Liquid Waste Data Collection Uses the Internet of Things (IoT) Using Data Queues

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Abstract: Industrial wastewater can pollute the environment if not managed properly. The concept of Internet of Things (IoT) can be implemented in monitoring liquid waste content remotely and providing notifications on Android devices by communicating via the internet. To apply this IoT concept, the tools or sensors used to measure the volume of liquid waste that comes out must be able to communicate with an Android smartphone or computer. This system consists of three units: input, process, and output. The input unit consists of a Ds18b20 temperature sensor, turbidity sensor, water flow sensor, and pH sensor which are used to measure input data to be sent to the process unit. The data received by the process unit is in the form of voltage which is converted based on the formula on each sensor. The processing unit uses the NodeMCU 8266 microcontroller to process data before it is sent to the output unit. The output unit consists of a 16x2 LCD and a web server which receives data from the processing unit for display. The results of system testing show that all input, process and output units can function properly as expected. Thus, the IoT concept can be applied to remote data collection and monitoring of industrial wastewater content to ensure that the liquid waste discharged meets predetermined quality standards and does not pollute the environment.

1 INTRODUCTION

Industrial liquid waste is the residue from the production process or industrial activities in liquid form, which is present at a time and place that can harm the surrounding environment. Liquid waste that is not managed properly can have a negative impact on aquatic ecosystems, affect the environmental balance, and even have a negative impact on living things. Therefore, waste must be managed properly and meet quality standards before being disposed of so as not to pollute the environment. According to the Regulation of the State Minister for the Environment Number 03 of 2010 concerning Industrial Liquid Waste Quality Standards (Nursidiq et al., 2021), liquid waste that is suitable for disposal must have a pH of 6-9. One method of measuring pH levels in liquid waste is to use a pH meter. In addition, the turbidity value is also an indicator, that is, it cannot exceed 25 NTU at turbidity and the temperature cannot exceed 38 degrees Celsius. To overcome this liquid waste, it is necessary to measure parameters such as temperature, pH, and turbidity using several electronic sensors such as DS18B20 Temperature, GE Turbidity Water Turbidity, and pH Sensors. The concept of Internet of Things (IoT) (Munawar, 2023) can be applied in monitoring liquid waste remotely via the internet. In implementing IoT, information such as pH, temperature and NTU can be sent to monitor liquid waste. This information will be sent and displayed on Web Monitoring, and stored by the server in real-time, so that it can be accessed via a PC or smartphone (Kusumawardhana et al., 2018).

2 RELATED WORK

Previously, research was carried out by Pramudya Mahardika Kusumawardhana, Mochammad Hannats Hanafi Ichsan, and Rakhmadhany Primananda in 2018 with the title "Implementation of Wireless Sensor Data Storage with MongoDB in the IoT Environment Using the MQTT Protocol" (Kusumawardhana et al., 2018). This study concludes that MQTT can

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be connected to the NodeMCU microcontroller in a wifi network with an accuracy rate of 75% within a distance of 4 meters to 20 meters. MQTTBroker can also send data stacks of 50, 100, up to 1500 data into a MongoDB database. Another study

conducted by Denny Kuriando, Agustinus Noertjahyana, and Resmana Lim in 2017 with the title ”Detection of Water Volume in Gallons Based on the Internet of Things Using Arduino and Android” (Kuriando et al., 2017), concluded that the water flow sensor has an error percentage of 0.48% and is suitable for use in the manufacture of water volume detectors. Research conducted by M. Irfan Wahyuni, Hollanda Arief Kusuma, and Sapta Nugraha in 2021 entitled “Development of an Internet of Things (IoT)-Based Water Flow Measurement Tool” (Kusuma et al., 2021), concludes that Water Flow Sensors can obtain information on water discharge and water usage every minute sent to the Thingspeak platform with an excellent data transmission success rate of 98.1%. The signal quality at the equipment placement location is in a sufficient and good signal condition. In addition, research conducted by Dwi Adhe Ayu Novitasari, Dedi Triyanto, and Irma Nirmal in 2018 entitled ”Design of a Microcontroller-Based Industrial Waste Monitoring System with a Website Interface” (Novitasari and Nirmala, 2018), concluded that the design system can transmit data readings with sensors using Arduino Mega 2560 to read the parameter values of pH, temperature, and turbidity of liquid waste. The value obtained from the measurement process is then converted from voltage form (analog) to digital form to be displayed on the website in graphical form and data tables for sensor reading values with an average difference in pH parameter readings of 2.14% and temperature of 0.37% . Finally, research conducted by Tri Rahajoeningroem and Asgia Setya Mardika in 2021 entitled “Control and Monitoring System of Tofu Liquid Waste Parameters as a Hydroponic Plant Nutrient Solution Based on the Internet of Things (IoT)” (Mardika and Rahajoeningroem, 2021), concluded on the 3rd of Liquid organic fertilizer/ The nutrient solution produced by the hydroponic process as many as 25 pieces had a TDS content of 833 ppm, a temperature of 26°C, and a pH content of 6, and was off-white in

