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Wastewater monitoring system in the textile industry

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ABSTRACT

Recently, a problem which often experienced by the Environmental Agency is to monitor the quality of industrial waste. The problem comes from manual monitoring of wastewater and the high cost of laboratory tests for each variable for the waste. This system is intended to develop a wastewater monitoring system considering the state of the environment and technology. This system uses 5 types of sensors to measure the quality of wastewater. The sensor will display measurement data both offline via liquid crystal display (LCD) and online via the website. For the pH sensor test, we obtained an error value approximately of 1.32% and accuracy of 98.68%. For the oxidation reduction potential (ORP) sensor test, we obtained an error value of 1.4% with 98.6% accuracy. We obtained an error value of 0.22% with 99.78% accuracy for the temperature sensor test. For the total dissolved solid (TDS) sensor test, we obtained an error value of 1.02% with 98.98% accuracy. The color sensor is validated using a spectrometer to measure the variation of color in remazol waste concentration. For the Client - Server communication test, the system has a delay of 2 seconds. One of the advantages of using a web server is the system has minimum network traffic.

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1. INTRODUCTION

Water pollution is mostly caused by industrial waste that is directly discharged freely without prior treatment, so a water monitoring system must be established continuously [1], [2]. Generally, industrial liquid waste is not treated first but is directly discharged into the environment such as rivers, lakes, and irrigation channels [3]. One of the waters polutions is caused by pollution by textile dyes from the textile industry that has sprung up [4]. The increase in clothing production has resulted in an increase in the amount of fabric production waste where 20% of global production waste comes from the textile and clothing sector [5].

Textile waste causes environmental complications if not properly handled before disposal [6]. Industrial waste directly discharged into the environment can be fatal to human health as well as other organisms [7]. Due to the usage of chemical substances during the dyes processing, wastewater from the textile sector contains biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), and pH levels that are much higher than the threshold of water quality standards [8].

The environment agency has difficulty in monitoring industrial waste, and some industries do not report wastewater treatment results [9]. In some cases, wastewater quality testing is still done manually, not in real time and is expensive. Expensive laboratory testing is one of the obstacles in controlling the quality of industrial wastewater [10].

Therefore, a wastewater monitoring system that is integrated with a website in a controller is made to connect sensors and websites into one tool. This website will be sent by the controller to then monitor the pH sensor, temperature sensor, oxidation reduction potential (ORP) sensor, electro-conductivity sensor and color sensor. It is hoped that this research will be able to provide a solution for an effective real time monitoring system for wastewater in the textile industry.

2. METHOD

2.1. Hardware designing

Figure 1 is shown the prototype design of the wastewater treatment design in the industry. In the design there are a box panel, sensors and textile waste water compartment. Figure 2 is the implementation of the wastewater treatment design at textile industry. Where there are ponds as a reservoir for wastewater that has been previously treated, panel boxes containing Arduino Mega, proxy, power supply and signal conditioning whitebox T1. As well as sensors attached to the waste pond.

