. INTRODUCTION

According to data from the Environment Ministry of the Republic of Indonesia, 59 Percent of Indonesian Rivers are Severely Polluted. The pollutant is due to many people and industry's behavior discharging waste directly into the river. The wastewater discharged by the industry does not meet the standards set by the government, so it becomes the dominant pollutant source that pollutes the river [1]. The wastewater is generated from various production processes that have taken place, including the washing process, drying process, the cooling process. Various elements of the rest of the products are carried in it, including solid particles and chemical compounds that can affect river water's acidity (pH). These particles and compounds may contain lead (Pb), mercury (Hg), and copper (Cu), which are harmful to the environment [2]. Water content like this can cause damage to the river ecosystem.

The government has regulated Waste Management for the industry through Government Regulation of the Republic of Indonesia (PP) No. 101/2014 concerning Management of Hazardous and Toxic Waste [3], Regulation of the State Minister of the Environment No. 01 of 2010 concerning the Management of Water Pollution Control [4], and Regulation of the Minister of the Environment of the Republic of Indonesia number P.93 / MENLHK / SETJEN / KUM.1 / 8 / 2018 Appendix II concerning Continuous Wastewater Quality Monitoring And in the Network for

Business and Activities [5], and Regulation of the Minister of the Environment number P.80 / MENLHK / SETJEN / KUM.1 /10 /2019 [6]. These regulations state the definition of liquid waste, wastewater quality standards, and wastewater Quality Monitoring which includes Power Of Hydrogen (pH) and Total Suspended Solid (TSS) [7].

Table 1 shows several parameters that need to be considered for industrial wastewater referring to the industrial sector. The fourteen industry types have two main parameters: pH with a measurement range of 0 – 14 and TSS with a measurement range of 0 – 3000 mg/l [5].

The power Of Hydrogen (pH) is the value of the acidity solution, which is influenced by H+ and OH- ions [8,9]. The more H+ ions there are, the more acidic the solution is; if there are fewer H+ ions, the solution becomes basic. As stipulated by Regulation of Minister of the Environment of the Republic of Indonesia Number 5 of 2014 concerning Wastewater Quality Standards, the pH level that can be disposed of from industrial waste ranges from 6 to 9, adjusted for the discharge water discharge in each industry.

Tabel 1 . Wastewater Parameters by Type of Industry [5].

No.	Jenis Industri	Parameter
1	Rayon	pH, COD, TSS, Debit
2	Pulp & Paper	pH, COD, TSS, Debit
3	Upstream Petrochemical	pH, COD, TSS, Debit
4	Paper	pH, COD, TSS, NH-3, Debit
5	Basic Oleochemicals	pH, COD, TSS, Debit
6	Palm Oil	pH, COD, TSS, Debit
7	Oil Refinery	pH, COD, TSS, NH-3, Debit
8	Oil and Gas Exploration and Production	pH, COD, TSS, NH-3, Debit
9	Gold and Copper Mine	pH, TSS, Debit
10	Coal mine	pH, TSS, Debit
11	Textile	pH, COD, TSS, Debit
12	Nickel mine	pH, TSS, Debit
13	Fertilizer	pH, COD, TSS, Debit
14	Industrial area	pH, COD, TSS, Debit

TSS is a material or suspended material that causes water turbidity consisting of mud, fine sand, and micro-organisms, mainly caused by soil erosion or erosion carried by water bodies [10,11]. TSS is one of the essential factors in decreasing water quality, causing physical, chemical, and biological changes [12]. Physical changes include the addition of solids, both organic and inorganic materials, into the waters, thereby increasing the turbidity, which will further inhibit the penetration of sunlight into water bodies. The high Total Suspended Solid can reduce the amount of dissolved oxygen in the water and disrupt aquatic ecosystems [13].

With the above considerations, we need a real-time device that can monitor TSS and pH levels, Sparing monitoring system. The monitoring data can be accessed anytime to keep the wastewater contamination below the permissible threshold.
Manufacturing device to monitor TSS and pH levels is become urged in order to prevent environmetal disaster. This device needs to be connected to the internet to connect the user with the device installed at the wastewater disposal site. In this way, users can always be up to date with the monitoring results anywhere and anytime as long as they are also connected to the internet [14]. In this paper, we report on manufacturing a real-time monitoring tool for TSS and pH levels for an industrial wastewater disposal system using the Internet of Things (IoT).

