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Prototype of an alcohol monitoring for raw water supply pumps control system

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Abstract: Monitoring of alcohol waste that could potentially enter the raw water intake pump of the Semanggi Water Treatment Plant (WTP) on the Bengawan Solo river is still done manually, with officer watching near the pump for 12 hours per shift. A prototype alcohol monitoring system designed to make more efficient device than manual method that needs 34,7 s to turn off the pump and finding the optimal distance between the sensor and the water pump. The working principle is automate pump control, so the water pump can automatically turn off when alcohol is detected by the sensor and turn on again when no alcohol is detected. The reaction time to turn off the pump is calculated from the time the 2 ml alcohol container is placed under the sensor until the pump turns off, while the time to turn the pump back on is calculated from the time the pump turns off until the pump turns back on. The reaction time of turning off the pump and restarting the pump at 7% alcohol percentage is 1.80 s and 0.72 s, while at 24% alcohol percentage is 0.87 s and 1.90 s. The Bengawan Solo river velocity ranges from 0.04 m/s to 0.27 m/s. Thus, this device turn off water pump time is faster by 94,8% than manual method and the optimal distance between the sensor and the water pump is more than 0.28 m and less than 0.39 m.

Keyword : Alcohol pollutant, MQ-3 sensor, water pump, raw water

1. Introduction

Water is the main human need used in daily activities, such as drinking, bathing, washing and other needs like raising fish for farmers (Ashar et al., 2020; Noor et al., 2019). The demand for water increases as the population grows, but the availability of clean water is still very limited. Reduced availability of clean water is caused by several factors, namely climate change, geology, and pollution. Water pollution can be in the form of waste and garbage that is carelessly disposed of into the river, like industrial waste. Industrial waste that is disposed of carelessly can have a negative impact on river ecosystem because it contains substances that are harmful and interfere with people's activities (Aufar, 2019; Dahruji et al., 2017). Examples of industrial waste in is alcohol waste.

According to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 5 of 2022, Such waste must undergo treatment at a Wastewater Treatment Plant (WWTP) before disposal. However, there are still many people who do not follow the regulations, such as what happened in Bekonang, Sukoharjo, Central Java. An alcohol seller dumped alcohol waste into the drainage that flows into the Samin River. The alcohol waste from the Samin river was eventually carried to the Bengawan Solo River because the Samin river is connected to the Bengawan Solo River. This caused big losses because the Bengawan Solo River the source of raw water for the Semanggi Water Treatment Plant (WTP).

Raw water is water from groundwater or surface water that untreated or has not undergone sterilization (Cairns, 2018; Katsanou and Karapanagioti, 2017). The raw water that contaminated with alcohol waste cannot be treated because it does not meet the raw water quality standards, as stated in the Minister of Health Regulation (Permenkes) No. 492/2010 concerning Drinking Water Quality Requirements. There is no explanation regarding raw water standards related to alcohol, so it can be concluded that raw water should not contain alcohol at all. If alcohol has the potential to enter the raw water intake pump, the operation of the Semanggi WTP must stop temporarily. The Semanggi WTP officer on guard at the Semanggi post near the raw water intake pump is divided into 2 shifts : 08.00-20.00 and 20.00-08.00. Semanggi WTP officers stand guard at the post to monitor alcohol that could potentially enter the raw water intake pump. If there is alcohol that could potentially enter the raw water intake pump, the officer will immediately disable the pump until the alcohol waste passes through the pump. There are 2 disadvantages of conventional method is Semanggi WTP officers have difficulty distinguishing whether the water is polluted or no when night comes and it takes a long time to turn off the pump, it takes about 34,7 s.

Previous research on water pumps, namely the Design of a Water Pump Monitoring Tool Using IoT-Based Water Flow Sensor by Muhammad Faishol in 2022. In this study, the pump connected to the relay used to take water will automatically stop if the water flow is less than 30 L/min because it indicates that the pump is damaged. There is research to detect alcohol using MQ-3 sensor by Dakhare, et al in 2022. The MQ-3 sensor is used to detect alcohol in drinks by taking measurements whose results are analog values or analog to digital converter (ADC) values. The MQ3 sensor is calibrated using alcohol with alcohol percentage of 25%, 50%, 75% and 100%. If alcohol is detected the red LED and buzzer will turn on. If no alcohol is detected, the green LED will light up. Thus, this research aims to make a device that more efficient than manual method and finding optimal position between the sensor and the pump This devices serves to turn off the pump automatically when there is alcohol that has the potential to enter the water intake pump and the pump will start again when the alcohol passes through the pump.

2. Experimental

The first step is to make a prototype of alcohol monitoring for raw water supply pumps control system. The second step is to test alcohol monitoring for the raw water supply pump control system to check whether the sensor can work as desired. The last step is to process and analyze the test data.

