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IMPLEMENTATION OF THE INTERNET OF THINGS (IoT) IN MONITORING AND CONTROL OF WATER TURBIDITY LEVELS IN KOI FISH BREEDING POND

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ABSTRACT

Water quality management is a critical aspect of environmental monitoring and aquaculture, particularly in maintaining optimal conditions for aquatic organisms. One of the main parameters affecting water quality is turbidity, which can indicate pollution and excessive suspended particles. Recent developments in Internet of Things IoT technology provide opportunities to improve real-time monitoring and automatic control of water quality. Therefore, this study aims to design and implement an IoT-based water turbidity monitoring and control system to monitor turbidity levels and automatically regulate water conditions. The proposed system utilizes an ESP32 microcontroller integrated with a turbidity sensor, ultrasonic sensor, relay modules, and water pumps, while Node-RED is employed as the data processing and visualization platform. Data communication is carried out using the MQTT protocol, enabling real-time data transmission and monitoring through a graphical dashboard. In addition, Telegram notifications are implemented to promptly inform users when turbidity exceeds predefined thresholds. The research method includes system design, hardware and software integration, and performance testing under various turbidity conditions. The testing results show that the system is able to accurately measure water turbidity, transmit sensor data reliably, and display real-time monitoring graphs via Node-RED. Furthermore, the system successfully performs automatic control of drain and fill pumps based on detected turbidity levels. In conclusion, the developed IoT-based system effectively monitors water turbidity in real time, provides automatic notifications, and autonomously controls water circulation when turbidity becomes excessive. Future research may include the integration of additional water quality parameters, such as pH and temperature, ensuring sustainability globally.

INTRODUCTION

Water quality is a critical factor in aquaculture systems, particularly in koi fish cultivation, where environmental conditions directly affect fish health, growth, and survival. One of the most influential water quality parameters is turbidity, which represents the concentration of suspended particles in water. High turbidity levels can reduce dissolved oxygen, disrupt fish metabolism, damage gill function, and promote the growth of pathogenic microorganisms. In many traditional koi farming practices, turbidity monitoring is still performed manually through visual observation, which is subjective and often leads to delayed corrective actions.

Advances in Internet of Things (IoT) technology provide new opportunities for developing real-time, automated, and objective water quality monitoring systems. IoT enables the integration of sensors, microcontrollers, and communication protocols to continuously monitor environmental parameters and trigger automatic responses when abnormal conditions occur. Several studies have demonstrated the effectiveness of IoT-based systems for water quality monitoring; however, many implementations rely on short-range communication or lack automated control mechanisms.

Therefore, this research aims to develop an IoT-based system for real-time monitoring and automatic control of water turbidity in koi fish ponds. The system integrates an ESP32 microcontroller, turbidity sensor, ultrasonic sensor, LoRa communication, MQTT protocol, Node-RED dashboard, and Telegram notifications. The proposed system is expected to provide accurate turbidity monitoring, timely notifications, and autonomous pump control to maintain optimal water conditions.

LITERATURE REVIEW

Water turbidity is defined as the level of water clarity affected by suspended particles such as sediment, organic waste, plankton, and microorganisms. In koi fish cultivation, an ideal turbidity range is generally between 10–40 NTU, while values above 80 NTU are considered harmful. Prolonged exposure to high turbidity can lead to stress, reduced feeding activity, and increased disease susceptibility. Ikhsan Kamil, Ujang Dindin. (2024)

The Internet of Things (IoT) is a technology paradigm that enables physical devices equipped with sensors and actuators to communicate over a network without human intervention. Steinbach, D., & Higginbotham, B. (2022)

In aquaculture, IoT has been widely applied for monitoring parameters such as temperature, pH, dissolved oxygen, and turbidity. ESP32 is commonly used as an IoT microcontroller due to its processing capability, low power consumption, and communication support. Lohith et al. (2024)

LoRa technology is suitable for long-range, low-power communication in environmental monitoring systems. MQTT is a lightweight publish-subscribe protocol widely adopted in IoT applications, while Node-RED provides a visual programming environment for data processing and visualization. Telegram has also been utilized as a notification platform due to its reliability and ease of integration.