2. METHODOLOGY

2.1. Calculation of TSS Value

TSS is a suspended material and does not dissolve in water. The brightness value will be low if the turbidity or TSS content is high; otherwise, it will be high if the turbidity or TSS content is low. Conventional measurements are carried out by taking samples of industrial wastewater at the monitoring location and measurements in the laboratory. The TSS value is obtained by calculating measurement results into the following equation [7]:

$$TSS\left({}^{mg}/_{l}\right) = \frac{RFD - FD}{SV} \qquad (1)$$

Where,
RFD = residue and Filter dryweight
FD = Filter dryweight
SV = Sample Volume

This method is ineffective and efficient because it continuously requires a continuous sampling process. With the sparing monitoring method, samples are identified by the sensors based on their level of turbidity. The sensors monitor the industrial wastewater discharged at the disposal site, and the sparing system continuously sends monitoring results to the users directly. Therefore, monitoring activities are becoming more effective, efficient, and economical [15].

2.2. Sparing Monitoring System

Figure 1 shows a block diagram of the arrangement of the system monitoring device that we built.

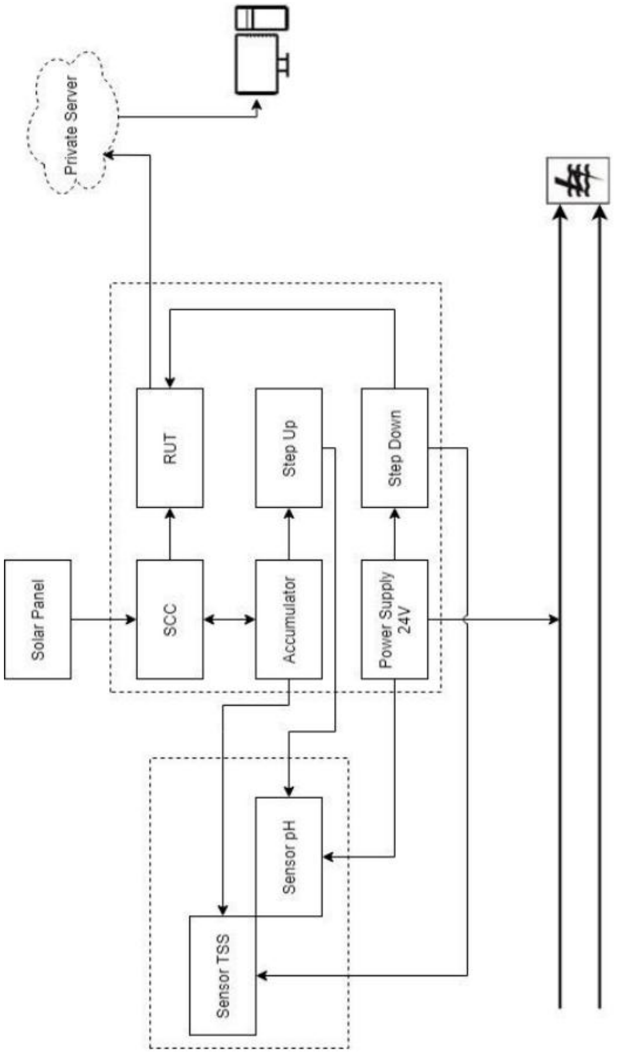

Figure 1. Diagram block of the device system.

This device has two sensors: a pH sensor and a TTS sensor. The source of electricity comes from the electrical PLN line and the solar panels. The solar panels supply electricity through a solar charge controller. The solar charge controller regulates the monitoring system devices' battery charging and electricity supply. The battery current serves as a backup power to prevent the monitoring process is shut down during the outage of the PLN power line.

2.3. Measurement of Power Of Hydrogen (pH)

The power of Hydrogen (pH) is measured using the BH-485-Ph sensor, as shown in Figure 2. This sensor consists of three components: an electrode (measuring and reference), a temperature meter, an amplifier, and an analyzer or transmitter.

The sensor works at a voltage of 24 V and uses Modbus RS485 for data communication. This sensor can detect the pH level in a range of 0,0 – 14,0 with an accuracy of ± 0,1 [16].

Figure2. Sensor BH-485-pH.

2.2. Measurement of Total Suspended Solid (TSS)

The value of Total Suspended Solids (TSS) was measured using the ZDYG 2087 01QXJ sensor (Figure 3). the sensor works at a voltage of 12 V. It could measure at a range of 0,01-20000 mg/L with a resolution of + 5%, which also using Modbus RS485 for the data communication [17].

