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INTERNET OF THINGS-BASED WATER DIRT DETECTION SYSTEM USING FUZZY LOGIC SUGENO ALGORITHM

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ABSTRACT

Water turbidity is one of the important indicators of water quality that affects human health and the environment. Many water sources are susceptible to pollution that can increase water turbidity. Traditional methods require manual sampling inefficiently and do not provide real-time data. Internet of Things (IoT) technology allows real-time and remote monitoring of water turbidity, The water turbidity detection system program created will use the Sugeno fuzzy logic method where this method can provide a percentage of water cleanliness based on selected input and apply predetermined rules so that it can produce NTUs output and percentage of water cleanliness. Based on the results of tests that have been carried out in this study, the System has a good level of functionality. the level of accuracy of the results of the system and manual calculations. obtained a level of error difference (error) of 13% meaning that from 100% error rate, the accuracy level value reaches 87% that the program is concluded to be running well. With the website, it can monitor and help make it easier for users to control the level of water turbidity in the environment without having to come to the location. From the tests carried out for the turbidity sensor components, it works well.

KEYWORDS *internet of things, water turbidity, fuzzy logic sugeno, NTU (nephelometric turbidity units)*

INTRODUCTION

People in Indonesia are still faced with a number of problems that are quite complex and until now have not been completely overcome, one of the problems faced is the low level of clean water services for the community. The clean water supply system is a national policy that aims to increase public access to quality water used daily. In this regard, there is a need for supervision of the quality of water distributed to the community by water service providers (Hajar et al., 2020; Toni & Widiasari, 2021). This is important to do considering that various water-

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borne diseases can arise from drinking and using water whose quality does not meet health requirements (Hanif et al., 2020). Water is an indispensable necessity for the life of living things, especially humans. The need for water in humans includes bathing, washing, cooking and so on (Sulianto et al., 2020).

However, the most important pollution is caused by various human activities such as industrial activities, agriculture, transportation and household activities. Household activities produce solid and liquid waste. Liquid waste that comes from household activities is also called domestic waste. Therefore, domestic wastewater needs to be treated and reused to reduce pollution that occurs in the aquatic environment (Ramadhani & Qoiriah, 2019). Therefore, it is necessary to carry out domestic liquid waste treatment. Household wastewater in Indonesia is relatively unaffordable by waste treatment technology, as well as the high cost of existing waste technology, so a household waste treatment system that is cheap and easy to implement, and can provide optimal results is needed (Nilasari et al., 2016; Zaenurrohman et al., 2023).

The process of turbid water can be done with a system Filtering or filtration. Filtration is one of the commonly used water treatment techniques to remove impurities or unwanted substances from water. Filtration techniques can be carried out using various types of filter media such as sand (e.g.: silica, anthracite), chemical or mineral compounds (e.g., lime, zeolite, activated carbon, resin, ion exchange), membranes, biofilters, or other filtration techniques (Zulkarnain et al., 2018). The development of water purifiers continues to be carried out, both in the purification process and in terms of embedded features. In the water purification process, the filtration process is not only carried out once. This is because water with a high level of turbidity is not enough for just one filtration process. In research, water purifiers using a double filtration system have been successfully used to purify household laundry wastewater (Nurwirasaputra et al., 2020).

To facilitate effective and efficient water quality monitoring, a monitoring tool based on Internet of Things (IoT) to monitor water quality anywhere and anytime (Attoriq et al., n.d.). The tool provides information about the monitored water quality level in the form of parameters that allow the user to predict the feasibility of water quality. Clean water quality parameters are also regulated by the Regulation of the Minister of Industry of the Republic of Indonesia No. 78 of 2016 with the provision of a turbidity level of clean water of 25 NTU and Total Dissolved Solids (TDS) of 1500 mg/L (Kurniadi, 2020) peraturan.go.id. Researchers using fuzzy logic method Sugeno. Fuzzy logic can be used to convey information from data that is ambiguous. Fuzzy logic It has several methods that can be used, namely; method Tsukamotomethod Mamdani, and methods Sugeno (Fauzi et al., 2019).