3 DATA COLLECTION TECHNIQUE

Previously, several waste monitoring system studies used the Arduino Uno/Mega 2560 R3 as a controller and an ethernet shield to add network functions (Najmul, 2021). In waste processing companies, waste from other companies is taken or delivered to the location of the waste processing company for monitoring and processing. In designing a liquid waste monitoring tool based on the Internet of Things, there are several problems that must be solved, namely the tool design system and the tool work system. This tool design system was built to overcome problems when designing an Internet of Things-based liquid waste monitoring tool which is quite complicated because it requires imagination in designing the component layout, program flow, and overall tool assembly. While the working system of this tool is designed to read sensors and store data in a database. The data can be accessed through the website for display. Data will continue to be stored every 5 seconds to get the latest value from the sensor. The hardware design of an Internet of Things-based liquid waste monitoring device begins with the creation of a system block diagram. Each block is connected to each other to show the structure of the system in a clear and simple way, making it easier to analyze how the circuit works.

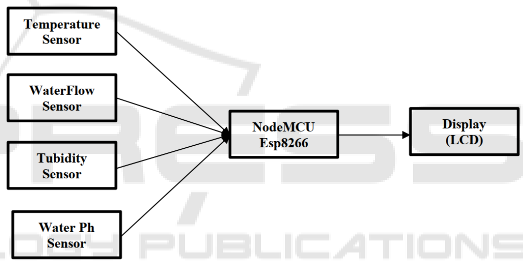

Figure 1: Data capture system block diagram.

The explanation and function of each circuit block are as follows: NodeMCU ESP8266 : Functions as the main controller for the entire system and connecting to the network. NodeMCU ESP8266 (Pangestu et al., 2019) can also retrieve data from other sensors and send it to the server via an internet connection. Ds18b20 Temperature Sensor: Serves as a temperature gauge in liquid waste. This sensor can provide information on the temperature of the liquid waste being monitored.WaterFlow Sensor: Serves as a measure of the volume of liquid waste. This sensor can calculate the amount of liquid waste flowing in liters per minute or other units.Turbidity Sensor : Serves as a measure of turbidity level in liquid waste. This sensor can provide information on how turbid the monitored liquid waste is.pH Sensor : Serves as a measure of the level of acidity in liquid waste. This sensor can provide information on the level of acidity in the liquid waste being monitored. LCD : Serves as a data display medium that can display information provided by sensors installed in the circuit, such as temperature, volume, turbidity, and acidity level of liquid waste.

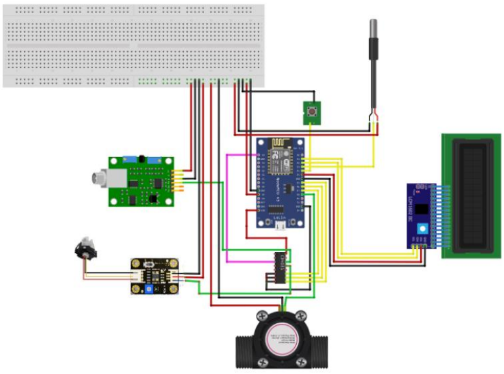

Figure 2: Overall components.

