THE DESIGN OF DETERGENT WASTE PROCESSING USING IoT-BASED COLOR SENSORS

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Abstrak

Deterjen merupakan salah satu produk yang banyak digunakan masyarakat untuk membersihkan pakaian. Produksi deterjen mengandung pewarna sintetis yang dapat mengandung logam berat seperti Kadmium (Cd) dan Cuprum (Cu). Sisa penggunaan deterjen biasanya dibuang ke lingkungan, dalam hal ini disebut dengan limbah deterjen. Limbah deterjen harus dikelola dan diolah dengan cara yang ramah lingkungan dan memenuhi baku mutu lingkungan sebelum dibuang ke lingkungan. Metode Fenton heterogen akan dipilih untuk menyelesaikan masalah ini. Tantangan lain yang perlu diselesaikan adalah inefisiensi waktu dalam pengolahan limbah deterjen, dimana pengguna harus melakukan pengolahan secara manual sehingga menghabiskan waktu hanya menunggu proses pengolahan limbah. Pada penelitian ini diciptakan suatu alat untuk mengatasi permasalahan pengolahan limbah batik menggunakan reaktor pengolahan limbah berbasis Internet of Things dengan menggunakan sensor warna. Penelitian ini menyimpulkan bahwa reaktor pengolahan limbah deterjen menggunakan sensor warna berbasis IoT dapat melakukan proses degradasi limbah deterjen. Pembacaan nilai sensor warna dilakukan berdasarkan nilai frekuensi pada skala 20%. Penentuan pemetaan nilai RGB pada sensor warna merupakan hasil penskalaan 20% dari frekuensi yang dibaca sensor dengan nilai pemetaan R = 35 Hz, G = 53 Hz, dan B = 40 Hz sebagai batas bawah dan R = 159 Hz , G = 174 Hz, dan B = 211 Hz sebagai batas atas frekuensi yang dibaca.

Kata Kunci: Internet of Things; Detergent; Reactor; Color Sensor; Degaradation

Abstract

Detergent is a product that is widely used by people to clean clothes. Detergent production contains synthetic dyes which can contain heavy metals such as Cadmium (Cd) and Cuprum (Cu). The remainder of detergent use is usually thrown into the environment, in this case we call it detergent waste. Detergent waste must be managed and processed in an environmentally friendly manner and meet environmental quality standards before being discharged into the environment. The heterogeneous Fenton method will be chosen to solve this problem. Another challenge that needs to be resolved is time inefficiency in processing detergent waste, where users have to carry out processing manually so they spend time just waiting for the waste processing process. In this research, a tool was created to overcome the problem of batik waste processing using an Internet of Things-based waste processing reactor using color sensors. This research concludes that a detergent waste processing reactor using an IoT-based color sensor can carry out the detergent waste degradation process. The reading of the color sensor value is carried out based on the frequency value on a scale of 20%. Determining the RGB value mapping on the color sensor is the result of 20% scaling of the frequency read by the sensor with mapping values R = 35 Hz, G = 53 Hz, and B = 40 Hz as the lower limit and R = 159 Hz, G = 174 Hz, and B = 211 Hz as the upper limit of the frequency read.

Keywords: Internet of Things; Detergent; Reactor; Color Sensor; Degaradation

1. Introduction

Detergent is a product that is widely used by people to clean clothes. Detergent production contains synthetic dyes which can contain heavy metals such as Cadmium (Cd) and Cuprum (Cu). The remainder of detergent use is usually disposed of into the environment. Even though detergent contains heavy metals which are dangerous for human health and the environment, in this case we call it detergent waste [1]–[5]. Detergent waste that is thrown directly into rivers can pollute river water and reduce river water quality [6]–[9]. Detergent waste that is thrown into rivers can reduce dissolved oxygen (DO) levels in the water and cause an unpleasant odor. Detergent waste that is thrown into the environment can cause various diseases in humans such as skin irritation, respiratory problems and cancer. This can threaten the health of humans who consume well water [10]–[13].

