



Prototype of Water Turbidity Monitoring Device for Sanitation Hygiene Based on Minister of Health Regulation No 2/2023

Nandang Gunawan Tunggal Waras¹⁾, Muhammad Chasien Pratama²⁾,

Dudi Adi Firmansyah³⁾, Ervanggis Minggar Kusumasari⁴⁾

^{1,2,3,4)} Metrology and Instrumentation Diploma 3 Study Program

Metrology and Instrumentation Academy

*Email: nandang.gunawan@akmet.ac.id

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ABSTRACT

Manual water quality monitoring in accordance with Minister of Health Regulation No. 2 of 2023 is urgently needed to detect early physical, chemical, microbiological, and radioactive contamination that could potentially endanger public health.. This water certainly has certain qualities, including its turbidity level. In accordance with Ministry of Health Regulation No.2/2023, the maximum turbidity limit for sanitary water is below 3 NTU. Therefore, a device is needed that can monitor the turbidity level of water practically. The purpose of this study is to design a prototype device for monitoring the turbidity value of sanitary hygiene water in accordance with Permenkes No. 2 of 2023. This study used the Analysis, Design, Development, Implementation, and Evaluation method. This method is expected to produce a structured and systematic approach to the development and design of the prototype that will be created. The prototype design process uses a TS 300B turbidity sensor to detect turbidity, NodeMCU ESP8266 as a microcontroller and IoT, and a 128x64 I2C OLED display. The application of IoT in this prototype is based on the use of a website to display and store measurement data. Testing was conducted on the TS 300B turbidity sensor on three samples with three repetitions, compared to the standard Nephelometric Turbidity Unit (NTU) solution. The test results showed an average accuracy and precision of 99.76% and 99.72%. Currently, some of the detection device models on the market have an accuracy of between 0-200 NTU with the added feature of data connectivity, but they are relatively expensive. Therefore, in the future, the role of IoT-based technology will be further optimized, with the aim of improving the quality of life for all.

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INTRODUCTION

Water is an essential commodity for all living things. In fact, about 71% of the earth is covered by water (Squyres, 1984). Therefore, water plays a crucial role for humans, and its role is very difficult or even impossible to replace (Udin et al., 2021). Water is typically used by humans for various activities, such as washing and bathing (Akhiat, 2017)–

(Fernanda, 2020). Sanitary water is the term used for water used in these activities, which is regulated in Minister of Health Regulation No. 2 of 2023. Sanitary water itself is water used by a person for personal hygiene, such as bathing and washing (Ministry of Health, 2023) – (Prajnagra et al., 2021). But, the clean water crisis has a serious impact on public health. Limited access to clean water can lead to waterborne diseases such as diarrhea, respiratory infections, and skin diseases. (Ageng & Riska, 2024). In fact, good water quality will greatly determine the quality of life of the community. Therefore, to meet these needs, water of guaranteed quality is required. Referring to Permenkes No. 2 of 2023, the safety requirements for sanitary hygiene water have been regulated, whereby sanitary hygiene water can be assessed based on its physical parameters (Pramesti & Puspikawati, 2020). One of the mandatory parameters in the physical parameters that must be reviewed in sanitary water is turbidity. Ministry of Health Regulation No. 2 of 2023 explains that sanitary water has a maximum turbidity value that can be considered acceptable, which is below 3 NTU (Ministry of Health, 2023). In today's rapidly advancing technological era, the development of early detection medical devices is greatly needed. This will be very beneficial in preventing worse health effects and enabling faster preventive measures to be taken. Turbidity is a phenomenon in which the transparency of water is reduced due to the mixture of several organic or inorganic materials (Cyfoeth Natural Resources, 2020). Water turbidity itself can be expressed in Nephelometric Turbidity units (NTU) (Sari & Fata, 2024). Usually, to measure water turbidity, manual methods are still used, such as using a turbidity meter or laboratory analysis (Sari & Fata, 2024) – (Fakrizal et al., 2022). However, this method is very time-consuming and ineffective because it cannot provide real-time readings. In addition, this method is also relatively expensive, and not all laboratories in some regions have measuring instruments that can read water turbidity values (Sari & Fata, 2024) – (Wang et al., 2024). Given these issues, there is a need to develop a device that can measure and monitor water turbidity practically and effectively, providing real-time turbidity readings and enabling remote monitoring.

