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Monitoring System for Water Turbidity and Air Muda with Microfiltration in IoT-Based Salt Crystallization Process Using Rule-Based Method

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A B S T R A C T

Salt is a mineral that humans need. Indonesia has abundant biodiversity, including 20,089 hectares of salt-productive land. However, despite this great potential, Indonesia still has to import salt to meet the national needs that continue to increase yearly. The increase in salt consumption is influenced by population growth. Salt is used in two main categories: consumption and industry. An efficient salt production process will produce higher-quality salt. However, currently, many salt farmers are still using manual methods that are less efficient and time-consuming, and also the water used as raw material has not been filtered. Microfiltration is carried out to reduce water turbidity, which aims to filter microscopic objects so that the water used in the salt crystallization process becomes cleaner. Salt production is carried out by the stage of the microfiltration process automatically based on the level of water turbidity, and the height of the salt evaporation container is regulated by the rule-based method as a control on the servo. By conducting this study, the percentage of ultrasonic sensor error reached 22.21%, and the higher the Analog to Digital Converter value was obtained, the lower the turbidity level (NTU). Using the rule-based method allows the condition of the servo motion to be determined with the value obtained through the sensor.

Keywords: salt, Internet of Things, prototype, microfiltration, turbidity, altitude.

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1. Introduction

Salt is one of the needs of the general public, a complement that is always present in the food processing process every day. Basically, humans need electrolytes for the body; with abundant biological resources in the Indonesian state, the fulfilment of these substances can be resolved by utilizing existing resources. In the broad scope of this country, the need for salt increases fully every year [1]. The extent of productive salt land in Indonesia reaches 20,089 Ha, but at the same time, Indonesia still has to import salt to meet national scale needs. Population growth is a significant factor in the increasing value of salt consumption[2].

The process of salt utilization is divided into two: consumptive and industrial. Consumptive salt must be iodized with 94.7 per cent NaCl content, and white salt that is specialized for the industry has a high enough NaCl Karan at 97 per cent [1]. Paying attention to the process of salt production will produce good salt quality, which can increase efficiency in salt making while increasing production [1]. The quality of salt is influenced by various factors, including the NaCl content in the salt, and the NaCl content depends on how concentrated the water used to make salt [3].

Salt produced from the process of evaporation and crystallization of seawater in salt ponds is known as coarse salt (krosok) in terms of quality, krosok salt has low quality, namely with an average sodium chloride (NaCI) content of only 85%, which still contains impurities and does not meet health standards because the quality is below quality III according to SNI / SII No 140.76 specifications so that this salt is used to meet the needs of industrial raw materials for salt materials, where color, impurities determine the price, and how it is made [4].

Various studies have been conducted to increase salt products' production yield and quality. Making simple filters is very influential on the quality of salt that is getting better and accelerating the crystallization process because of the clear salt water raw materials [5], monitoring and controlling turbidity as a determining factor in the quality of salt products, the government limits the value of water turbidity to a value of 5 NTU in Permenkes RI No.492 / MENKES / PER / IV / 2010 concerning water quality requirements [6], and controlling the quality management standards of salting land with the highest quantity of salt products in the water level ranging from 3-5 cm [7].

At this time, salt-making is still done manually, both by monitoring the water level and turbidity of the salt used in making salt. The process is very time-consuming and less efficient [2]. Therefore, automation is needed to monitor the height and turbidity of the water used in making salt [8].

The development of science and technology has advanced to produce things that never existed in the past, providing many benefits for human survival until the realization of a system, namely the Internet of Things..

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2. Theory Fundamental

2.1. Air Muda and Water Turbidity In Salt Crystallization

Air muda is salt water still in the open sea; this water is often found on the shoreline, which has a low NaCl content that has not experienced the evaporation of the amount of time in the seawater. This young water has a reasonably low salinity concentration, only around 23-23ppt, with an average of 23.33 ppt [16]. This coincides with how the microfiltration process is carried out to obtain a level of turbidity that meets the standards used as a reference in the research process.

The turbidity of salt water intended in this study is the turbidity that often occurs when taking young water on the shoreline. In the process of making salt, of course, clean water resources are needed to minimize diseases caused by less clean raw materials. So, in making salt, microfiltration is needed to reduce the turbidity level of young water and support the crystallization of good and suitable salt [17]. The turbidity of the water in question has a turbid standard of 5 NTU in Permenkes RI No.492 / MENKES / PER / IV / 2010 concerning water quality requirements as a reference in conducting this research.