METHOD

This study was conducted through several stages, including system design, hardware and software implementation, and performance testing of the IoT-based water quality monitoring system using LoRa communication.

1. System Design The system consists of two main parts: the Node and the Gateway. The Node functions as a sensor unit placed in the pond, while the Gateway serves as the receiver and data processing center.
   - Node acts as the transmitter, consisting of a SEN0175 turbidity sensor and an ESP32 microcontroller as the main processor. The ESP32 collects and processes the sensor data, then transmits it via the LoRa E220-900T22D module to the gateway. An LED indicator is also included to provide the operational status of the node.

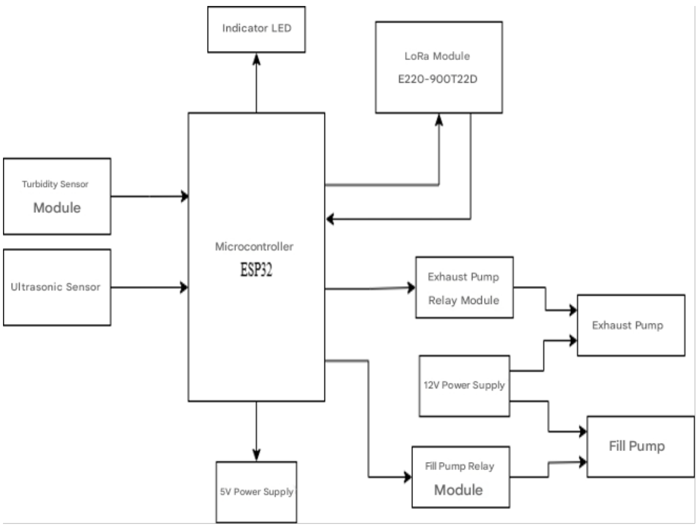

Fig. 1 Block Diagram Node

   - Gateway functions as the receiver and data processor. Data from the node are received by the LoRa module, processed by the ESP32, and forwarded to the Raspberry Pi. The Raspberry Pi runs Node-RED as the central data management platform, providing a real-time monitoring dashboard and sending automatic notifications via Telegram bot whenever the parameters exceed the defined thresholds. The gateway is also connected to a wireless access point (WAP), allowing users to access the dashboard from a laptop or smartphone.