Previously, there have been studies related to measuring or monitoring water turbidity. One such study, conducted in 2022, created a prototype that enables the measurement of water quality using turbidity and total dissolved solids (TDS) parameters (Reforma et al., 2022). The prototype in this study used a turbidity sensor and a TDS sensor to detect water, as well as an LCD screen to display the readings. This prototype was not yet integrated with IoT. In addition, in 2023, there was a related study in which a turbidity detector was created to monitor water quality based on IoT (Sumarahinsih et al., 2023). The role of IoT in this prototype is to accelerate the data transmission process. In addition, IoT acts as a monitoring tool if water turbidity exceeds the threshold.

In this study, a turbidity sensor was used to detect water turbidity, integrated with NodeMCU ESP8266 as the microcontroller and also as a connector to the IoT. For this study, the water turbidity readings will be displayed on the Blynk application.

METHOD

Research Time and Location

The research was conducted from January 2025 to May 2025. Data collection was conducted at the Final Project Workshop Laboratory of the Academy of Metrology and Instrumentation (Akmet). The ADDIE (Analysis, Design, Development, Implementation,



and Evaluation) method was used in the research (Kumala, 2024). This method is expected to produce a structured and systematic approach to the development and design of the prototype that will be created.

1. Analysis

This stage involves observing quality water, reviewing relevant journals that can assist in the creation of this prototype.

2. Design

This design is carried out to create an overview of the prototype that will be used as a reference for the creation of tools obtained from the literature study.

3. Development

At this stage, the prototype will begin to be created with reference to the design that has been made.

4. Implementation

After the prototype has been completed, it is necessary to implement and test the prototype, such as calibration and testing of the prototype to determine the performance and reliability of the sensors in the prototype that has been created

5. Evaluation

The data obtained from the testing will be evaluated to obtain the final results of the prototype that has been created.

Design

This prototype is designed with hardware that will later be programmed by software. The design for this prototype includes an input system consisting of a 3.7V battery and a TS 300B sensor, a processor in the form of NodeMCU ESP8266 with internet, and an output consisting of a 128x64 I2C OLED and a website display. Figure 1 shows the block diagram of the prototype.

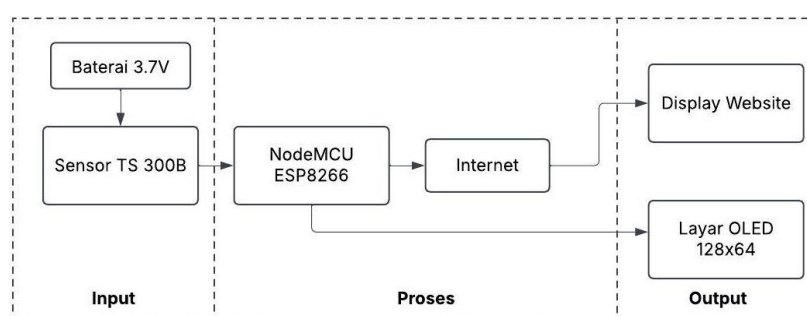


Figure 1. Block Diagram of Prototype

The prototype works by starting with a 3.7V battery that provides electrical current to operate the entire device in the prototype. Then, the NodeMCU ESP8266 will connect to the internet via the activated Wi-Fi. After that, the TS 300B sensor will detect the turbidity of the water being read, and the data read by the TS 300B sensor will be forwarded to the NodeMCU ESP8266 for processing. The sensor output will be processed on the NodeMCU ESP8266, which will produce an NTU value. The reading results will be

displayed on the 128x64 I2C OLED and also on the website display. The prototype of an Internet of Things (IoT)-based water hygiene monitoring device uses several components in its design. Each component used in this prototype has its own function. A 3.7V battery is used as the power source for the prototype. Next, a switch is used to connect to the battery to control the prototype's power on and off. Then, the TP 4056 charging module functions as a charger when the battery used in the prototype runs out of power, so that the battery can be recharged and used again as a power source for the prototype. Finally, the TS 300B sensor is used to detect water turbidity. NodeMCU ESP8266 as a microcontroller processes the sensor output and functions as a connector between the prototype and IoT in the form of a website display that shows the reading results and water turbidity status. Then, the 128x64 I2C OLED screen displays the turbidity readings and water status on the prototype. Figure 2 shows the schematic design of the circuit for the Internet of Things (IoT)-based hygiene sanitation water turbidity monitoring device prototype.