2.2. Internet of Things (IoT)

The Internet of Things is a technological transformation integrating the physical and digital world through smart objects. In research that has been conducted, the use of IoT devices on a global scale has jumped rapidly from 7.6 billion in 2019 and is expected to reach 24.1 billion by 2030 [11]. The concept used in IoT aims to expand the connected network continuously, anywhere, in sharing data, remote control, monitoring, and other ways.

The Smarthome prototype is an example of the use of IoT that can be done using a smartphone to facilitate users in controlling lights, doors, or gates. Monitoring and controlling periodically using a smartphone. This system consists of microcontrollers, DC motors, relays, and IoT Blynk [8]; this technology is used to control the use of lights and doors at home.

In the scope of IoT in the salt-making process, Arduino UNO is used to measure air muda height and turbidity value. The use of these devices with the aim that the raw material for making salt can be known the turbidity value contained therein to improve the quality of production.

There are also hardware and software used to support prototypes that have been built using the Internet Of Things (IoT) system as follows:

2.2.1. Sensor Ultrasonik

HC-SR04 Ultrasonic sensor measures distance by utilizing ultrasonic wave emission on the input side and received by the output side. In this condition, it is intended to measure the distance of the water level in the storage container between the surface and bottom of the water.

2.2.2. Sensor Turbidity

A turbidity sensor is a sensor that is intended to measure the level of water turbidity by calibrating using the standards set by the ministry regarding the value of water turbidity, the resulting turbidity level of salt water, with the use of light as the main calibration factor [12]. The use of turbidity sensors here aims to obtain the turbidity value of the salt water that will be processed in the evaporation container.

2.2.3. Servo

The servo is a rotary actuator used to play clockwise or vice versa [13]. The servo motor here plays a role in rotating the faucet on the storage container when it occurs according to the rules that have been made. The servo in this prototype regulates the water capacity in the storage container.

2.2.4. Blynk IoT

Blynk IoT is a monitoring software used to monitor IoT devices. Blynk is also often called a digital dashboard with a more attractive interface to function; Blynk is also designed as a remote control on microcontrollers to make it easier to handle conditions that occur in the field in real time [8][15].

2.2.5. Arduino Uno

Arduino is an open-source microcontroller device that is quite cheap and easy to use; this device can read sensors and finger buttons, with the resulting output turning on servo motors, LEDs, pumps, or data to the cloud [16].

2.2.6. ESP-01

The ESP-01 WiFi module, made by Espressive Systems, is based on the ESP8266 microprocessor and uses a 32-bit micro MCU. The ESP-01 module also complies with the IEEE802.11 b/g/n wireless protocol and includes a comprehensive TCP/IP protocol stack. This multifunctionality helps integrate network features into various devices (from smart home gadgets and sensors to broader applications), thereby enhancing the connectivity and functionality of the devices. In addition, the ESP-01 can serve as an independent network controller, expanding the horizons of IoT innovation[19].

2.3. Algorithms Rule-Based

The rule-based method is a method used to determine problem-solving conditions using predetermined rules; the rules that have been determined have two parts, namely conditions and actions. Conditions and actions will be implemented as an algorithm to determine the steps to solve the problem. The rule-based method is simple and uses logical propositions in the form of IF (condition) ......THEN (action), where if IF ... the condition is proper, then THEN .... will not be executed, THEN ... will be executed if it meets the predetermined conditions of the rule [10][20]. In the condition of servo control in the IoT system, it can be written that the servo will turn on when the height contained in the evaporation container is less than 2 cm and will turn off when the container exceeds 5 cm..

3. Research Methods

3.1. Research Flow

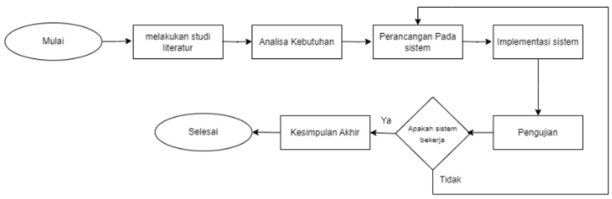

Figure 1. Research Flow

In the process of making a system, the beginning of making a structured system has several stages that will be passed, starting from literature studies, analyzing needs, designing systems, implementing (prototypes), testing systems, and evaluating if there are improvements in the system again before concluding.