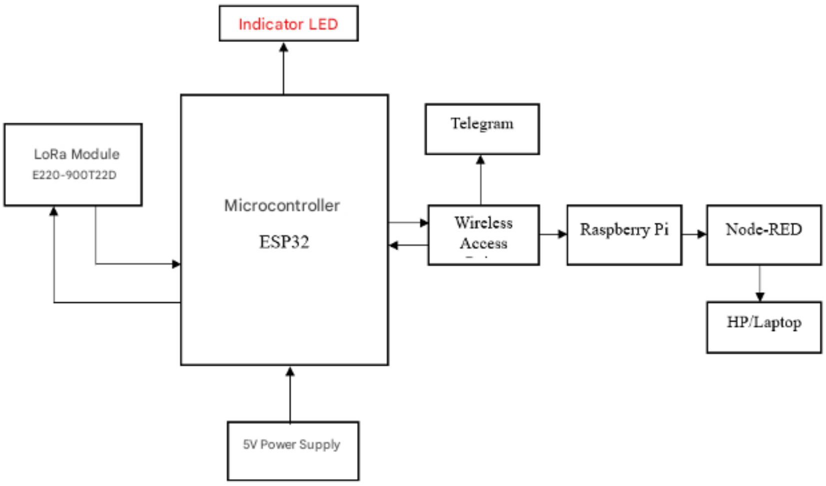

Fig. 2 Block Diagram Gateway

2. Flowchart

The system workflow begins at the node, which consists of an ESP32, a SEN0175 turbidity sensor, and a LoRa module. After initialization and power verification, the ESP32 reads the turbidity value, formats it into JSON, and sends the data to the gateway via LoRa. At the gateway, the data is received, parsed, validated, and then published to the MQTT broker with the topic "fish/monitoring." The broker distributes the data to all subscribers, including the Node-RED dashboard. Node-RED visualizes the data in real-time through graphs and indicators, comparing the values to predefined thresholds. If an abnormal condition is detected (e.g., very turbid water <600), an automatic alert is sent to the user via Telegram. This workflow integrates the node as the sensing and sending unit, the gateway as the receiver and publisher, the MQTT broker as the distributor, Node-RED as the visualization platform, and Telegram as the alert mechanism, ensuring efficient, real-time, and responsive monitoring of koi pond water quality.

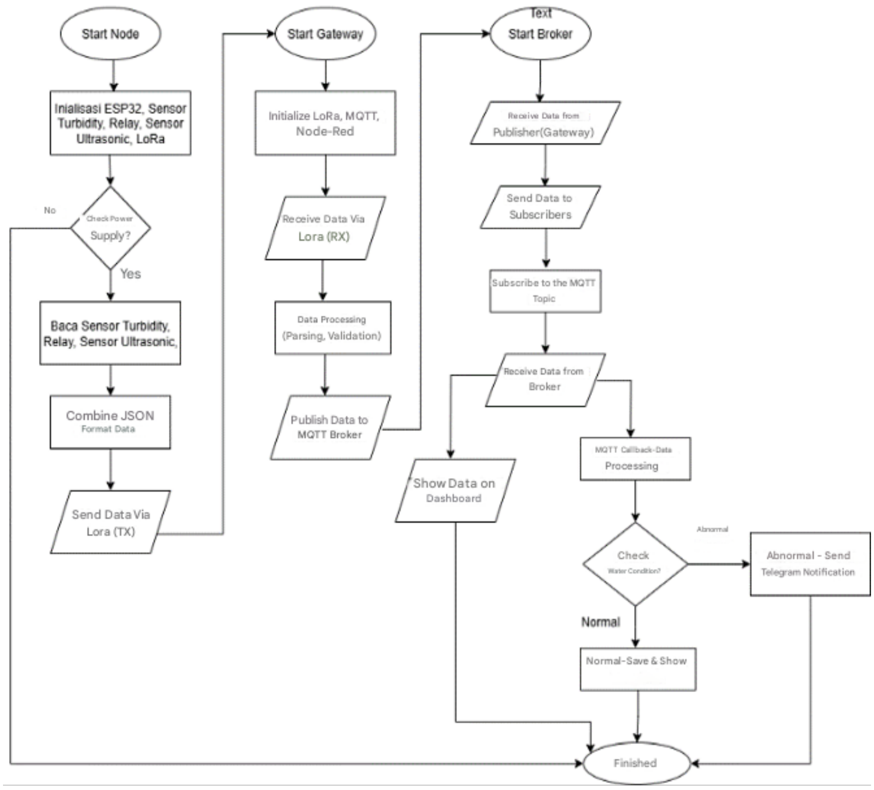

Fig. 3 Flowchart

RESULT

The hardware design phase is a crucial part of developing an IoT-based water quality monitoring system using LoRa technology. This design focuses on optimizing the integration of sensor nodes, gateways, power supplies, and solar panels to ensure continuous operation in outdoor environments. The nodes, consisting of turbidity sensors, transmit real-time data to the gateway via LoRa communication. The gateway then processes and forwards the data to a server for dashboard visualization and Telegram notifications. As shown in Figure 3.5, the hardware design depicts the complete system configuration, including the placement of nodes in the pond, gateways, batteries, and solar panels, ensuring reliable water turbidity monitoring with minimal manual intervention.