The Fuzzy Set was first introduced by Lotfi Zadeh in 1965 in a monumental scientific paper titled "Fuzzy Set". In the scientific paper, the basic idea of fuzzy set is explained which includes inclusion, union, intersection, complement, relation and convexity (Robiah et al., 2022; Saputra et al., 2021). Lotfi Zadeh explained that the integration of Fuzzy Logic into information systems and process engineering is to produce applications such as control systems, household tools, and decision-making systems that are more flexible and sophisticated compared to conventional systems.

Advantages of Fuzzy Logic Compared to other logic systems, fuzzy logic is capable of producing equally heavy decisions. Fuzzy logic models feelings or intuition by converting the value of the crisp into a linguistic value by fuzzification and then incorporating it into rules created based on knowledge. The second advantage is that Fuzzy logic is suitable for use in most problems that occur in the real world (Susanto et al., 2020).

The use of Fuzzy Logic Sugeno in water turbidity sensor data processing can provide more reliable and accurate results. Therefore, it is necessary to develop a system that integrates IoT with Sugeno's Fuzzy Logic to create an effective water turbidity monitoring solution

Here is the Flowchart of the Fuzzy Sugeno algorithm to determine water conditions:

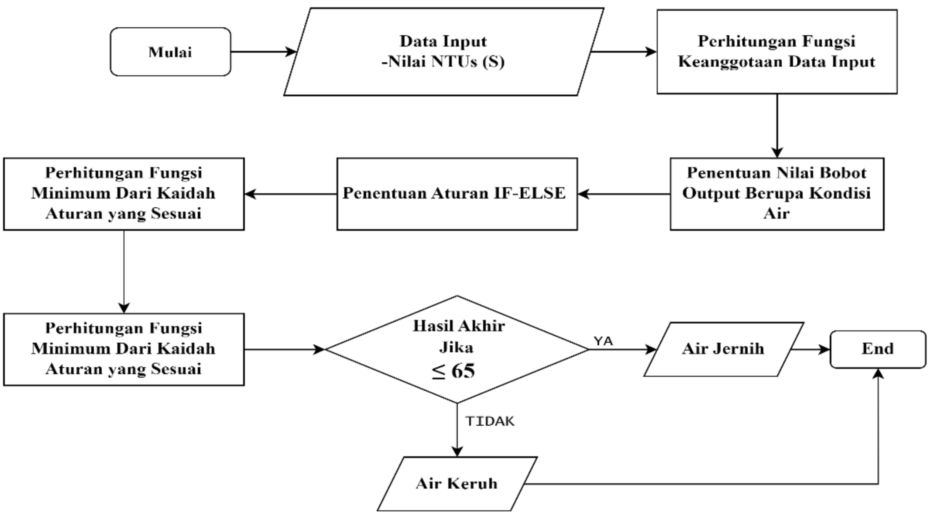

Figure 1. Sugeno Fuzzy Algorithm Flowchart

Sugeno Fuzzy Method Calculation

The following is a brief explanation of the functions and flow of the program:

1. The input data used in the research on the implementation of the fuzzy sugeno algorithm is a variable, namely NTUs (S).
2. The membership function of each variable is represented by an ascending linear and linear descending curve. The S variable has both good and bad membership functions.
3. The output weight value of the fuzzy sugeno process is determined in the form of filtation results with the membership function, namely NTUs. The output weight value is in the form of clear and turbid water conditions where the water cleanliness percentage is determined through a fuzzy rule that integrates the input of NTUs values where the water cleanliness percentage value is calculated from the filtered water results.
4. Then the fuzzy rules are determined which are based on the fuzzy set on each input. The rule of the rules used with the aggregation function used is the AND function. This aggregation function combines all the outputs

of a fuzzy rule into a single fuzzy set. The form of the fuzzy sugeno rule is as follows
IF x is A1 AND.. Xa is An THEN y= f(x1, X2.. Xa)
Where x is the input parameter, A is the value of the input parameter, and f is the output value which is both a constant and a linear equation.