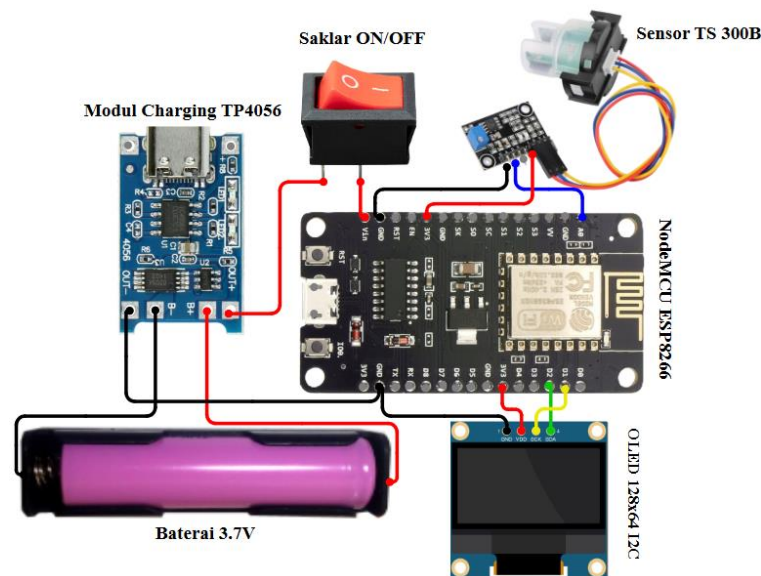


Figure 2. Circuit Schematic

To determine the capabilities of the prototype that has been created, it is necessary to test the prototype after it has been designed (Maksalmina et al., 2024). The prototype can be considered successful when it can read turbidity values in water within a range below 3 NTU based on the reference in Minister of Health Regulation No. 2 of 2023, and the readings can then be displayed on the website. Calibration of the TS 300B sensor was carried out to determine the accuracy and precision of the sensor used, and finally, testing of sanitation hygiene water samples was carried out to determine the turbidity value of the sanitation hygiene water tested and to draw conclusions about the quality of the sanitation hygiene water tested. Testing and sampling of the prototype were carried out on three household sanitary water samples, namely House A, House B, and House C. Figure 3 shows the sampling of household sanitary water taken as samples. The sample testing was carried out by taking 30 data points taken from 30 different dips from each sample. Each sample was taken from a different location. then each sample was given a

turbidity value which was compared with the maximum permissible turbidity range based on the reference.

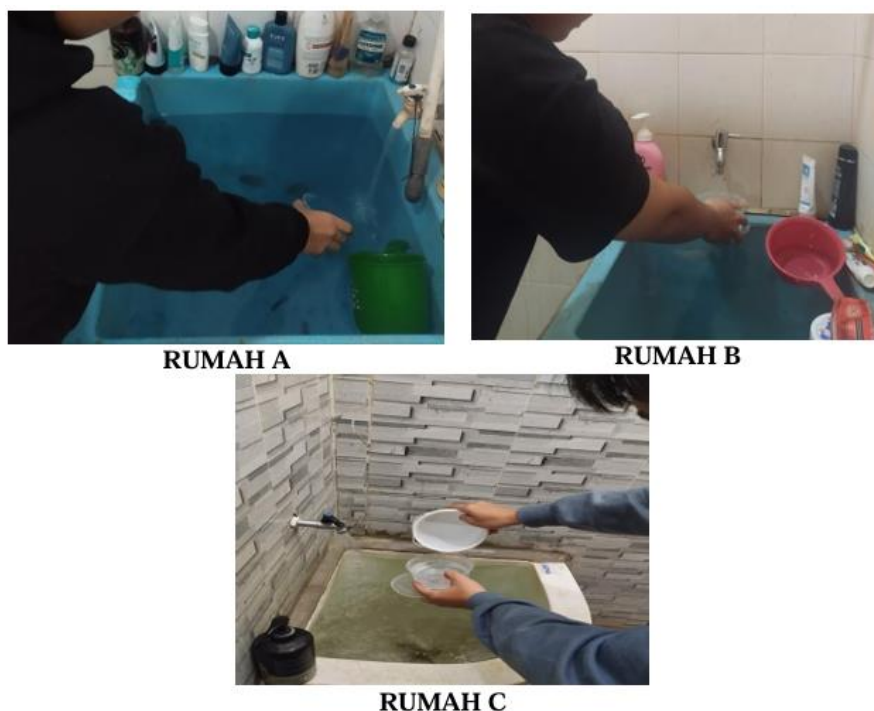


Figure 3. Collection of Water Samples for Household Sanitation Hygiene

Table 1 below shows the maximum turbidity limits for sanitary water in accordance with Minister of Health Regulation No. 2 of 2023.