Figure3. Sensor ZDYG 2087 01QXJ.

The sensor measures using the infrared light scattering principle. The emitted infrared light will scatter as it passes the water. The intensity of the scattered light is proportional to the concentration of the suspended solids in water.

2.4. Internet of Things (IoT)

The internet of things is an internet platform that allows one object to send data through the internet directly [18,19]. The RUT955 is a reliable 4G/LTE router for the sparing monitoring system. The unit is equipped with an IoT gateway that serves as a liaison. The unit also has I/O ports, GNSS, RS232/

RS485, cellular facilities equipped with connectivity via Dual-SIM fail-over, and GPS with position coordinate tracking using GLONASS/ GALILEO/ BEIDOU to identify the device's location remotely [20].

3. RESULTS AND DISCUSSION

3.1. Design and Build Monitoring System Device

The pH and TSS monitoring system's design is arranged in such a way, as shown in Figure 3.

Figure3. Sensor ZDYG 2087 01QXJ.

The 20Wp solar panel at the top forming a triangular roof aims to prepare this device to be used in a remote location. The solar panel rests on an iron pole that stands on an iron truss easel. Below the solar panel is placed a panel box containing various electronic devices. The sensor is located on the bottom of the control box panel, considering that the sensor will be placed at the discharged wastewater pool at a certain depth.

Inside, the control box panel is filled with various components used to operate the system. Figure 4 shows the arrangement of several parts according to their function in the panel box. Those arranged parts, namely are:

1. The AC MCB is used as a PLN power line breaker.
2. The Step Down unit is used to lower the voltage from the power supply.
3. The RUT955 is used as an IoT Gateway.
4. The Fuse is used as overcurrent protection.
5. The Terminal Block is used as a regulator of the current supply to the system unit.
6. The Solar Charge Controller is used as a regulator of charging to the battery.
7. The Power Supply of 24 VDC is used as the primary source of the circuit.
8. The DC MCB is used as a power line breaker from the accumulator.
9. The Relay interlock between the battery and the PLN electrical source.
10. The Step Up unit increases the voltage from the battery.
11. The Accumulator is used as the power storage from solar panels.

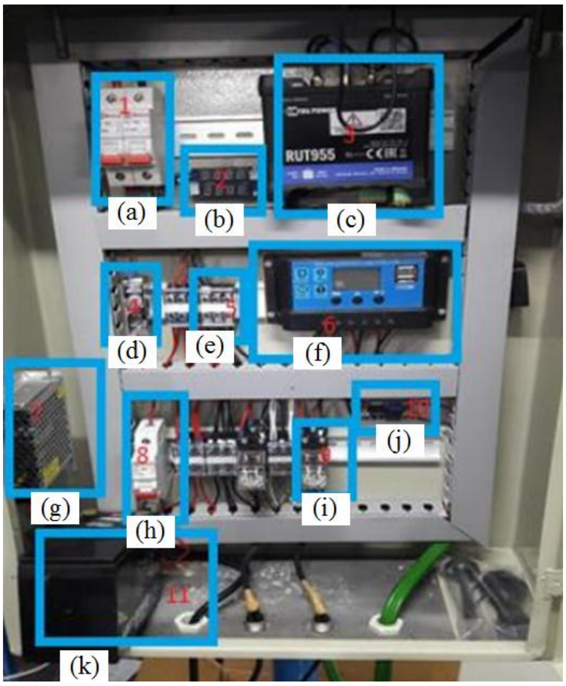

Figure 4. a) MCB AC, b) Step Down, c) RUT955, d) Fuse, e) Terminal Blok, f) Solar Charge Controller, g) Power Supply 24VDC, h) MCB DC, i) Relay interlock, j) Step Up, k) Accumulator.

3.2. Workflow Diagram

Figure 5 shows a workflow sparring monitoring system diagram that we built. This workflow is made in a simple way in order the monitoring process becomes effective and efficient. The diagram consists of several step, including: initiation of RUT955, sensor configuration for data transmission, data retrieval, and data transmission to the internet via IoT Gateway [21,22].

The system starts working when the device is turned on. The RUT955 unit will do booting for a few moments. After that, the system initiates the two sensors, BH - 485 - pH and ZDYG 2087 01QXJ. Afterward, the monitoring system sends a command to the sensor to detect the pH and TSS levels. That sensor later started to collect pH and TSS data from the wastewater and send it to RUT955.