The problem being addressed is the negative impact of environmental pollution due to detergent waste. Detergent waste must be managed and processed in an environmentally friendly manner and meet environmental quality standards before being discharged into the environment. Several research methods have been carried out previously, including the photocatalyst method, photodegradation method, and heterogeneous Fenton method [14]–[17]. Photocatalysis and photodegradation methods in previous research have been widely used, these methods are still less effective for degrading detergent waste because they are still conventional and difficult to carry out regular monitoring. Meanwhile, the heterogeneous Fenton method is quite effective for degrading detergent waste because it has a catalyst as a degrader [18], [19]. So the heterogeneous Fenton method will be chosen to solve this problem.

Another challenge that needs to be resolved is time inefficiency in processing detergent waste, where users have to carry out processing manually so they spend time just waiting for the waste processing process. Currently, waste processing equipment has experienced significant developments. However, this tool still has a drawback, namely that waste monitoring is done manually. Research [20] also discusses batik waste processing methods using an Artificial Neural Network with COD, BOD, TDS, TSS parameters. In this research, we created a tool to overcome the problem of batik waste processing using an Internet of Things-based waste processing reactor using color sensors. The advantage of the tool created is that waste processing is done automatically, easy to apply by the user and this tool is easy to control via the user's smartphone. This reactor can help users in the long-term degradation process of detergent waste. Renewable innovations carried out in reactors can let users know that the degradation process has been completed. So the user can determine whether the waste will be thrown away or remain in the reactor.

2. Methode

The system design stages for making a prototype of a detergent waste processing reactor using an IoT-based color sensor were carried out in several stages, including the design stage and the prototype-making stage. This system was created to be implemented simultaneously with the Fenton method. The Fenton method is a method for degrading organic compounds by forming OH free radicals, which then decompose organic compounds into harmless compounds (H2O and CO2). Making a system block diagram to facilitate understanding of the system flows in the prototype-making stage of the waste processing reactor as in Figure 1. In this research, the initial design began with the creation of a system block diagram. Color sensor as input, microcontroller as processor then for output there are several including LCD, Blynk, relay 1 for mini pump, relay 2 for 12 V pump. Relay 3 for stirrer motor.

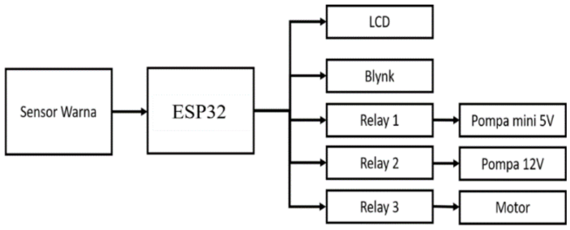

Figure 1. Block Diagram

Making a circuit scheme for arranging components that are used to help carry out wiring in the system. Schematic of a detergent waste processing reactor circuit using an IoT-based color sensor. Refer to Figure 2 which shows it in full.

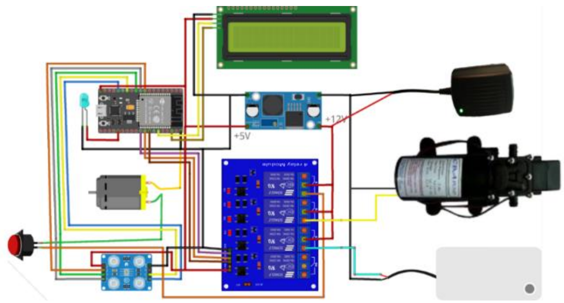

Figure 2. Circuit Scheme

Based on Figure 1 and Figure 2, it can be explained that the color sensor is the input, the microcontroller is the processor, then for the output there are several, including LCD, Blynk, relay 1 for the mini pump, relay 2 for the 12 V pump. Relay 3 for the stirrer motor. The initial voltage on the reactor given the power supply is 12V which is used for components, namely the stirrer motor, DC water pump, for the microcontroller, relay, LCD and also the color sensor using a working voltage of 5V. At stepdown the 12V voltage is reduced to 5V to provide stable voltage to the color sensor. Then the microcontroller gives command signals to several components including the LCD, color sensor, and three relays to control the reactor according to the program.