This process starts with finding supporting literature, including scientific journals, previous research, books, and related articles. The data collected in this study include the distance of the water level in the evaporation container and the turbidity level in the storage container. The system requirements analysis stage includes the need for hardware and software to be used. The system design stage begins with monitoring the water turbidity level, water level control, and servo motor control, as well as designing software using Blynk IoT as an interface display on Android and the web. Implementation starts with the system design that has been made, and then the test is carried out. The objective of the test is to compare the measurement results of the distance sensor, turbidity sensor, servo control testing, and application testing.

3.2. Threatment water model

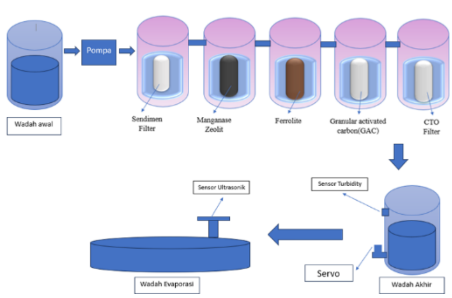

Figure 2. Treatment Water Model

Miniature model of salt raw material water treatment (air muda). This prototype consists of four water reservoirs; the first is the process of filtering young water impurities from external substances such as dust in the air and microplastic particles mixed in young water (sea water); the second is the process of settling impurities in water, and the third is the filtration process and the fourth is a water storage medium that will be controlled and monitored for turbidity and height. All hardware designs will be placed in the reservoir. The ultrasonic sensor detects the water level, and when the water is sufficient to flow on the crystallization table, the tap on the filter will automatically close. The turbidity sensor is used to read the turbidity of the air muda.

3.3. Arsitektur System

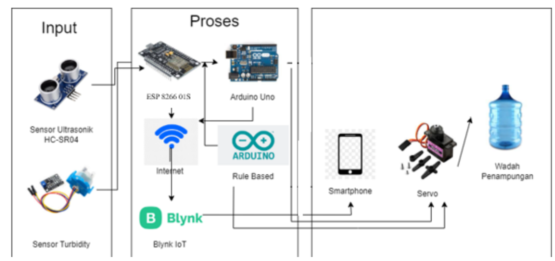

Figure 3. Arsitektur System

3.4. System Requirements Analysis

Analyze the needs needed to achieve the points needed to make decisions on system development. We will discuss the hardware and software needed to run the research process this time.

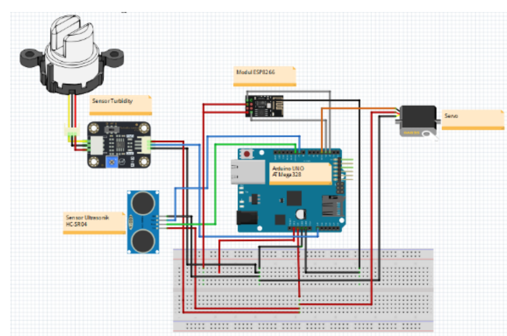

Figure 4. Wiring Sistem

3.5. Rule-based Method Implementation

The application of the Rule-based method in the Internet Of Things (IoT) system that is built to control the Servo through the data generated from the level of water level in the evaporation container is connected to the data obtained regarding the level of water turbidity in the storage container.

The actions that will be implemented in the control process on the Servo use condition rules and actions as follows:

Rule		Tingkat ketinggian		Kekeruhan air		Output
[R1]	IF	0 > 5cm	AND	Tingkat kekruhan air tidak melebihi 5 NTU	THEN	Nyalakan Servo
[R2]	IF	0 > 5cm	AND	Tingkat kekeruhan air Melebihi 5 NTU	THEN	Tidak menyalakan servo
[R3]	IF	5 cm > 0	AND	Tingkat kekeruhan air tidak melebihi 5 NTU	THEN	Matikan servo

Figure 5. Rule - Based

1. If the evaporation basin height is less than 5 cm and the water turbidity level does not exceed 5 NTU, the servo will be turned on. This condition indicates that the evaporation container is empty, so refilling it requires a note that the water in the reservoir's turbidity level does not exceed 5 NTU.
2. If the height condition in the evaporation container is less than 5 cm and the water turbidity level exceeds 5 NTU, the servo will not be turned on. This condition shows that even though the empty evaporation container, the water in the water turbidity level storage container exceeds the predetermined value, and the servo will not be turned on.
3. Suppose the condition in the evaporation container is more than 5cm, and the turbidity level of the water in the turbidity level container does not exceed the predetermined value. In that case, the servo will be turned off..