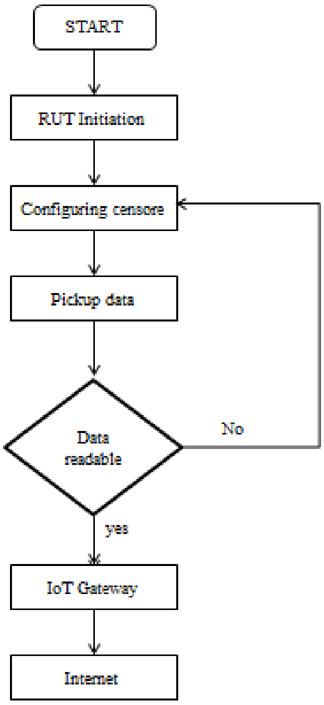

Figure 5. Workflow Diagram of the device.

Furthermore, RUT955 dispatched the data into the IoT platform through the internet network using the IoT Gateway. Data from sensors will be sent every 10 minutes according to government regulations [6]. Thus the data can be monitored via the web for processing and analysis.

3.3. IoT Configuration

Transmission monitoring data to the internet via RUT955 uses the Modbus data server feature (Figure 6). In Modbus data to server, a configuration is done by entering the protocol to be used and setting the data format to be issued using JSON format. Afterward, the segment count is set, which functions to limit or provide a segment from the existing data, followed by entering the URL that uses and sets the sending period and data filtering.

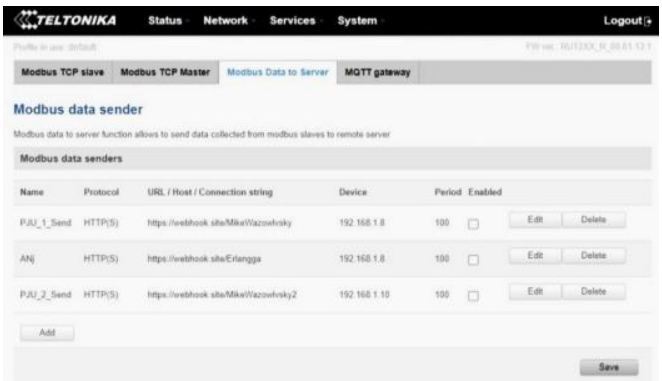

Figure 6. Modbus data to server feature on RUT955.

This research uses https://webhook.site as an internet platform. The monitoring data from a device platform will receive and displays the monitoring data from a device. Data acquisition is stored on a google spreadsheet. Configuration is done using the custom action feature on the webhook.site, as shown in Figure 7.

The data displayed on the website shows that the pH and TSS sensors are functioning and capable of sending information through the IoT platform. In addition to integrating with webhook.site, this pH and TSS sparing monitoring system can also be integrated with various IoT platforms and connected to the internet via 3G, LTE, Wifi, and LAN connections.

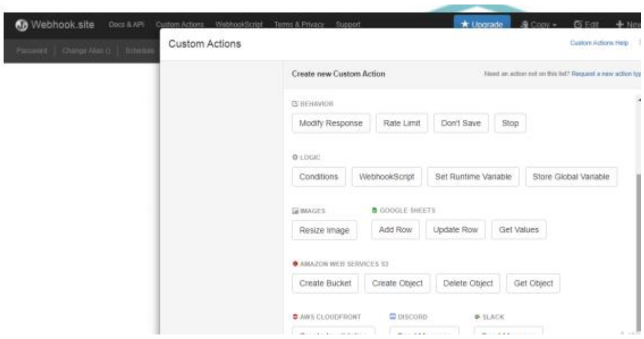

Figure 7. The custom action feature on webhook.site.

3.4. Testing the Sparing Monitoring System for pH and TSS.

3.4.1. pH meter

The concept of measuring pH consists of a pair of positive and negative terminals. The positive terminal is the measuring electrode, and the negative terminal is the reference electrode. The reference electrode provides a stable voltage compared to the voltage received by the positive terminal.

The concentration of dissolved hydrogen ions interacting with the measuring electrode will increase the voltage at the positive terminal, resulting in a voltage deviation from the negative terminal. The magnitude of the deviation indicates the pH level in the liquid medium being measured.

The accuracy of pH sensor readings on liquid media is identified using a reference liquid with a pH of 4,00; 6,86; and 9,18. Sparing measurements were carried out for 100 seconds for each data collection. The data collected in this test are 24. The data from the pH sensor measurements are shown in Figure 8.