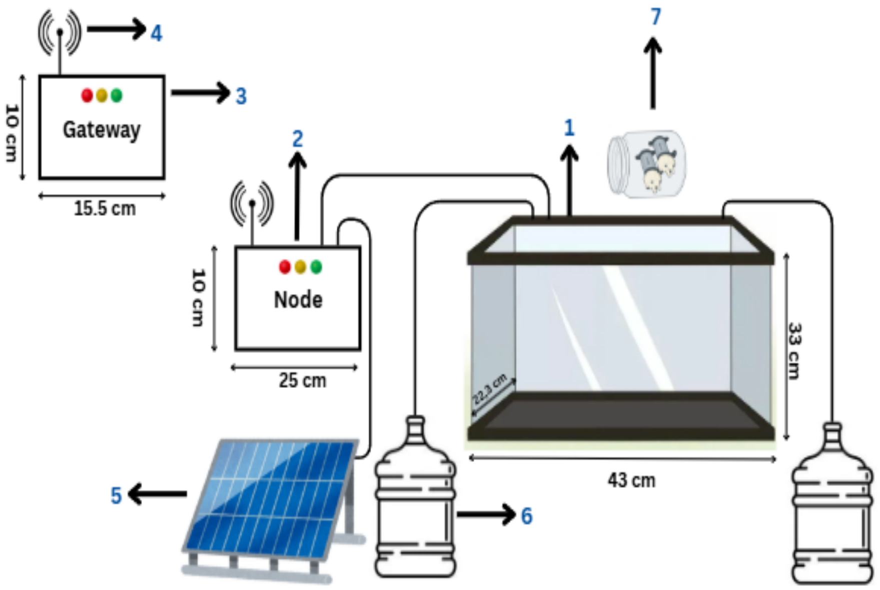

Fig. 4 Mechanical Design

The experimental results of the IoT-based water turbidity monitoring system using LoRa communication are summarized as follows

Table 1 Turbidity Sensor Data Transmission Test Results

NO	Time	Turbidity Value (NTU)	Turbidity Status	Drain Pump Status	Status of the Filling Pump	Telegram
1	13.05	682.09	The sensor detects no water.	OFF	OFF	None
2	13.08	681.20	The sensor detects no water.	OFF	OFF	None
3	13.11	684.78	The sensor detects no water.	OFF	OFF	None
4	13.14	1004.44	Clean Water	OFF	OFF	None
5	13.15	1008.91	Clean Water	OFF	OFF	None
6	13.19	924.75	Clean Water	OFF	OFF	None

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7	12.31	590.76	Murky Water	ON	OFF	WARNING! Abnormal water conditions
8	12.31	573.75	Murky Water	ON	OFF	WARNING! Abnormal water conditions
9	12.32	582.70	Murky Water	ON	OFF	WARNING! Abnormal water conditions

As shown in Table 4.1, the SEN 0175 Turbidity sensor successfully transmitted turbidity data that showed a significant difference compared to the theoretical value. Where the value should be clear water has an NTU value ranging from 10–40 NTU, while turbid water is in the range of >80 NTU. However, the sensor measurement results showed significantly different values, namely 900–1200 NTU in clear water conditions and 600 NTU in turbid water conditions. This difference can be caused by sensor voltage instability or signal interference on the microcontroller analog pin which causes the reading results to be inaccurate.

Fig. 5 Turbidity Sensor Testing for Telegram Notifications

The integration with Telegram was tested by simulating abnormal conditions. When the turbidity reached 590.76 NTU, the system automatically sent a recurring alert, such as "WARNING! Abnormal water conditions" to the user's Telegram account.