2.1. Tools and Materials Preparation

The tools and materials are Arduino Uno, MQ3 sensor, relay, water pump, 96% alcohol, aquades, Arduino Ide, and pot for water pump container. All tools and materials were checked for functionality to ensure consistent sensor performance, such as the accuracy of the sensor. 96% alcohol was diluted with distilled water to 7%, 10%, 14%, 21%, and 24%. When first used, the MQ-3 sensor was preheated for 24 hours before testing.

2.2. Making Alcohol Monitoring Prototype in Raw Water Supply Pump Control System

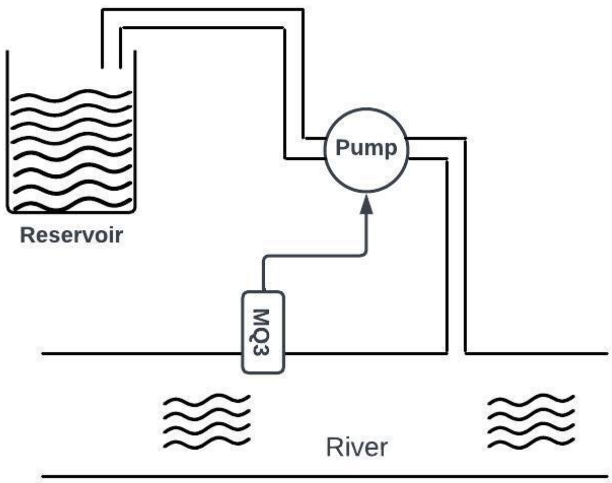

Figure 1. Alcohol monitoring for raw water supply pumps control system illustration

The MQ-3 sensor is used to detect alcohol that could potentially enter the pump. The way this system that shown in Figure 1 works is that when the MQ-3 sensor detects alcohol in the water, the sensor will send an output to the Arduino Uno. If the alcohol exceeds the limit, the Arduino Uno sends an output to the relay and the relay will cut off the electricity to the pump so that the pump will stop taking water and the pump will start again when the ADC value is less than the limit. The circuit will be arranged on a protoboard to make it easier to rearrange the circuit if there is an error in the circuit. Arduino IDE is used to program the device and read the ADC value on the serial monitor.

2.3. Testing of Prototype of Alcohol Monitoring for Raw Water Supply Pumps Control System

Testing the prototype of the alcohol monitoring tool on the raw water supply pump control system is done by calibrating the sensor, so the sensor is working properly and accurately. Sensor testing is done to determine sensor accuracy and sensor precision. Calibration is done by putting 2 ml of alcohol in the container, then the container is placed just below the sensor mouth with a distance of 1.5 cm from the sensor for 30 seconds, shown in Figure 2. The result of this sensor calibration is the ADC value at each alcohol alcohol percentage.

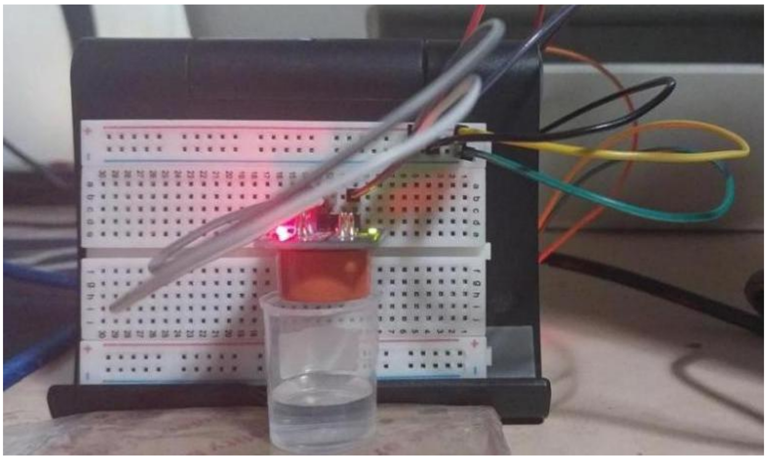

Figure 2. Calibration

2.4. Data Acquisition

The data taken is the ADC value at 7% to 24% alcohol concentration, the reaction time to turn off the pump and the time the pump starts again after the sensor detects alcohol. The ADC value at each alcohol alcohol percentage is used to find the calibration graph equation. The calibration graph equation is used to get the sensor reading results in order to find the zero point. The zero point is the point where the alcohol content is close to 0%. The turn off pump reaction time is the time until the pump shuts down after a container of 2 ml alcohol is placed under the sensor. The pump restart time, which is calculated from the time the container is moved away from the sensor until the pump restarts, is the time the pump restarts. The pump restarts because the ADC value is below the limit. By obtaining the pump reaction time, the optimal distance between the sensor and the pump can be found.