Table 1. Maximum Range of Physical Parameters for Water Hygiene and Sanitation

Parameter	Permissible Maximum Level	Unit
Temperature	± 3	$^{\circ}\text{C}$
Turbidity	< 3	NTU
Total Dissolved Solid	< 300	mg/L
Color	10	TCU
Smell	odorless	-

RESULT

The design of the IoT-based water hygiene, sanitation, and turbidity monitoring prototype hardware can be seen in Figure 4. It consists of a component box, a component box cover, and a sensor container cover. These parts are intended to protect the interior of the prototype. The interior of the component contains sensitive components that can affect

the measurement results. Meanwhile, on the outside of the prototype, detection sensors and a display screen are installed to show the measurement results.



Figure 4. Prototype Form

For this prototype, the website display was created using the XAMPP application with Sublime Text as the text editor. On the website, there is a table that will display the turbidity measurement values, the status of the water being read, and a graphical display of the turbidity readings. Figure 5 shows the display of the website that was created.

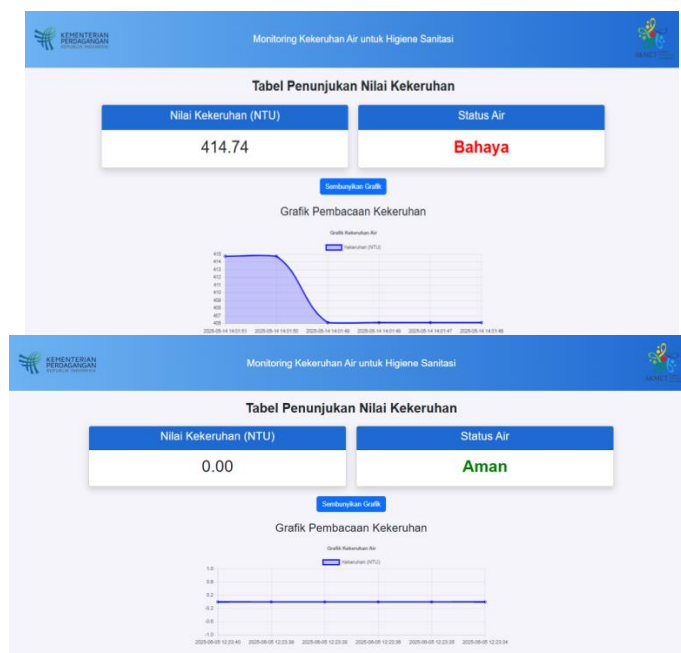


Figure 5. Testing Simulation On Website Display

However, specific applications such as use in sanitary hygiene water have not yet been explored. This prototype was developed to measure the turbidity levels of sanitary hygiene water in accordance with existing and applicable regulations, and to enable monitoring of sanitary hygiene water turbidity through a website display.

Sensor TS 300B Testing

The TS 300B sensor was tested by comparing with standard turbidity solutions of 10 NTU, 100 NTU, and 200 NTU. Table 2 shows the test results of the TS 300B turbidity sensor tested using test points of 10 NTU, 100 NTU, and 200 NTU. From the data, it is known that the largest error (%) value obtained is 0.35 at the 200 NTU test point, and the largest accuracy (%) is obtained at the 10 NTU test point, which is 100%.

Table 2. TS 300B Turbidity Sensor Test Results

Sensor TS 300B							
Standar (NTU)	Testing	Average (NTU)	Bias (NTU)	Standard of Deviation (NTU)	Error (%)	Accuracy (%)	Precision (%)
10.00	Up	10.00	0.00	0.00	0.00	100.00	100.00
	Down	10.00	0.00	0.00	0.00	100.00	100.00
100.00	Up	100.08	-0.08	0.11	0.27	99.73	99.66
	Down	100.18	-0.19	0.16	0.30	99.70	99.51
200.00	Up	200.02	-0.02	0.28	0.42	99.58	99.57
	Down	200.02	-0.02	0.30	0.43	99.57	99.56
Average					0.24	99.76	99.72

Source: Personal Document, 2025

Sanitation Water Sample Testing

This test was conducted using three sanitation water samples taken from several houses. Sample A was sanitation water from house A, sample B was sanitation water from house B, and sample C was sanitation water from house C. Figure 6 shows the sanitation water samples used.



Figure 6. Sanitation Water Samples

The turbidity of each sample was measured using a prototype, with 30 readings taken from each sample. From this data, the water quality status of each sample was determined using the 2023 Minister of Health Regulation No. 2 as a reference.