5. To simplify the three input variables contained in the rule rule, the minimum function (MIN) is used by taking the smallest value of the domain that has the maximum membership value in the rule rule. The value of the MIN function is called the α- predicate.
6. To produce one output value, which is in the form of water conditions, the weight average function is used which is the average of the minimum value with the fuzzy output value in each rule. The function of the weight average is as follows.
   W = Σ z∗a-predicate
   Σ a-predicate
   Where W : weight average
   Z : Fuzzy Output tiap rule
   α-predicate: Minimum value per rule
7. then a simplification of the W result is carried out so that there is a fractional value that becomes the output. So that it will be in accordance with the output value of water conditions, namely clear water and turbid water. Simplification is done by rounding the output value to the nearest whole number.

Variables Determinant of Water Conditions

The fuzzy algorithm in this study will produce an output in the form of NTUs units. The fuzzy used is a Sugeno model fuzzy. In this study, Sugeno's fuzzy algorithm was designed using linguistic variables that function as input variables in determining water conditions and 2 output variables. These variables are the value of NTUs, the percentage of water cleanliness, clear water, and turbid water. Both variables have their own membership functions. Here are the values of the membership functions of the two variables

NTUs(S) value variables

The value of NTUs in this water condition is an integer that has a range of 0-25 clear water and 25-100 turbid water. The initial number on this variable is 0, while the maximum value is 100. The following is the membership function of the value variables NTUs.

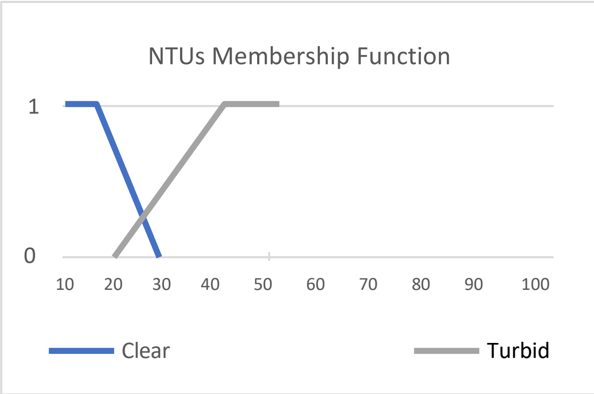

Figure 2. NTU Membership Chart

Percentage Variable (W)

The percentage variable in this water condition is the process of filtering turbid water to become clear and then the percentage value of water cleanliness is obtained. The percentage used in this system is calculated from the water that has been filtered. The resulting value is an integer that has a range of 100-0. If the percentage of water cleanliness value is high, the water is clear. Meanwhile, if the percentage of water is low, the water is cloudy.

The following are the functions of the water cleanliness percentage membership:

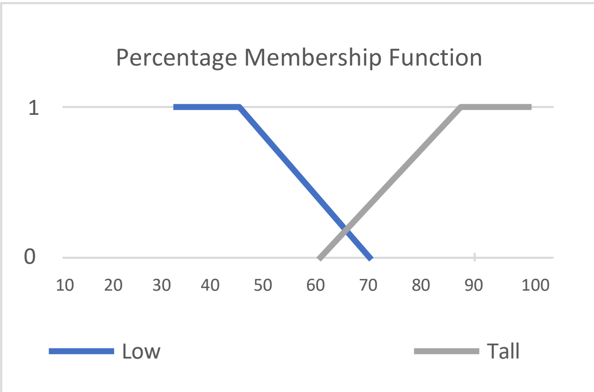

Figure 3. Percentage Membership Chart

Method determination fuzzy logic which will be used refers to the results of the research by stating among the three fuzzy methods. Logic, the Sugeno method has a smaller error value compared to the Tsukamoto method and the Mamdani method. Based on the results of the study, the Sugeno method is the best method to use to make decisions (Paraijun et al., 2022).