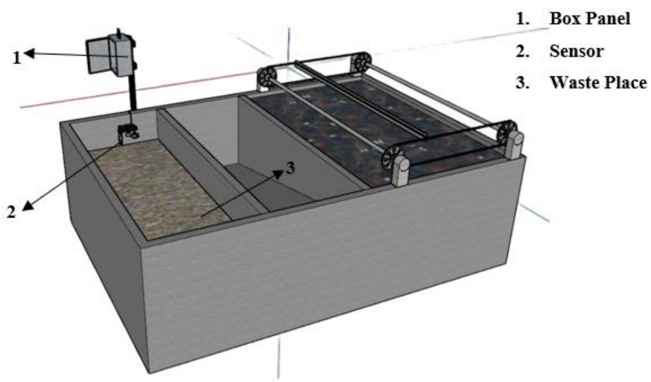

Figure 1. Wastewater monitoring system hardware design

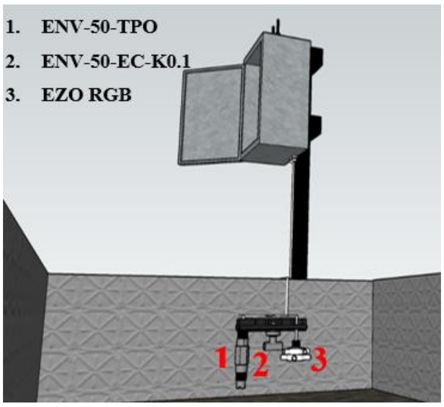

Figure 2. Placement of sensors

Figure 3 is a wiring design that will be implemented in this research. In the wiring, power from electrical source is used, namely 220 VAC/50 Hz, then the air conditioning (AC) voltage enters the 5 volts of direct current (VDC) power supply. The voltage from the power supply serves to provide power supply to Arduino Mega, Whitebox signal conditioning and liquid crystal display (LCD) Nextion. Power the proxy and router using a 12V 1A AC to direct current (DC) adapter. There are 5 signal conditions that function to process signals from 2 sensor probes. The 5-signal conditioning includes 1 pH sensor, 1 ORP sensor, 1 total dissolved solid (TDS) sensor, and 2 temperature sensors [11]–[15].

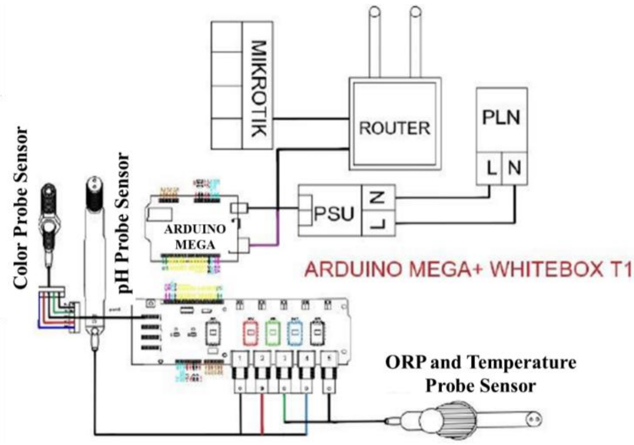

Figure 3. Wiring hardware designing

The input of the monitoring system is in the form of physical variables from wastewater then sensed by sensors [16]. The sensor readings will be changed according to the sensor output which is transmitted to signal conditioning to be converted into a standard signal [17]. After the signal is in accordance with the standard, the signal is transmitted to the Arduino Mega controller to be processed and then converted from analog data to digital data [18]. After processing, digital data such as bit 1 or 0 is displayed through the display in the form of LCD and website with the results in the form of measured values by the sensor.

2.2. Wastewater measurement system

In the measurement block diagram Figure 4. Input from the sensor is in the form of temperature, ORP, pH, conductivity, and color values from the wastewater reservoir which are sensed by ENV-50-TPO, ENV-50-EC-K0.1 and EZO RGB sensors. The sensor readings will be sent to signal conditioning to be converted to standard signals so that the data can be read by the controller [19]. Because it uses a universal asynchronous receiver-transmitter (UART) communication system, signal conditioning sends signals to the controller in the form of bit data that matches the measurement results [20], [21]. Data entering the Arduino Mega controller will be processed into data converted to digital data such as bits 1 or 0 so that it can be displayed through a display in the form of an LCD and data is also transmitted to the internet via transmission control protocol/internet protocol (TCP/IP) communication via an ethernet cable with a web server system.