The sensor reading curve appears not precisely at the reference pH value used. Overall the displayed pH value is above the reference pH value. At pH 4, the monitoring curve approaches the reference value, especially in the data range of 8 – 16. At pH 6,86, the monitoring curve shows a higher value at the beginning of the reading. The new monitoring results are close to the reference value in the data range of 18 - 24.

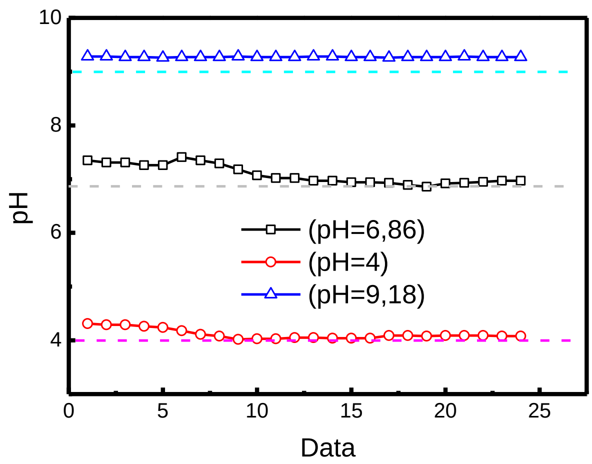

Figure 8. pH sensor reading results.

Likewise, at pH 9,18, the monitoring result curve always shows a higher pH value (pH 9,27 – 9,28) than the reference value. When referring to the BH-485-Ph sensor datasheet, the value is still within the tolerance of this sensor deviation reading value, which is 0,1.

3.4.2. TSS Meter

The measurement concept of Total Suspended Solid is based on identifying the captured infrared light scattering emitted by the sensor. The scattering of infrared light resulting from the reflection of the Suspended Solid is compared with the intensity of the light fired. The intensity deviation is proportional to the concentration of suspended matter in the liquid.

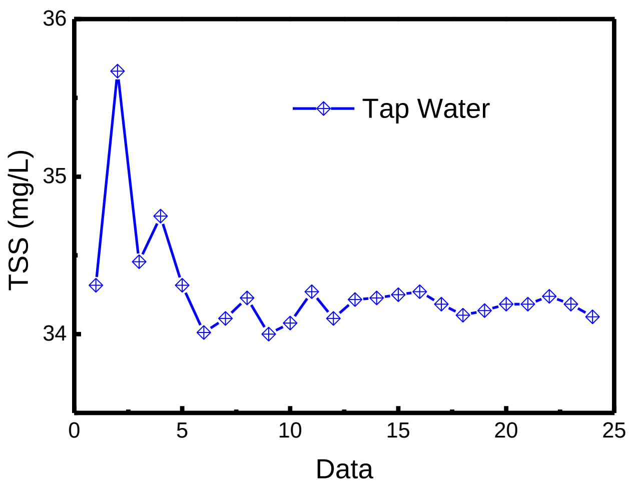

Figure 9. TSS sensor reading results.

Identification of TSS sensor readings on liquid media is made using tap water. The data collected were 24 with a time lag of 100 seconds for each data collection. Figure 9 displays the measurement data of the TSS sensor. The TSS measurement results' average value was 34.28 mg/L. This value is too significant to describe the concentration of TSS in the tap water used as the measured liquid medium. It is necessary to make adjustments to the sensor in order to obtain an accurate value. Starting from the calibration of the monitoring data, the position of the sensor placement to the monitored liquid media, and other necessary adjustments.

3.4.3. Power Consumption

The operational power consumption of the sparing monitoring system is calculated using the datasheet for each part of the electronic equipment used. The results of the calculation of the power consumption are shown in Table 2.

Table 2. power consumtion of the device unit

Device Unit	Power Consumtion	Voltage, Current
RUT955	12W	(12VDC,1A)
Sensor pH	24W	(24VDC,1A)
Sensor TSS	12W	(12VDC, 1A)
Total Power	48W	

4. CONCLUSION

Research has been carried out on IoT-based sparing monitoring system devices using RUT955 to measure the pH and TSS of industrial wastewater in remote areas. This sparing system uses two sources of electric current to operate: PLN and the sun. Solar electricity stored in the battery is used to overcome the problem of breaking the electricity supply from PLN.

The device made has been successfully connected to the internet using the webhook.site platform. Acquisition data storage is carried out using the google spreadsheet platform. The pH and TSS data measured by the sensor sent by RUT955 can be received and displayed on the internet platform. The measurement results that the sensor has carried out need to be calibrated so that the data sent is more accurate.

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