Implementation of fuzzy logic rules to determine water conditions based on two input variables: NTU (Nephelometric Turbidity Unit) and water clarity percentage. The rules of fuzzy logic are used to overcome uncertainty and complexity in system modeling. This research aims to enable real-time measurement of water clarity and can provide solutions to prevent water pollution.

RESEARCH METHOD

For the water turbidity detection system program that is made, it will use the fuzzy logic sugeno method where this method can provide a percentage of water cleanliness based on the input that has been selected and apply the rules that have been set so that it can produce NTUs output and water cleanliness percentage.

System Development Methods

The system development method is a stage that must be passed which can be in the form of observation or implementation stage that is carried out scientifically to compile, analyze and conclude data so that it can be used in the development of a system.

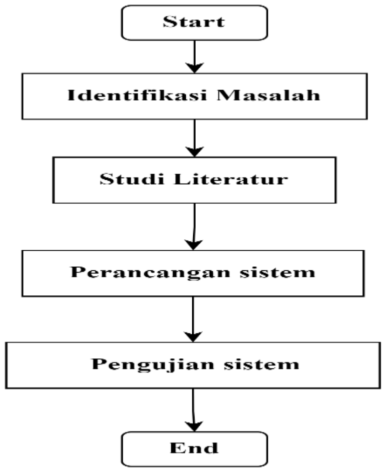

Figure 4. Research Stages

Figure above is the first step in designing an Internet of Things (IoT)-based water turbidity control system.

System Planning

Software Requirements

Some of the specifications that are required for the software used to design and build applications can be seen in table below.

Table 1. Software Specifications

No.	Software	Description
1	Windows 10-64 Bit	Operating System (OS)
2	Visual Studio Code	Builder App
3	Arduino IDE	Sketch Program
4	Mendeley	Citations Plugin Software
5.	Draw.io	Flowchart Maker

Hardware Requirements

Some specifications of hardware requirements used to design and make tools to classify water clarity can be seen in table below.

Table 2. Hardware Specifications

No.	Hardware	Description
1.	Laptop	Lenovo T430
2.	Microcontroller	ESP32
3.	Sensor	Turbidity
4.	LCD	16X2
5.	Filtrasi	Nanotec Clear
6.	Water Pump	Power Head AM-1200A

System Architecture Design

Based on this research, a web-based water turbidity control system was designed. The design of the system application architecture can be seen as shown in the image below.