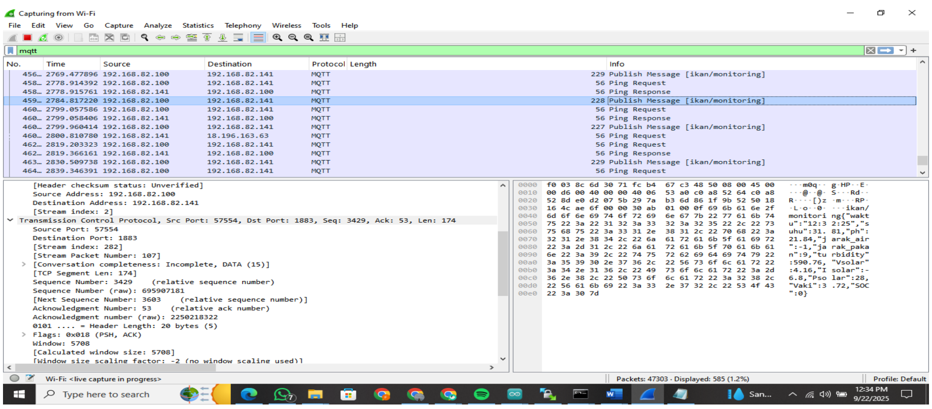

Fig. 6 Data Capture Using Wireshark

Wireshark analysis confirms that sensor data is transmitted from the node to the gateway and forwarded to the MQTT broker. Captured packets show the connection, subscription, publishing, and ping processes. The data payload is transmitted in JSON format, containing opacity values identical to the sensor readings. The observed sequence of Subscription Requests before Publish Messages is consistent with the MQTT protocol rules, where subscribers must register before receiving published data.

In conclusion, the research results show that this system is capable of monitoring water turbidity in real-time, transmitting data reliably via LoRa, visualizing it on a dashboard, and sending notifications via Telegram effectively.

DISCUSSION

The results indicate that the proposed IoT-based system effectively addresses the limitations of manual turbidity monitoring. Real-time data transmission and visualization allow users to monitor pond conditions remotely. The integration of automatic control reduces response time and human dependency, which is crucial for maintaining stable water quality.

Compared to conventional monitoring methods, this system provides objective measurements and continuous operation. The use of LoRa enhances communication reliability for ponds located far from control centers. However, the system currently focuses only on turbidity and water level parameters.

CONCLUSION

Based on the result and analysis, it can be concluded that:

1. The turbidity sensor installed on the ESP32 is capable of detecting the level of water clarity or turbidity by reading the NTU value. The reading results are then categorized into several conditions: no water/not submerged, clear water, moderately turbid water, and very turbid water. This data is not only displayed via the serial monitor but also sent to the MQTT broker and visualized on the Node-RED dashboard, so users can monitor water conditions directly in an easier and more informative way.
2. Data from the turbidity sensor is successfully sent via MQTT to Node-RED and displayed as a gauge and historical graph, making it easier to analyze changes in water quality over time. Furthermore, the system is equipped with a Telegram notification feature that automatically alerts when the water is very turbid. With this integration, users no longer need to perform continuous manual checks; instead, they can simply monitor the data through an internet-connected device.
3. If the sensor reading indicates very cloudy water, the ESP32 automatically activates a relay to turn on the drain and fill pumps in the specified sequence. This water draining and filling process can occur without direct user intervention, but can still be monitored via the Node-RED dashboard and Telegram notifications. Thus, this system has proven that IoT-based monitoring and control can help maintain water quality more practically and efficiently.

REFERENCES

Abd Halim, I. H., Mahamad, A. I., & Mohd Fuzi, M. F. (2021). Automated Alert System for River Water Level and Water Quality Assessment using *Telegram* Bot API. *Journal of Computer Research and Innovation*, 6(3), 65–74. doi: 10.24191/jcrinn.v6i3.234.

Atmoko, R. A., Riantini, R., & Hasin, M. K. (2021). IoT real time data acquisition using MQTT protocol. *Journal of Physics: Conference Series*, 853(1). doi: 10.1088/1742-6596/853/1/012003.