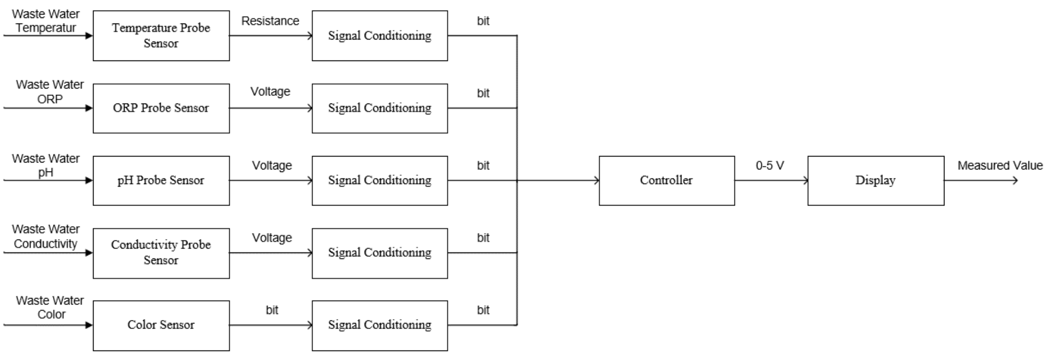

Figure 4. Measurement block diagram of effluent monitoring system

Data from the sensor will enter signal conditioning. In signal conditioning, the incoming signal will be processed into a standard signal. Then the data will be transmitted to the controller via the UART communication protocol. To be displayed via a web server, data from the controller will be sent via the TCP gateway protocol with the internet network [22]–[24]. Port forwarding allows other devices to remotely view the data value display [25]. The sensor to web data flow diagram is shown in Figure 5.

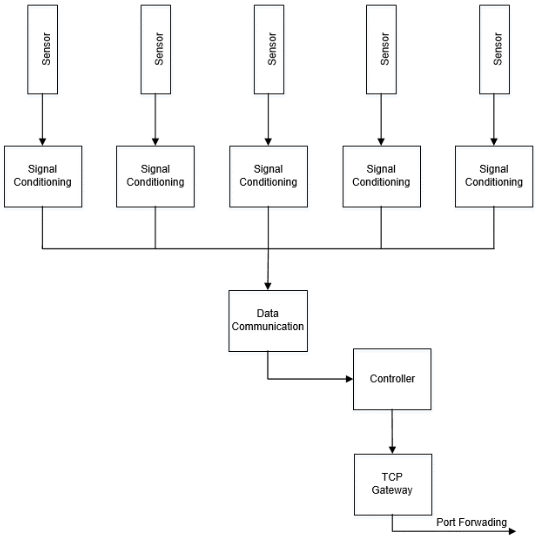

Figure 5. Sensor-to-web data flow diagram

2.3. Software designing

Arduino Mega 2560 receives digital signals from signal conditioning in the form of pH sensor data, ORP sensor, temperature sensor I, TDS sensor, temperature sensor II, and RGB color sensor. There is an ethernet shield that functions to connect the Arduino Mega 2560 to the local network [26]. After being able to enter the local internet protocol (IP), then make the local IP a global IP with the port forwarding method. Port forwarding requires a router to connect the local network to an outside network connection and a proxy that functions for internet gateway access [27]. After being connected, the web server that was originally local can now be accessed by outsiders to see the value of wastewater measurement results. The complete monitoring diagram is shown in Figure 6.

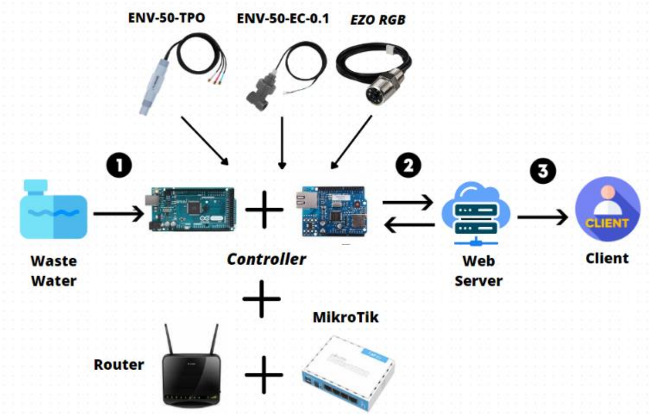

Figure 6. Block diagram of monitoring system

Software design is needed to display sensor measurement data to the web and LCD display. The software system of monitoring wastewater quality will be made using Arduino Mega as an embedded system for web server configuration [28]–[30]. The web server built on Arduino Mega is still local, so a port forwading method is needed so that the server IP or web IP can be accessed via the internet so that it can be accessed by the client. Therefore, additional devices such as routers and proxy are needed. Routers function to forward data from one network to another or distribute IP addresses [31]. Meanwhile, mikrotik functions to initialize the local IP address so that it can be accessed via the internet via the forwading port [32].