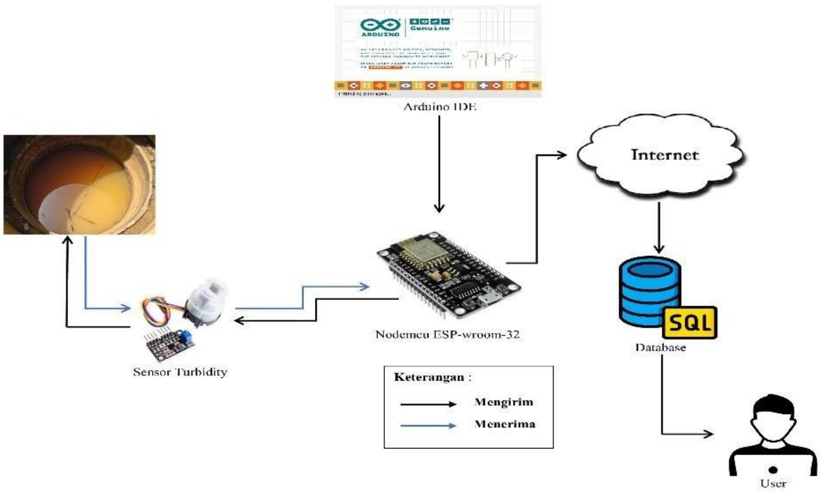

Figure 5. System Architecture Design

Based on figure 5, system design is one of the flows in building a system that aims to be an intermediary between two devices, software and hardware, namely between turbidity sensors and websites so as to achieve the same goal. The turbidity sensor will read the turbidity of the water and then send the sensor results to the website and the data is stored on the database server in the form of the final result produced by the turbidity sensor in the form of water clarity level using Fuzzy Logic Sugeno and when the user makes a command, the command will be processed in a computer, laptop or smartphone, to carry out the command, it must first be connected to the internet network. This water turbidity control system is used to detect water turbidity where the sensor will send data to the website in the form of filtered water products to determine the percentage of water cleanliness and NTUs. Sugeno's Fuzzy Logic method is designed for the purpose of measuring water clarity in real-time and can provide a solution to prevent water pollution.

System Testing

This test is carried out by providing input and then assessing the output produced. If the output obtained is in accordance with what is desired or expected, then the testing process is successful, if the testing process is not as we want, it can be categorized as failed. Tests that only show the interface that we can see and analyze directly in the detailed evaluation process we can only know the inputs and outputs in this test.

RESULT AND DISCUSSION

Prototype and Website Display

The overall water purification system consists of the components that make up the entire water purification system, namely the filter tube, panel box, water reservoir, and mechanical frame. The panel box serves as a component container, made of plastic. The reservoir is made of acrylic and measures 65 cm long, 45 cm wide, and 45 cm high which has a capacity of 131.6 liters to hold water. The filtration tube is 16.5 cm in diameter and 50 cm high made of pvc pipe material. Wooden beams are used on the mechanical frame. An automatic water purification system has been designed.

Figure 6. Prototype View

The website has a display that can connect users and systems using the optical display located within the website. The results of the design process include the creation of an Internet of Things (IoT)-based website for a water turbidity monitoring system.

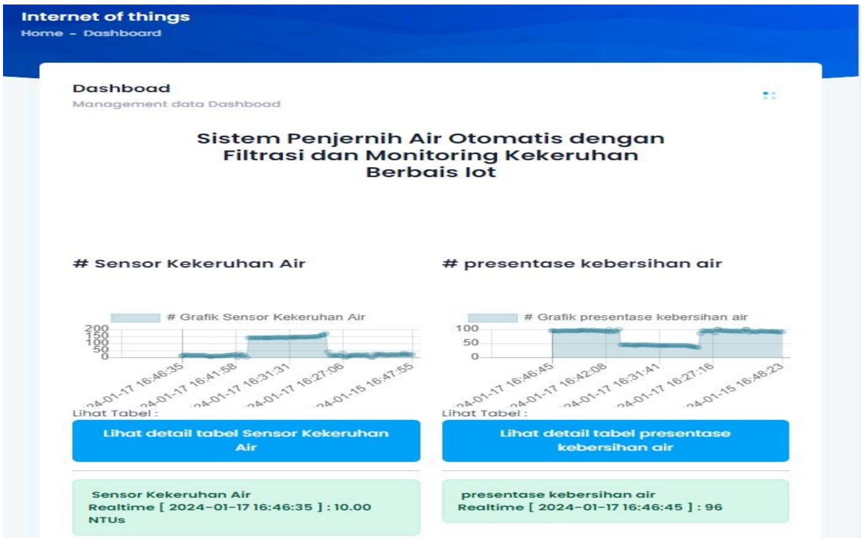

Figure 7. Website Display

Sensor Accuracy Testing

In this test, the level of turbidity of the water is read using a turbidity sensor. This test aims to determine the results of water that has passed through the filtration process. Then it will be input into the log menu and processed into data. The website will print the final data results in Excel format after the turbidity sensor reads the data in real time, which automatically generates detailed data. Shown in figure 8.