Bakar, A. A. A., Bakar, Z. A., Yusoff, Z. M., Ibrahim, M. J. M., Mokhtar, N. A., & Zaiton, S. N. (2025). IoT-Based *Real-time* Water Quality Monitoring and Sensor Calibration for Enhanced Accuracy and Reliability. *International Journal of Interactive Mobile Technologies*, 19(1), 155–170. doi: 10.3991/ijim.v19i01.51101.

Cumming, S., & Branch, P. (2023). A LoRa-Based Monitoring System for Agriculture. *2023 33rd International Telecommunication Networks and Applications Conference (ITNAC)*, 196–203. doi: 10.1109/ITNAC59571.2023.10368491.

Ekene, S., et al. (2024). 619603182. *Vol. 8, No. 5.*

Fitriadi, R., Palupi, M., Sanudra, S. R., Putra, J. J., & Azril, M. (2024). Application of Microbubble Technology to Increase Oxygen Content in the Aquaculture of Tambaqui (Colossoma macropomum). Journal of Aquaculture and Fish Health, 13(3), 328–339. https://doi.org/10.20473/jafh.v13i3.43381

Gani, M. N., Hanifatunnisa, R., Hasanah, R., Yamin, M., & Rohman, D. S. (2024). Pemantauan kualitas air berbasis teknologi *LoRa* dengan metode Naïve Bayes. *JITEL (Jurnal Ilmiah Telekomunikasi, Elektronika, dan Listrik Tenaga)*, 4(2), 145–154. doi: 10.35313/jitel.v4.i2.2024.145-154.

Hendri. (2023). Optimisasi Pembelajaran Online di MTS Al Falah menggunakan Node.js Express dan MongoDB. *J. Processor*, 18(2), 136–143. doi: 10.33998/processor.2023.18.2.831.

HORIBA. (2024). *Water Quality Measurement in Aquaculture and Fish Farming*. HORIBA Scientific Application Note. Retrieved from https://www.horiba.com/int/water-quality-measurement-in-aquaculture-and-fish-farming

Ikhsan Kamil, & Ujang Dindin. (2024). Kualitas Air Budidaya Ikan Koi (Cyprinus Rubrofuscus) pada Sistem Vertiqua Menggunakan Filter Biofikal Atas. Habitat (Jurnal Asrihindo). Diunduh dari https://journal.asrihindo.or.id/index.php/Habitat/article/download/61/112/298

Jamlos, M. A., Subramaniam, S., Mustafa, W. A., & Idrus, S. Z. S. (2023). Water quality monitoring system using Raspberry Pi. *AIP Conference Proceedings*, 2608, 82–96. doi: 10.1063/5.0129035.

Jonnalagadda, S. (2021). Introduction to TCP/IP Protocol Suite.

K. SaThierbach et al., "No 主観的健康感を中心とした在宅高齢者における 健康関連指標に関する共分散構造分析Title," Proc. Natl. Acad. Sci., vol. 3, no. 1, pp. 1–15, 2021, [Online]. Available: http://dx.doi.org/10.1016/j.bpj.2021.06.056%0Ahttps://academic.oup.com/bioinformatics/article-abstract/34/13/2201/4852827%0Ainternal-pdf://semisupervised-3254828305/semisupervised.ppt%0Ahttp://dx.doi.org/10.1016/j.str.2013.02.005%0Ahttp://dx.doi.org/10.10

Kori, D. N., & R, R. (2022). Measuring Water Quality using Arduino and *Turbidity* Sensor. *International Journal of Computer Applications*, 184(36), 1–4. doi: 10.5120/ijca2022922450.

Kumar, R. (2023). An Overview of Computer Networking As an Introduction. *A Peer-Reviewed Journal About*, 5(32). Available: https://www.researchgate.net/publication/372108480_An_Overview_of_Computer_Networking_As_an_Introduction.

Light, R. A. (2022). Mosquitto: server and client implementation of the MQTT protocol. *Journal of Open Source Software*, 2(13), 265. doi: 10.21105/joss.00265.

Lohith, H., & Science, I. (2024). A Review of Modern Computer Networking Technologies, 4, 1844–1851.