3. RESULTS AND DISCUSSION

3.1. Wastewater measurement system

Wiring components on a panel box with dimension 35 cmx25 cmx15 cm as shown in Figure 7. Wiring components starts with a series of sensors to signal conditioning. Where there are 5 sensors that are wired to signal conditioning by having different port addresses adjusted to the datasheet of the signal conditioning, then wiring from signal conditioning to the controller with I2C communication or only has 2 data cables, namely SDA and SCL. So it must be connected to the I2C pin on the Arduino Mega and the VCC and GND pins. From the controller then wiring to the router and proxy using an ethernet cable. As well as wiring the controller to the display in the form of a Nextion LCD with UART communication so that it is connected to the RX TX pin on the Arduino Mega and VCC and GND pins. Finally, the controller wiring to the power supply to run the system. Wiring components is shown in Figure 8. Component placement must be considered properly to make the panel more efficient and neat in the process.

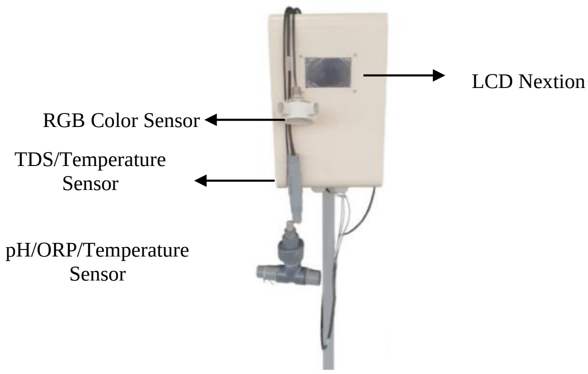

Figure 7. Panel frame

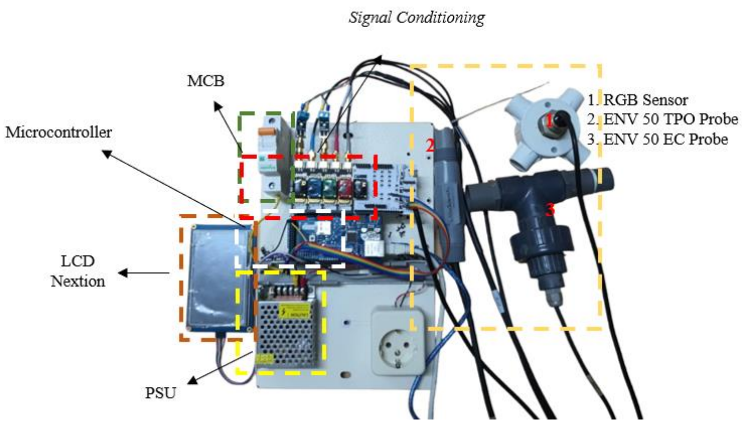

Figure 8. Wiring components in panel box

3.2. Sensor performance test

Remazol B is a dye used for the batik and textile industry. Remazol B is a water-soluble anionic dye that has a toxic effect on water organisms and can pollute the environment if not properly treated before disposal. The original color varies from blue to green. Remazol B is generally stable in the neutral to slightly acidic pH range, around pH 4 to 7. Remazol B can be used at varying operational temperatures depending on the dyeing method and the type of fabric used. For ORP values is -350-+145 mV.

There are five parameters that are measured including pH, ORP, TDS, temperature, and color. The sensor measurement is compared with the standard measuring instrument of each parameter. Data collection starts at 11.00–14.30 local time every 10 minute of measurement. The location of the data collection was carried out at the environmental engineering laboratory, Institut Teknologi Sepuluh Nopember, Surabaya.The performance test of each sensor is given by Figures 9 to 12 respectively.