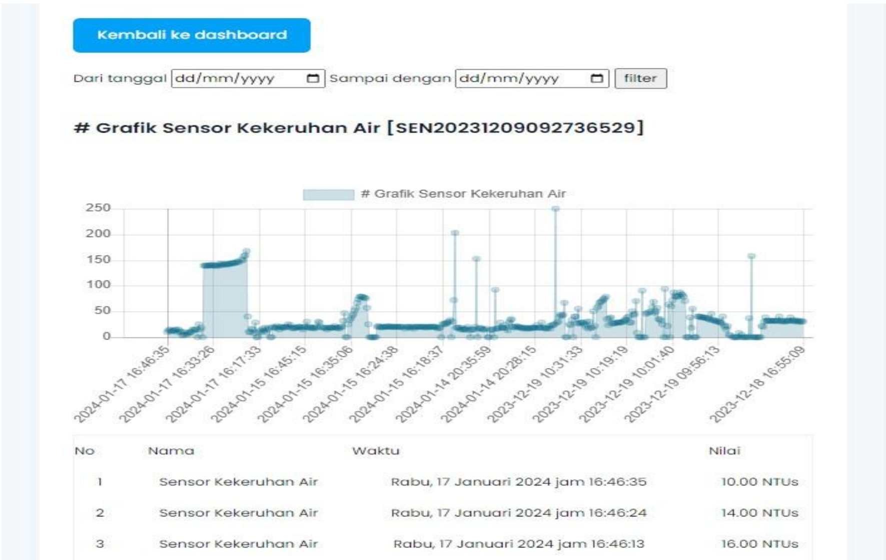

Figure 8. Graph of water turbidity sensor

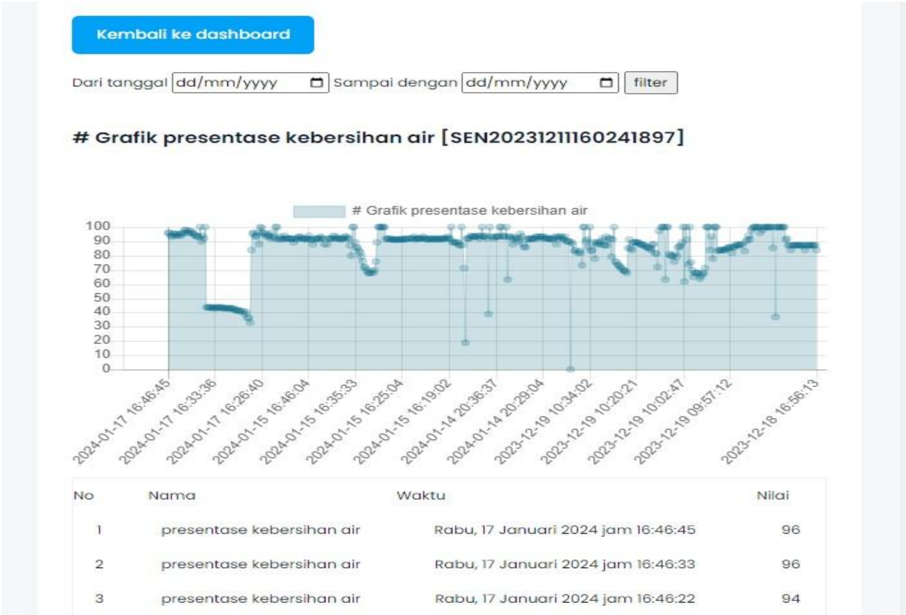

Figure 9. Water Cleanliness Percentage Graph

From the results of measurements using the turbidity sensor, the data shown in the figure above shows the final results of the water quality process of 10.00 NTUs and the percentage of water cleanliness of 96% of the calculation results using Fuzzy Logic Sugeno.