Lu, X., Zhu, J., Long, T., & Xiong, J. (2024). Application of Single Chip Microcomputer in Smart Home Products. *Journal of Computer Electronics and Information Management*, 15(2), 23–26. doi: 10.54097/c4qk7q43.

Mulyono, S., Qomaruddin, M., & Anwar, M. (2021). Anwar, MS. *Jurnal Transistor Elektro dan Informatika (TRANSISTOR EI)*, 3(1), 31–44.

Nadia Wartingrum, dkk. (2023). Implementasi Sistem Monitoring Kualitas Air Berbasis *LoRa* pada Tambak Nila. *e-Proceeding of Applied Science*, 9(3), 1029.

Nurhayati, D., Hastuti, S., & Dwiastuti, S. A. (2022). Performa Reproduksi Ikan Koi (Cyprinus Carpio) dengan Strain Berbeda. *Sains Akuakultur Tropika*, 6(1), 96–106. doi: 10.14710/sat.v6i1.13009.

R. A. Elektro, J. T., Jakarta, P. N., Siwabessy, J. P., & Beji, K. (2022). Desain Sistem Monitoring Cerdas Kualitas Air, 24(1), 28–39.

Shekhar, C., anon, anon, anon, & anon. (2025). *International Journal of Research Publication and Reviews*. SSRN Electronic Journal, 6, 16338–16347. doi: 10.2139/ssrn.5134717.

Steinbach, D., & Higginbotham, B. (2022). Clearing Muddy Ponds, 1–7.

Sukarno, S. A., Maulana, G. G., & Andrea, F. (2024). MITOR: Jurnal Teknik Elektro.

Taufik, A., & Fadlil, A. (2023). Sistem Monitoring pH dan Kekeruhan Kolam ikan Koi Berbasis *Internet Of Things* Menggunakan Aplikasi Blynk. *Jurnal Teknologi Elektro*, 14(1), 56. doi: 10.22441/jte.2023.v14i1.010.

USEPA. (2021). Factsheet on water quality parameters: *Turbidity*. *Factsheet Water Quality Parameters*, 2008, 1–3.

Wagyana, A., & Widhiantoro, D. (2021). Rancang Bangun Dashboard Untuk Prototipe Modul Latih *Internet Of Things* Berbasis Flow-Based Programming. *Prosiding Seminar Nasional Penelitian dan Pengabdian Pada Masyarakat*, 149–154.

Yustian, G. Y. (2022). Kontrol otomatis kekeruhan, suhu, dan pH air aquascape menggunakan metode fuzzy logic. *Universitas Negeri Malang*, 19(1).

Zhang, S. (2024). The Importance of Computer Network Applications and Security. *Journal of Computer Electronic Information Management*, 12(3), 55–58. doi: 10.54097/3fu2t2ft.

"Gambar LoRa". [Online]. Available: https://images.app.goo.gl/Yti4pmRUWtzmdCzL7

"Gambar Raspberry Pi". [Online]. Available: https://images.app.goo.gl/qE4QgRgDf9n9A4Ge6

"Gambar sensor *turbidity*". [Online]. Available: https://images.app.goo.gl/uqwtbsJzEzEEgkSe6

"Gambar sensor ultrasonic". [Online]. Available: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.tokopedia.com%2Fnn-digital%2Fhc-sr04-hc-sr04-sensor-ultrasonic...

"Lapisan TCP/IP". [Online]. Available: https://www.cloudcomputing.id/pengetahuan-dasar/mengenal-tcp-ip

"No Title". [Online]. Available: https://docif.telkomuniversity.ac.id/apa-itu-iot/

"Pompa Air". [Online]. Available: https://images.app.goo.gl/MfJgpURnZqQz7c346

"*Relay* 2 Channel". [Online]. Available: https://www.blibli.com/p/5v-12v-relay-module-2-channel-low-level-trigger...

"UNIT 1 - Arduino Programming for IoT Boards - SCSA1407".