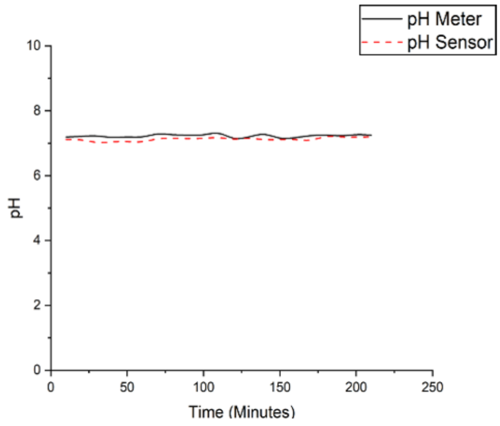

Figure 9. Performance test of pH sensor

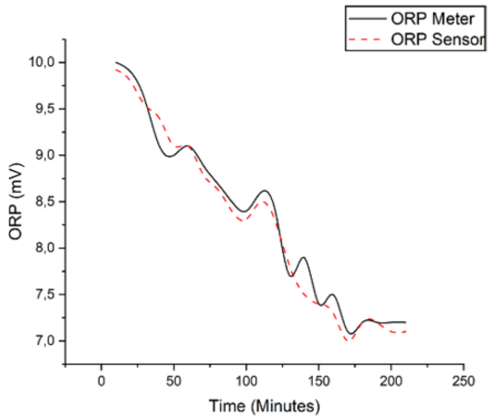

Figure 10. Performance test of ORP sensor

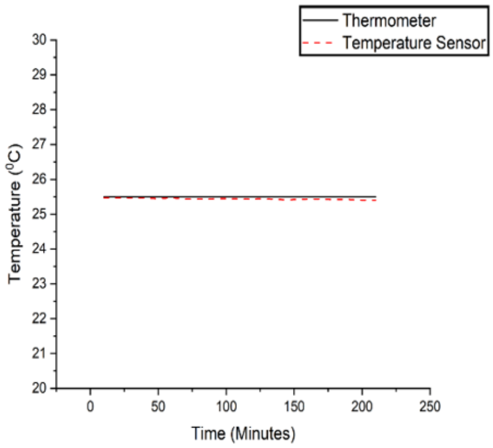

Figure 11. Performance test of temperature sensor

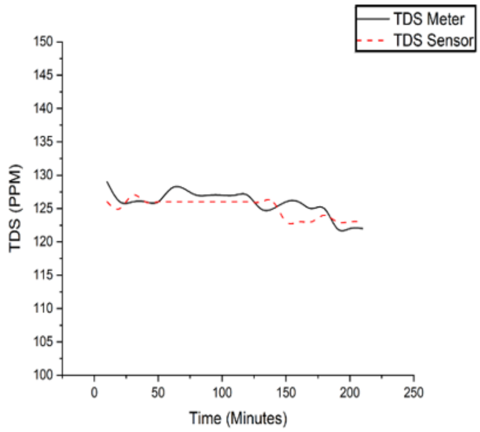

Figure 12. Performance test of TDS sensor

The performance test of all sensors was carried out with remazol B dye textile waste and compared with the standard measuring instrument for each parameter. The pH sensor test obtained an error value of 1.32% the accuracy value is 98.68%. ORP sensor testing obtained an error value of 1.4% the accuracy value is 98.6%. Temperature sensor test obtained an error value of 0.22% the accuracy value is 99.78%. TDS sensor testing obtained an error value of 1.02% the accuracy value is 98.98%. Testing of RGB color sensor carried out in the Laboratory of Solid Waste Management and Hazardous and Toxic Materials, Department of Environmental Engineering ITS with two type of batik wastewater.

Figures 13 show a linear graph of the relationship between absorbance and concentration. The experiment was carried out with 20 concentration variations from 5 mg/L-100 mg/L, with 2 industries of batik wastewater colors. From the graph, the higher concentration value of a substance, which means the substance is more concentrated, implies higher of the light spectrum. These results are in line with the Lambert-Beer Law which states that the higher the concentration, the higher the absorbance produced, and vice versa, the lower the concentration the lower the absorbance produced. The higher the concentration value, the more intense the color of the substance. Conversely, the smaller the concentration of the substance, the brighter the color value. This experiment proves that the RGB sensor works well to measure the color of light from remazol B textile waste so that the RGB color sensor has valid measurements.

3.3. The advantages of the system

System testing is intended to test the performance of the wastewater monitoring system. The system testing mechanism takes data 25 times with an interval of 1 minute. In system testing, the results obtained in the form of a time difference or delay between the data displayed via LCD and the website are 2 seconds. This shows good performance in the form of the superiority of the port forwarding-based web sever system compared to the third-party website system in integrating the internet of things (IoT) system. Because the web server has its own server which means there is minimal possibility of network traffic, data security is safer and more robust in data transfer. System testing data is shown in Figure 14.