The 3D design of the tool is seen in 26 Figure 3. A flowchart of the detergent waste processing reactor system is also prepared at this stage to assist in understanding the system workflow. Flowchart as in Figure 4. The information in Figure 3 is as follows:

a) Top view of the reactor

b) Front view of the reactor

c) Rear view of the reactor

d) Left side view of the reactor

e) Reactor seen on the right

1. Tube
2. ESP32
3. LCD
4. Antenna
5. Sim800l v2
6. Color sensor and mini pump
7. Stirring motor
8. Relay 1
9. Pump
10. Relays 2 and 3
11. Hose
12. Stepdown

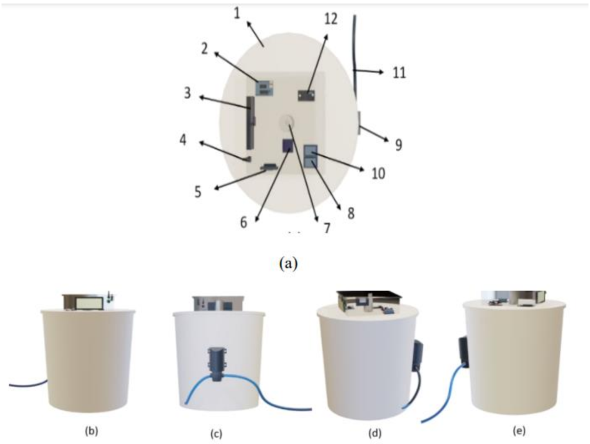

Figure 3. 3D Design

3. Result and Discussion

3.1 Color Sensor Calibration

The initial stage of making a prototype is carried out by testing the electronic components used such as color sensors, microcontrollers, relays, and actuators. Starting by calibrating the TCS3200 color sensor using a color palette. The color palette used is taken from Adobe Illustrator software by adjusting the RGB color values in the software. The red color is set by maximizing the value of the red color, namely with the values R = 255, G = 0, and B = 0. The green color is set by maximizing the value of the green color by setting the values R = 0, G = 255, and B = 0. The blue color is set by maximizing the blue color value with the composition of the values R = 0, G = 0, and B = 255 [21], [22].

Reading frequency values are carried out by bringing the color sensor closer to the red, green, and blue color palette in dim light conditions and at varying distances, namely 2 cm, 4 cm, and 6 cm. Readings by varying the distance are carried out to obtain the lowest and highest frequency values at a predetermined distance. The frequency values at the closest and farthest distances are used to map the program to set the frequency values to RGB values with a range of 0 - 255. This aims to get a value of 0 - 255 which is used to determine the detected color according to that used in the RGB value. The results of frequency data collection for color sensor calibration are presented in Table 1.