The DS18B20 temperature sensor (Saha et al., 2021) is a single or 1 wire only digital temperature sensor communication data line pin. Each DS18B20 sensor has a 64-bit serial number unique, meaning that it can use multiple sensors on the same power bus (multiple sensors connected to the same GPIO). This is especially useful for recording data for temperature control projects. The Waterflow (Zhang et al., 2021) sensor works to read the resulting rotor rotation speed by the speed of the water flow. The working principle of this sensor measures the flow of water in a certain way calculate the rotation of the wheels contained in this tool. In the wheel has a magnet and when it rotates it produces a corresponding magnet Hall effect phenomenon. The phenomenon of the Hall Effect is based on the effect of a magnetic field on moving charged particles. The faster the current flows With this sensor, the rotation of the rotor will be faster so that the numbers are read on the sensor to be large. Turbidity (Noor et al., 2019) Sensor is a sensor module that reads the turbidity of water particles turbidity is basically invisible to the naked eye. More particles in water indicates that the level of water turbidity is also high. The higher it is water turbidity Changes in the output voltage through the sensor Measures the pH (acidity or freedom) of liquids. Acidity meter (pH meter) (Helmy et al., 2020) usually consists of a measuring probe connected to an electronic device Measures and displays the pH value. Basics of Measuring pH Potency for using a pH meter the electrochemical reactions that occur between the contained solutions in a known glass electrode with an externally supplied solution34 unknown glass electrode. this problem Due to the thin layer of glass bubbles interact with hydrogen ions Relatively small and active. LCD (Liquid Crystal Display) (Aljamali and Molim, 2021) is an electronically modulated optical device which uses the modulating light properties of liquid crystal composites with Polarizers. The LCD circuit functions to display the currently lit data set of tools. I2C is a two-way serial communication standard using two identical channels specifically designed to send and receive data. The I2C (Anand and Azheruddin, 2019) system consists of SCL (Serial Clock) and SDA (Serial Data) channels that carry data information between I2C and controller. IC CD4051 (Huda, 2021) is IC 4051 which is a working IC as multiplexers and demultiplexers. This type of IC has 8 analog channels can function as digital automatically. When used as a multiplexer, This IC can select one of eight inputs.

4 DATA QUEUE

Queue (Brock et al., 2019) is a type of data structure that is used to store and organize data in a FIFO (First In First Out) manner, meaning that data that enters first will be issued first as well. This algorithm is often used in applications or systems that require queuing, such as messaging systems, customer service systems at banks, or data retrieval systems on IoT sensors. In its implementation, the ”queue” algorithm uses an array as a placeholder for the received data queue. The array has a variable ”maxsize” which determines the maximum size of the queue. In addition, there are also other variables needed to set the position of data in the queue, such as ”amount” which stores the amount of data currently in the queue, ”front” which indicates the position of the data at the front in the queue. , and ”back” which shows the last data position in the queue.

Here is a detailed description of the ”queue” algorithm:

1. Declare the variable ”maxsize” as the maximum size of the queue, which indicates the maximum amount of data that the queue can accept.
2. Declare a ”queue” structure consisting of several variables, namely:
   - ”amount” which is an integer type variable to store the amount of data currently in the queue.
   - ”front” which is an integer type variable to indicate the position of the frontmost data in the queue.
   - ”behind” which is an integer type variable to indicate the last data position in the queue.
   - ”data” which is an array of type char to store data in a queue.
3. Create an ”enqueue” function that is used to enter data into the queue. This function accepts parameters in the form of data to be included in the queue. The steps performed in this function are:

- Check whether the queue is full or not (if the amount of data in the queue has reached the maximum size). If it is full, displays an error message and exits the function.
- If the queue is not full, add data to the queue at the ”back” position by copying the data into the ”data” array at the same index as ”back”.
- Increase the ”count” variable by 1 to indicate that the number of records in the queue is increasing.
- Shift the position ”back” to the next index (modulo ”maxsize”) to indicate the position of the new last data.