3.6. Scenario Test

The test carried out on the Internet of Things monitoring system built is to see the results of the accuracy level on each sensor in order to get the measurement results of the data obtained on the height gauge sensor, measuring the water turbidity level in the storage container. Determining whether all the devices used to build this IoT system are functioning correctly to meet the goals set and the steps taken for the system's performance.

Table 1. Scenario Ultrasonik Sensor Test HC-SR04

No	Sensor Ultrasonik HC-SR04 (cm)	Water Level (cm)	Remain Level (cm)	Error Percentage
1	Average value Level Ultrasonik HC-SR 04(cm)	5 cm	(Water Level - Value sensor ultrasonik)/ sensor ultasonik	(Remain Level*Water level) /100
2	Average Value Level Ultrasonik HC-SR 04(cm)	2 cm	(Water Level - Sensor value ultrasonik)/ sensor value ultasonik	(Remain Level * Water Level) /100

Table 2. Scenario Turbidity Sensor Test

No	Analog to Digitsl Converter Value	Voltage	Turbidity Value
1	Nilai yang diperoleh dari pembacaan analogRead pada sensor	ADC value * (5/1024)	Voltage value

4. Results and Discussion

4.1. HC-SR04 Ultrasonic Sensor Test

The sensor used is HC-SR04 to determine the level of accuracy that exists; testing is carried out with a manual ruler comparison, showing that the accuracy obtained has an average error of 22.21% using the following formula [18].

$$Error\ Percentage = \frac{\text{manual ruler} - \text{Sensor value}}{\text{maual ruler}} \qquad (1)$$

Table 3. Result Sensor Ultrasonik Accuration Test

No	Sensor Ultrasonik Level (cm)	Result value manual Ruler (cm)	Sensor Ultrasonik Error (%)
1.	4,8	5	0,2
2.	6,9	7	0,1
3.	7,5	8	0,5
4.	11,6	12	0,4
5.	14,7	15	0,3
Error average percentage			0,0036 %

4.2. Sensor Turbidity Test

Testing the turbidity sensor in two conditions, namely cloudy and clear, is done to determine the turbidity obtained in the two conditions that have occurred.

Table 4. Sensor Turbidity Test

No	ADC value	Turbidity Value (NTU)
1	769	17,31
2	743	20,11
3	732	21,29
4	738	20,65
5	777	16.45
6	898	3,44
7	899	3.33
8	913	1,83
9	910	2,15
10	908	2,37

4.3. Application of Rule Based Method

At this stage, the Rule is made to perform conditioning in servo movement to select conditions that allow the servo to move; the following code is used using the C programming language integrated with the Arduino IDE.

4.4. Discussion

From the results of the accuracy testing carried out, it is concluded that the use of sensors to perform calculations with related parameters requires stable power and away from electromagnetic fields because it interferes with the reading of analogue sensors, be it turbidity sensors or Ultrasonic sensors, the average error accuracy rate of each sensor is also high.

```
if (((int)distance <= 15 && (int)distance >= 5)  && ((int)kekeruhan <= 5 && (int)kekeruhan >= 0)){
  myServo.write(180); // Servo membuka ke 90 derajat
  Serial.println("Servo pada sudut 90 derajat.");
} else {
  myServo.write(90); // Servo kembali ke posisi 0 derajat
  Serial.println("Servo pada sudut 0 derajat.");
}
```

Figure 6. Rule Based

5. Conclusion

The tests show that the accuracy level will decrease depending on the unstable voltage, resulting in a reading that is entirely lacking in its presentation. Some sensors have inadequate modules that make it impossible to calibrate to get maximum results.

Overall, in this study, the turbidity level is very dependent on light, so the value that appears can be maximized. The lack of calibration references related to turbidity sensors means it must be done using a linear equation formula, which is impossible because the analogue signal will never be stable.

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