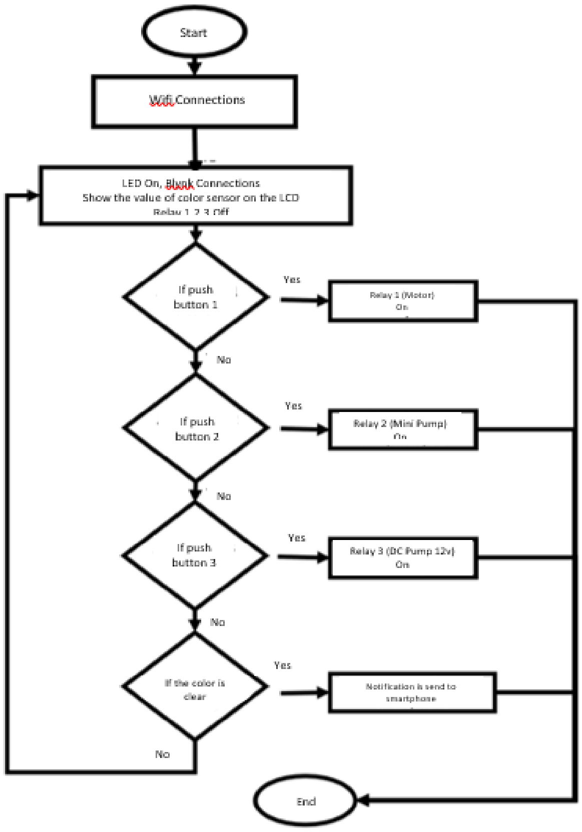

Figure 4. Flowchart

From Table 1 it can be seen that the red color frequency value in testing using a red color palette resulted in 35Hz at a distance of 2 cm. The increase occurs by increasing the distance of the color sensor to the color palette used, 77Hz at a distance of 4 cm and reaching 159Hz at a distance of 6 cm. The frequency value in green is 53Hz at a distance of 2 cm, 145Hz at a distance of 4 cm, and 175Hz at a distance of 6 cm. Then, for testing in blue, the frequency was 40Hz at a distance of 2 cm, 112Hz at a distance of 4 cm, and 211 at a distance of 6 cm. The green and blue frequency values obtained from color reading have a greater value than red. This also applies to green, so the frequency values for red and blue as well as blue will be higher than the color detected. When the calibration process is carried out, the voltage used on the color sensor and the voltage used on the microcontroller is not very stable. It can be seen in Table 1 that the voltage read on the color sensor ranges from 5.09 - 5.21 V and on the microcontroller ranges from 5.10 - 5.25 V. These voltage changes can be caused by increasing frequency readings on the color sensor and processing on the microcontroller. However, the change in voltage does not have much impact on the reading of the frequency value and the working system of the reactor.

3.2 RGB Frequency Mapping

The next stage is to map the RGB color frequencies into color values with a range of 0 – 255. The mapping process is carried out by taking the appropriate frequency values when reading the red, green, and blue color palettes in Table 1. The frequency values used for red are 35Hz as the lower limit and 159 as the upper limit with mapping 0 – 255. The frequency values for green are 53Hz and 174Hz while the frequency values for blue are 40Hz and 211Hz. Mapping is done in the program after frequency reading. After carrying out the mapping process, the next stage is to test the TCS3200 color sensor using a color palette to detect color values based on frequency mapping. The TCS3200 color sensor testing process is carried out in the same way as frequency reading for calibration. Testing is carried out by placing the color sensor at a distance of 2 cm, 4 cm, and 6 cm, from the detected color palette. The results of the tests carried out are in Table 2. From this test, the values obtained were R = 242, G = 167, and B = 205 at a distance of 2 cm using a red color palette. Tests on a green color palette with a distance of 2 cm obtained values of R = 172, G = 224, and B = 167. Tests carried out on a blue color palette with a distance of 2 cm obtained values of R = 91, G = 170, and B = 244.

Table 1. Data Color Sensor Frequency

No	Color	Red Color Frequency (Hz)	Green Color Frequency (Hz)	Blue Color Frequency (Hz)	Color Sensor Voltage (V)	Microcontroller Voltage (V)	Distance of sensor to color (cm)
1	Red	35	77	61	5.13	5.11	2
2	Red	77	193	155	5.09	5.1	4
3	Red	159	335	264	5.16	5.07	6
4	Green	60	53	70	5.21	5.2	2
5	Green	156	145	180	5.18	5.25	4
6	Green	280	174	306	5.12	5.13	6
7	Blue	95	78	40	5.13	5.13	2
8	Blue	223	197	112	5.1	5.13	4
9	Blue	365	345	211	5.07	5.1	6

From the results in Table 2, it can be concluded that the color values from the readings will adjust to the detected color palette. If the detected color is red, the R-value will be greater than the G and B values. This also applies to the G value being higher than the R and B values on the green palette. The B value will also be higher than the R and G values in the Blue color palette reading. Then the reading of the pallet is influenced by distance and will provide less accuracy. The greater the distance between the color sensor and the color being detected, the accuracy of the color sensor will decrease.

3.3 Actuator Testing

Actuator testing is carried out by turning on the actuator under several conditions. The first condition is to turn on one of the actuators being tested and the other two are turned off. The second condition is that two actuators are on and one actuator is off. The third condition is that all the actuators used are on. From these conditions, actuator test data was obtained as in Table 3 which shows the input and output voltages obtained from the test.

The results seen for the first condition on the stirrer motor are 12.09 V read input voltage and 11.98 V read output voltage. For the second condition in the stirrer motor test, the input voltage was 11.51 V and the output voltage was 11.43 V. The third condition in the stirrer motor test was the input voltage was 11.39 V and the output voltage was 11.33 V. Changes The voltage decreases due to the increase in the actuator used. Actuators that use voltage cause the input and output voltage to decrease. A decrease in input and output voltage also occurred when testing the 12V DC pump and the mini pump. This decrease occurs when the number of active.