Manual and System Calculation Accuracy

Table 3. Manual and System Calculation Accuracy

It	NTUs and Percentages	System	Manual calculation	Information
1	if NTU = 49 and percentage = 80	Turbid	Clear	-
2	if NTU = 21 and percentage = 91	Clear	Clear	□
3	if NTU = 00 and percentage = 100	Clear	Clear	□
4	if NTU = 45 and percentage = 82	Turbid	Clear	-
5	if NTU = 8 and percentage = 96	Clear	Clear	□
6	if NTU = 17 and percentage = 93	Clear	Clear	□
7	if NTU = 62 and percentage = 75	Turbid	Turbid	□
8	if NTU = 12 and percentage = 95	Clear	Clear	□
9	if NTU = 23 and percentage = 90	Clear	Clear	□
10	if NTU = 16 and percentage = 93	Clear	Clear	□
11	if NTU = 52 and percentage = 79	Turbid	Turbid	□
12	if NTU = 16 and percentage = 93	Clear	Clear	□
13	if NTU = 89 and percentage = 64	Turbid	Turbid	□

14	if NTU = 00 and percentage = 100	Clear	Clear	□
15	if NTU = 56 and percentage = 77	Turbid	Turbid	□

Based on the results of the tests carried out. The system has a good functional level, the degree of correctness of the results of the system and manual calculations. Getting an error rate of 13%, this shows that the accuracy level value reaches 87% of the 100% error rate that it concludes that the program is running well.

Example The calculation is done manually according to Fuzzy's calculation. The steps are as follows. Calculate using the value of NTU = 16 and percentage = 90.

1. Using rule 1:
   rule1= 0.5 x persen +0.5 x ntu
   rulel = 0.5 x 90+ 0.5 x 16
   rulel = 45+8
   rule1 = 53
2. Using rule 2:
   rule2 = 0.8 × ntu +0.2 x persen
   rule2 = 0.8 x 16+0.2 x 90
   rule2 = 12.8 + 18
   rule2 = 30.8
3. Calculate the final result using the Sugeno method:
   $$\text{finalResult} = \frac{\text{weight1xrule1+weight2xrule2}}{\text{weight1+weight2}}$$
   $$\text{finalResult} = \frac{0.6\times53+0.4\times30.8}{0.6+0.4}$$
   $$\text{finalResult} = \frac{31.8+12.32}{1}$$
   finalResult = 44.12
4. Determine the conditions based on the final result:
   Since finalResult = 44.12, then the condition is "Clear Water".
   So, for input NTU = 16 and percentage = 90, the result is "Clear Water".

CONCLUSION

Based on the analysis and discussion of the research results from several experiments, the following conclusions were obtained: 1. The results of the detection of water turbidity level based on the Internet of Things using sugeno fuzzy logic The system has a good level of functionality with an error rate of 13%, resulting in an accuracy rate of 87%, The Sugeno Method provides more reliable and accurate results in processing water turbidity sensor data. 2. The existence of a website can monitor and help make it easier for users to control the level of water turbidity in the environment without having to come to the location. From the tests conducted for the turbidity sensor components to run well, users can see NTUs data, water quality graphs and water cleanliness percentages.

The system designed and developed in this study has succeeded in achieving the expected goal, which is to provide effective and efficient water turbidity monitoring solutions, as well as provide real benefits in water quality management for health and the environment. This filtration process is qualified to be reused as water for washing, watering plants and reducing water pollution.

REFERENCES

Attoriq, M., Anggara, F., & Jumeilah, F. S. (n.d.). *Penerapan Algoritma Fuzzy Logic Sugeno dan Algoritma A* pada Game Battle City*.

Fauzi, S., Eosina, P., & Laxmi, G. F. (2019). Implementasi Convolutional Neural Network Untuk Identifikasi Ikan Air Tawar. *Seminar Nasional Teknologi Informasi*, *2*, 163–167.

Hajar, S., Badawi, M., Setiawan, Y. D., Siregar, M. N. H., & Windarto, A. P. (2020). Prediksi Perhitungan Jumlah Produksi Tahu Mahanda dengan Teknik Fuzzy Sugeno. *J-SAKTI (Jurnal Sains Komputer Dan Informatika)*, *4*(1), 210–219.