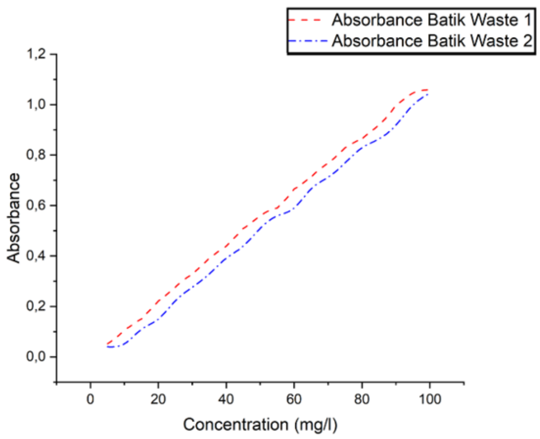

Figure 13. Performance test of RGB sensor in wastewater from batik industry 1 and 2

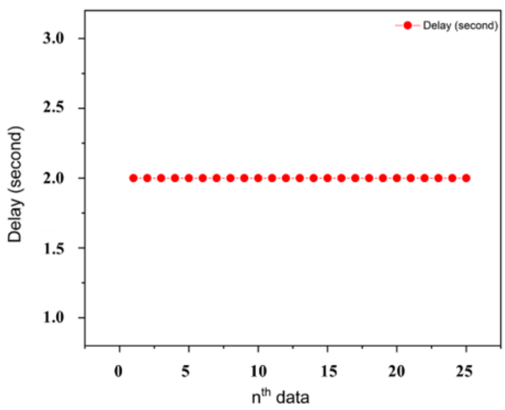

Figure 14. Delay sending data to the website

Wastewater physic chemical parameters are indices used in determining wastewater quality. The parameters analyzed in this study were pH, ORP, temperature, TDS, and color. There are currently many studies to analyze wastewater quality parameters. In previous research written by [1]. made a real time monitoring tool for wastewater quality that is connected to the cloud and uses a group special mobile (GSM) module to send data to users. Potentially exposed to heavy network traffic. Furthermore, research by Siregar *et al.* [9] there is a data transmission delay of 20-30 seconds and sends a notification if the reading exceeds the set point. The use of the IoT system is carried out by [33] using a third party for sending data to the cloud, using Thingspeak for the monitoring system there is a delay of 15 seconds On the other hand, research by Martínez *et al.* [34] developed a monitoring system with wireless sensor network (WSN) technology based on the IoT can send data from several points with set points. However, it requires quite high resources. Therefore, to get a low-cost monitoring system and get an advantage in data transmission, the port forwarding method is the best option. The research discussed in this paper has advantages in data transmission delay and low cost and industrial quality sensors for wastewater quality monitoring system. The other advantage in this paper is uses a RGB color sensor to measure the color density of textile wastewater [35]. The darker the color of textile effluent, the higher the dye content and the more harmful it is when exposed to the environment [36], [37]. RGB color sensors allow not only obtaining an estimate of the color of a liquid but can also aid in the identification of particles in the liquid. These sensors are widely applied for pollutant (oil) detection, filter monitoring, industrial sewage treatment control [38], and wastewater quality evaluation [39]. Therefore, the addition of a color sensor has the advantage of measuring the color quality of wastewater.

4. CONCLUSION

Implementation of a wastewater monitoring system by monitoring pH, ORP, temperature, TDS and color offline using a Nextion LCD integrated with a web server using the port forwarding method. Testing the pH sensor obtained an error value of 1.32% value 98.68%. ORP sensor testing obtained an error value of 1.4% with 98.6%. Temperature I sensor test obtained an error value of 0.22% with 99.78%. TDS sensor testing obtained an error value of 1.02% with 98.98%. Testing of RGB color sensor carried out in the Laboratory of Solid Waste Management and Hazardous and Toxic Materials. The higher the concentration of a substance, the higher the absorbance value and the more intense the color of the substance. Based on the results of sensor testing and data transmission to the website, this system can be implemented as a real time wastewater monitoring system so that it can replace manual monitoring.

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