3.4 Interface Based on Internet of Things

Referring to Figure 5 which shows the interface display in the Blynk application from an Internet of Things-based reactor system, 1) the overall interface display consisting of LCD, Gauge for RGB (Red, Green, Blue), as well as buttons for the stirrer motor, buttons waste color detection or data check and pump button to remove waste. 2) display for live ESP32-CAM camera captures. 3) display zeRGBra from the Blynk application to find out what colors are read by the color sensor. 4) a notification display on the Blynk application on the smartphone that says "Batik waste has been degraded, ready to be thrown away".

Table 2. Data Color Based on Mapping

No	Color	Red Color Frequency (Hz)	Green Color Frequency (Hz)	Blue Color Frequency (Hz)	Value of Red (R)	Value of Green(G)	Value of Blue (B)	Distance (cm)
1	Red	35	95	74	242	167	205	2
2	Red	76	198	157	163	0	82	4
3	Red	121	295	235	79	0	0	6
4	Green	76	68	100	172	224	167	2
5	Green	170	146	196	0	60	23	4
6	Green	176	163	203	0	24	13	6
7	Blue	115	94	48	91	170	244	2
8	Blue	256	221	123	0	0	132	4
9	Blue	354	324	188	0	0	35	6

Table 3. Actuator Test Data

No	Actuator	Condition of Stirer	Condition of DC Pump	Condition of Mini Pump	Voltage *input* (V)	Voltage *output* (V)
1	Stirer Motor	On	Off			
2	Stirer Motor	On	*OFF*	*OFF*	12.09	11.98
3	Stirer Motor	On	295	235	79	0
4	DC Pump 12 V	Off	*On*	*OFF*	11.51	11.43
5	DC Pump 12 V	On	146	196	0	60
6	DC Pump 12 V	On	*On*	*On*	11.39	11.33
7	Mini Pump	Off	94	48	91	170
8	Mini Pump	On	*On*	*OFF*	11.67	11.21
9	Mini Pump	On	324	188	0	0

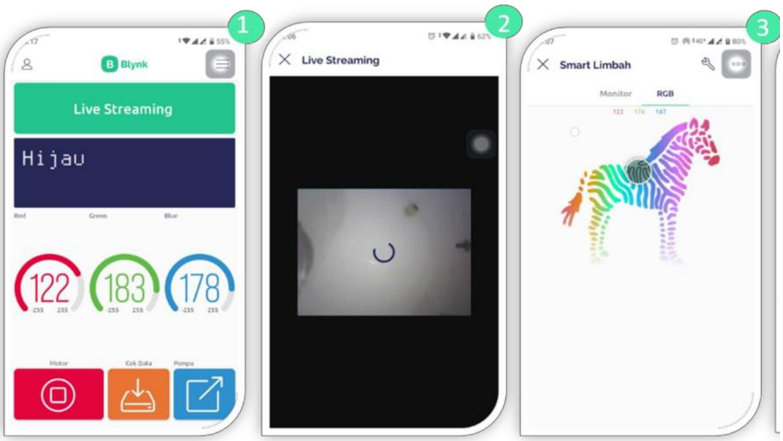

Figure 5. Interface from Blynk Application

4. Conclusion

In general, this research concludes that the detergent waste processing reactor using IoT-based color sensors can carry out the detergent waste degradation process. The reading of the color sensor value is carried out based on the frequency value which is scaled to 20%. Determining the RGB value mapping on the color sensor is the result of scaling 20% of the frequency read by the sensor with the mapping values R = 35 Hz, G = 53 Hz, and B = 40 Hz as the lower limit and R = 159 Hz, G = 174 Hz, and B = 211 Hz as the upper limit of the frequency read. The color sensor in the reactor used can detect color changes in detergent waste or liquid with RGB values, namely R >= 63 95 and <= 115, G values >= 85 and <= 140, and B values >= 225 and B <= 255 as the set of points used.
It is hoped that the results obtained from this research will provide knowledge regarding the use of color sensors, IoT, and also the degradation process in detergent waste.

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