Table 3. Sanitation Hygiene Water Sample Test Results Data

Sample	Average Prototype Readings (NTU)	Water Status	Maximum Turbidity Level (NTU)
Sample A	1.11	Safe	< 3
Sample B	1.30	Safe	
Sample C	1.25	Safe	

Based on the data in Table 3, obtained from each test sample after reading the turbidity value and comparing it with the reference in Minister of Health Regulation No. 2 of 2023, where the maximum permissible turbidity parameter for sanitary water is below 3 NTU, it was found that all tested samples were still within the maximum range for turbidity values, meaning that the sanitary hygiene water was still safe for use. The highest turbidity value obtained from the prototype reading was found in sample B, with a turbidity value of 1.30 NTU. Sample B has a higher NTU value, presumably because the water sample was taken from a water tank that had not been used for several days.

DISCUSSION

The development of an Internet of Things (IoT)-based hygiene sanitation water turbidity monitoring prototype in this study demonstrates a practical and effective approach to real-time water quality monitoring. The integration of the TS 300B turbidity sensor with an IoT system enables continuous measurement of turbidity values and visualization through a web-based platform. This capability aligns with current trends in smart environmental monitoring, where IoT technology is increasingly utilized to improve accessibility, efficiency, and responsiveness in water quality management.

The turbidity measurements obtained from the prototype comply with the Indonesian Ministry of Health Regulation No. 2 of 2023, which establishes turbidity limits for hygiene and sanitation water. The recorded turbidity values for sanitation water samples (1.11 NTU, 1.30 NTU, and 1.25 NTU) were within acceptable thresholds, indicating that the prototype is suitable for monitoring household sanitation water quality. Turbidity is a critical physical parameter, as elevated turbidity is often associated with the presence of suspended particles that may harbor pathogenic microorganisms and reduce the effectiveness of disinfection processes.

The accuracy (99.76%) and precision (99.72%) of the TS 300B sensor observed in this study indicate a high level of measurement reliability. These results are consistent with previous studies reporting that optical turbidity sensors can provide accurate and stable measurements when properly calibrated. High sensor performance is essential to ensure that monitoring systems can reliably detect changes in water quality that may pose health risks to users.

One of the key strengths of this prototype is its low-cost and simplified design compared to commercially available turbidity monitoring devices. Cost-effective monitoring tools are particularly important for household and community-level applications, where access to laboratory-based water testing is often limited. By enabling direct use by the public,



this system supports community participation in maintaining water quality and aligns with preventive approaches in environmental health.

Furthermore, the web-based monitoring feature enhances usability by allowing users to access turbidity data remotely and in real time. This feature is consistent with the concept of smart sanitation systems, which aim to improve decision-making through timely and transparent data availability. The proposed future development of integrating alert notifications via buzzer or messaging applications such as WhatsApp or Telegram would further strengthen the system by enabling early warning when turbidity exceeds permissible limits, thereby supporting rapid corrective actions. Despite these advantages, this study has several limitations. The prototype focuses solely on turbidity as an indicator of water quality and does not include other important parameters such as pH, residual chlorine, or microbiological indicators. In addition, field testing was conducted on a limited number of samples, which may not fully represent variations in household water quality. Future research should expand the monitoring parameters, incorporate automated alert systems, and evaluate long-term performance under diverse environmental conditions. Overall, the findings of this study indicate that the developed IoT-based turbidity monitoring prototype has strong potential as an affordable and user-friendly tool for hygiene and sanitation water monitoring. Its implementation can contribute to improving household water quality surveillance and supporting public health protection through early detection of water quality deterioration.

CONCLUSION

The design and implementation of an IoT-based hygiene sanitation water turbidity monitoring prototype has been successfully designed, capable of integrating water turbidity measurements using the TS 300B sensor. This prototype is also capable of determining NTU values in accordance with the provisions of Ministry of Health Regulation No. 2 of 2023 and can display NTU readings and water status on a website, enabling water monitoring through the website. Test results show that the TS 300B sensor used in this prototype has an accuracy of 99.76% and a precision of 99.72%. The prototype can also be used to measure the turbidity of sanitary water. Test results on sanitation hygiene water samples showed 1.11 NTU in sample A, 1.30 NTU in sample B, and 1.25 NTU in sample C. This prototype is a low-cost and simplified version of similar devices available on the market. It is intended for direct use by the public to monitor the turbidity of water used for hygiene and sanitation in their homes. For further research and development, if turbidity exceeds the threshold, the system will send a notification via buzzer or WhatsApp/Telegram.

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