2.5. Data Analysis Method

The data analysis technique is divided into two parts, namely finding zero point and and calculation of the optimal distance of the sensor. Zero point can be calculated with extrapolation method on graph equation. Zero point is zero alcohol percentage zero, so if y = 0, x could be found.

$$y = mx \pm c$$

y=0, then

$$\pm c = mx$$

$$x = \frac{\pm c}{m}$$

The optimal distance of the sensor can be determined by calculating the minimum distance of the sensor and the maximum distance of the sensor. The minimum distance between the sensor and the pump is sought so that the pump is placed in the range where the pump turns off when alcohol is detected, while the maximum distance between the

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sensor and the pump is sought so that the pump is placed in the range where the pump turns back on when alcohol has passed through the pump. If less than the minimum distance or more than the maximum distance, alcohol can enter the pump. The equation for the minimum and maximum distance between the sensor and the pump is as follows

$$Minimum\ distance = reference\ river\ speed\ \times longest\ pump\ turn\ off\ time \quad (3)$$

$$Maximum\ distance = reference\ river\ speed\ x\ (longest\ pump\ turn\ off\ time + fastest\ pump\ turn\ on\ time \quad (4)$$

3. Result and Discussion

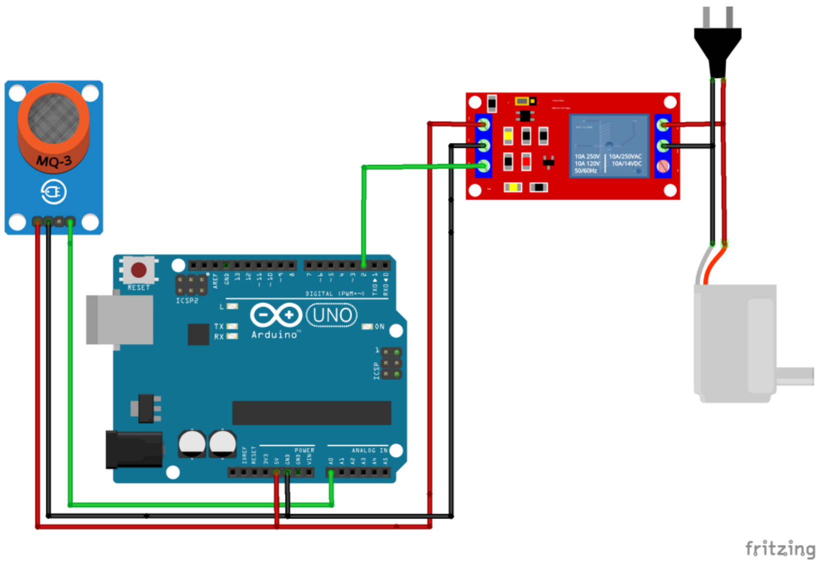

Figure 4. Prototype alcohol monitoring device in the raw water supply pump control system schematic

The voltage source or Vcc (5v) and ground from the arduino uno is connected to the protoboard. A0 pin on the MQ-3 is connected to pin A2 on the arduino because the data is analog, while the IN pin on the relay is connected to pin 2. The water pump is connected to the relay on normally closed and common contact. The water pump is inserted into a pot filled with water. Arduino Uno has an ADC with a resolution of 10 bits so that the output of the value is calculated by the following equation:

$$ADC\ Output = \frac{Vin}{Vref} \times 1023 \quad (5)$$

where Vin is the sensor output voltage, Vref is the reference voltage and 1023 is the total number of bits in the arduino uno ADC, which is 10 bits. The value will be displayed in the arduino IDE serial monitor. Sensor calibration is done to get the equation of ADC value comparison with known alcohol content so that the value of sensor alcohol read out, percentage error, and sensor accuracy can be found. The most data that appears on the arduino IDE serial monitor for 30 seconds will be selected to be compared with the known alcohol content and made a graph in excel. Comparison of ADC values with known alcohol alcohol percentage s is used to obtain calibration graphs and calibration graph equations. The calibration result is shown in Table 1.