4. Create a function ”dequeue” which is used to pull data out of the queue. This function does not accept any parameters. The steps performed in this function are:
   - Check whether the queue is empty or not (if the number of data in the queue is 0). If empty, displays an error message and exits the function.
   - If the queue is not empty, save the data in the ”front” position.

```
like the following syntax

#include <ESP8266WiFi. h>
#include <SoftwareSerial. h>
#include <QueueArray. h>

// declare pins for pH sensor (in this example,
pins D4 and D3)
Software Serial pH sensor(D4, D3);
// declare queue to store pH values
QueueArray<int> pHValues;

void setup() {
    // start serial communication
    Serial. begin(9600);
    // set baud rate for pH sensor
    pHsensor. begin(9600);
    //connect to WiFi
    WiFi. begin("ssid", "password");
    // wait for WiFi connection
    while (WiFi. status() != WL_CONNECTED) {
    delay(1000);
    Serial. println("Connecting to WiFi...");
    }
    Serial. println("Connected to WiFi.");
    }
void loop() {
    // declare variable to store sensor value
    int sensorValue;
    // send command to read pH value
    pHsensor. println('R');
    // wait for 500 milliseconds for the pH
    sensor     to respond
    delay(500);
    // read data sent by pH sensor
    while (pHsensor.available()) {
        sensorValue = pHsensor.read();
        if (isDigit(sensorValue)) {
            pHValues. push(sensorValue - '0');
        }
    }
    // check if queue is not empty
    if (!pHValues. isEmpty()) {
    Serial. print("pH: ");
    // print all pH values in the queue
    while (!pHValues.isEmpty()) {
        // convert pH value from integer to
        floating point and print to serial
        monitor
        Serial. print(pHValues. pop() /
        100.0, 2);
        Serial. print(", ");
    }
    Serial. println();
    }
    // wait for 5 seconds before taking
    the next pH reading
    delay(5000);
}
```

Table 1: Data retrieval.

Time	pH	Volume	Turbidity	Temperature
9:47:34	7.00	0.77	39.21	27.81
9:47:40	7.00	0.77	41.38	27.81
9:47:46	7.00	0.77	41.22	27.81
9:47:52	7.00	0.77	41.61	27.81
9:47:58	7.11	0.77	41.07	27.81
9:48:04	8.81	0.77	39.28	27.81
9:48:09	8.10	0.77	40.60	27.81
9:48:15	7.79	0.77	40.68	27.81
9:48:21	7.65	0.77	40.99	27.81
9:48:27	7.42	0.77	39.90	27.81
9:48:33	7.39	0.77	40.06	27.81
9:48:39	7.31	0.77	39.05	27.81
9:48:44	7.37	0.77	39.90	27.88
9:48:50	7.54	0.77	39.44	27.81
9:48:56	7.28	0.77	39.75	27.81
9:49:02	7.31	0.77	39.21	27.81
9:49:08	7.28	0.77	39.36	27.88
9:49:14	7.34	0.77	39.28	27.88
9:49:19	7.39	0.77	40.37	27.88

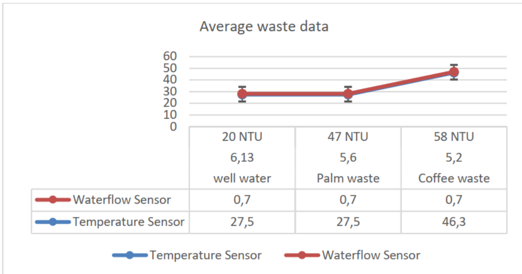

Figure 3: Graph of average waste data.

5 CONCLUSIONS

Based on the results of research that has been done, it can be taken conclusion as follows: From the results of the tests that have been carried out, it can be seen that the Tool Internet Of Things (IoT) Based Liquid Waste Monitoring that can increase the parameters of pH, temperature, turbidity and waste volume displayed on a 16 x 2 LCD and website interface, Based on the test results of the tool, the server receives data every 300 milliseconds but the server stores sensor data every 5 seconds, After testing the liquid waste monitoring system as a whole with 3 different liquids namely tap water, palm waste and coffee. Percentage of successful tests of all monitoring systems is 100%.

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