Hanif, S., Rahmawati, D., Alfita, R., Awal, A. S., & Doni, A. F. (2020). Automatic Clean Water Treatment System Using the Sugeno Fuzzy Method. *Journal of Physics: Conference Series*, *1569*(3), 32087.

Kurniadi, A. (2020). Implementasi Convolutional Neural Network Untuk Klasifikasi Varietas Pada Citra Daun Sawi Menggunakan Keras. *DoubleClick: Journal of Computer and Information Technology*, *4*(1), 25–33.

Nilasari, E., Faizal, M. F. M., & Suheryanto, S. (2016). Pengolahan Air Limbah Rumah Tangga dengan Menggunakan Proses Gabungan Saringan Bertingkat dan Bioremediasi Eceng Gondok (Eichornia crassipes),(Studi Kasus di perumahan Griya Mitra 2, Palembang). *Jurnal Penelitian Sains*, *18*(1), 8–13.

Nurwirasaputra, H. F., Sumaryo, S., & Pangaribuan, P. (2020). Perancangan sistem monitoring kualitas air secara real-time untuk budidaya perikanan menggunakan metode fuzzy logic. *EProceedings of Engineering*, *7*(2).

Paraijun, F., Aziza, R. N., & Kuswardani, D. (2022). Implementasi Algoritma Convolutional Neural Network Dalam Mengklasifikasi Kesegaran Buah Berdasarkan Citra Buah. *Kilat*, *11*(1), 1–9.

Ramadhani, R. Y., & Qoiriah, A. (2019). Implementasi Algoritma Fuzzy Sugeno sebagai Pendukung Keputusan dalam Penentuan Skor Akhir pada Game Edukasi Simple Nomic. *Journal of Informatics and Computer Science (JINACS)*, *1*(01), 48–55.

Robiah, S., Indra, J., Fitri, A., & Masruriyah, N. (2022). Penyiraman Air dan Nutrisi untuk Tanaman dalam Pot Secara Otomatis Menggunakan Arduino Uno D= dengan Algoritma Fuzzy Logic. *Scientific Student Journal for Information, Technology and Science*, *3*(2), 227–234.

Saputra, A. R., Sasmito, A. P., & Rudhistiar, D. (2021). Rancang Bangun Pakan Dan Filterisasi Pada Budidaya Ikan Channa Menggunakan Metode Fuzzy Berbasis Arduino. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *5*(2), 668–675.

Sulianto, A. A., Kurniati, E., & Hapsari, A. A. (2020). Perancangan Unit Filtrasi untuk Pengolahan Limbah Domestik Menggunakan Sistem Downflow. *Jurnal Sumberdaya Alam Dan Lingkungan*, *6*(3), 31–39.

Susanto, S., Hikmayanti, H., & Indra, J. (2020). Implementasi fuzzy logic pada tambak ikan bandeng berbasis internet of things (IoT). *Scientific Student*

Journal for Information, Technology and Science, *1*(1), 26–32.

Toni, N., & Widiasari, I. R. (2021). Perancangan Sistem Kontrol Kekeruhan Air Berbasis Website Internet of Things. *JATISI (Jurnal Teknik Informatika Dan Sistem Informasi)*, *8*(3), 1515–1528.

Zaenurrohman, Z., Susanti, H., Hazrina, F., & Rahmat, S. (2023). Sistem Penjernih Air Otomatis Dengan Filtrasi Berulang Dan Monitoring Kekeruhan Berbasis Iot. *Infotronik: Jurnal Teknologi Informasi Dan Elektronika*, *8*(1), 1–11.

Zulkarnain, I., Istanto, K., & Asnaning, A. R. (2018). Rancangan Sistem Filtrasi Ganda untuk Pengolaan Air Limbah Laundry Rumah Tangga. *Prosiding Seminar Nasional Pengembangan Teknologi Pertanian*.