Table 1. Calibration Table

No	ADC Value	Alcohol Percentage (%)
1	555	7
2	567	10
3	593	14
4	630	21
5	640	24

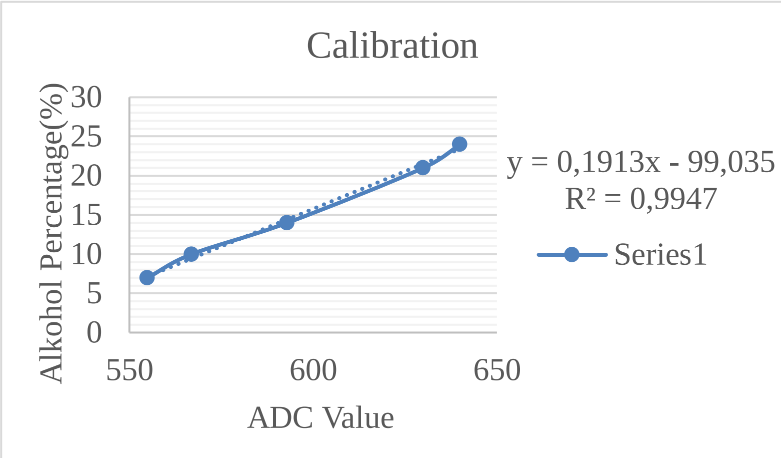

Figure 5. Calibration Graph

The graph that shown in Figure 5 has the equation y = 0.1913x-99.035 with R^2 = 0.9947. The coefficient of determination (R^2) is close to 1 indicating that the data is highly linear and well-fitted. This correlation shows that as the alcohol concentration increases, the sensor's output voltage also increases, resulting in a higher ADC value. R^2 in this research is higher than R^2 Ikhsan and Munasir (2022), which is 0,9527. Once the graph equation is obtained, the alcohol concentration can be determined by substituting the ADC value into the equation. The extrapolation method is used to identify the zero point, which represents the alcohol concentration approaching 0%. This zero point serves as the threshold between clean water and alcohol-contaminated water. In this study, the zero point corresponds to an ADC value of 518, meaning that any ADC value exceeding 518 indicates alcohol contamination in the water.

Table 2. Time Reaction To Turn Off and Turn On The Pump

Alcohol Percentage (%)	The reaction time to turn off the pump (s)			The reaction time to turn on the pump again (s)		
7	1,71	**1,80**	1,78	0,73	**0,72**	0,73
10	**1,46**	1,38	1,37	0,93	**0,92**	0,93
14	1,31	**1,32**	**1,32**	1,25	**1,18**	1,25
21	0,99	0,99	**1,00**	1,77	1,79	**1,70**
24	0,86	**0,87**	0,80	1,91	**1,90**	**1,90**

Based on Table 2, it can be concluded that the higher the alcohol content, the faster the pump turns off because the ADC value rises rapidly until it almost reaches the measured ADC value as in the calibration table. The higher the alcohol content, the higher the ADC value and the longer it takes for the pump to restart because the ADC value will gradually decrease and the pump will restart when it is below zero. The data taken at the reaction time to turn off the pump is the longest time, while the time taken at the reaction time to turn on the pump again is the fastest time so that alcohol does not enter the pump. The longest pump shutdown reaction times at 7% and 24% were 1.8 seconds and 0.87 seconds, respectively. The fastest pump restart reaction times at 7% and 24% were 0.72 seconds and 1.9 seconds, respectively.

Table 3. Minimum and maximum distance between sensor and pump at 7% concentration

7% Concentration		
River current velocity (m/s)	The minimum distance between the sensor and the pump (m)	The maximum distance between the sensor and the pump (m)
0,04	0,072	0,1
0,155	0,28	0,39
0,27	0,49	0,68

Table 4. Minimum and maximum distance between sensor and pump at 24% concentration

24% Concentration		
River current velocity (m/s)	The minimum distance between the sensor and the pump (m)	The maximum distance between the sensor and the pump (m)
0,04	0,039	0,1
0,155	0,14	0,43
0,27	0,24	0,75

According to Satrya et al. (2019), the current velocity of the Bengawan Solo river during the dry season ranges from 0.04 m/s to 0.27 m/s. River current velocity data was used because the lower volume reduces the ability to dilute alcohol waste, causing it to accumulate. The 7% and 24% concentrations represent the lower and upper limits used in this study, covering the full range of potential alcohol contamination. It can be concluded from Table 3 and Table 4 that the distance range at 24% is greater than that 7%. That is happened because the ADC value increases more rapidly and takes longer to decrease at higher alcohol concentrations. The minimum distance taken is the biggest because if there is still a smaller minimum distance, alcohol can enter the pump because the pump has not turned off. The maximum distance taken is the smallest distance because if the maximum distance is larger, the pump has started again so alcohol can enter the pump. Thus, the optimal ensor placement is between 0.28 m and 0.39 m from the pump. There are 3 conditions that cannot be fulfilled due to the sensor's slower reaction time and lack of sensor stability.

4. Conclusion

The prototype of alcohol monitoring device for raw water supply pump control system can work as designed. This device is more efficient device because the device longest time to turn off is 1,8 s and manual turn off time is 34,7 s, so this device is faster by 94,8%. The optimal distance between the sensor and the pump is defined as the range where the pump shuts off upon alcohol detection and remains off until the alcohol has completely passed. Based on the result, the optimal sensor placement is between 0.28 and 0.39 m from the pump.

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