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Classification of water quality based on dissolved solids and turbidity parameters with the utilization of total dissolved solids sensor and turbidity sensor

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ABSTRACT

Clean water quality is essential for public health, but its scarcity is increasing amid population growth and industrialization. Monitoring turbidity and total dissolved solids (TDS) is essential to determine the quality of clean water. This study addresses the urgent need for accurate and reliable water quality monitoring to test the applicability of TDS and turbidity sensors in taking measurements, aiming to develop efficient monitoring solutions for public health and sustainable water management. The TDS sensor operates according to the principle of electrical conductivity, with a range of 0 to 1000 ppm and an accuracy of ±10%. The turbidity sensor detects water turbidity by determining the level of turbidity particles. The ESP32 microcontroller integrates Wi-Fi and USB capabilities. The hardware and software design ensures accurate sensor readings, which are critical to successful water quality measurement and monitoring. The test results show satisfactory accuracy of the TDS sensor with an average error of 0.09% and good accuracy of the turbidity sensor with an average error of about 1.536%. Concerning the above two parameters, in this study, among 15 water samples, seven were clean, meeting the standard, while eight water samples were dirty, exceeding the limit, making them unsafe for human consumption.

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1. INTRODUCTION

Clean water quality has become an increasingly urgent and vital public health issue in the context of population growth and growing industrial activity. The limitations of clean water resources are becoming more pronounced and keeping water clean is becoming increasingly complex. Polluted water can cause a number of serious health problems for humans, such as aquatic and infectious diseases [1]. Therefore, maintaining a sustainable supply of clean water is a key aspect of maintaining general public health. Ensuring the sustainability of clean water supply is a crucial aspect in maintaining overall public health [2]. The increasing scarcity of clean water resources underscores the importance of understanding, monitoring, and improving the quality of water accessible to the public. An optimal level of public health can be achieved by easy access to safe and clean water free from contaminants potentially harmful contaminants for human health [3].

To determine whether the quality of the water is good for use, there are several important aspects that need to be checked, namely crucial parameters in clean water [4]. The content of these parameters greatly influences whether the water quality is clean or not. Parameters include turbidity levels, total dissolved solids (TDS), pH, heavy metal content, and presence of organic and inorganic contaminants [5]. The level indicates the clarity of water influenced by suspended particles such as clay, silt, or other organic matter [6]. Total dissolved solids (TDS) indicates the amount of dissolved material in the water, such as mineral salts, metals, cations, or anions [7]. The acidity (pH) of water is also an important factor, as water with too low or too high a pH can be corrosive and hazardous to health [8]. The presence of heavy metals and other organic and inorganic contaminants should also be monitored as they have the potential to cause adverse side effects. By regularly and consistently monitoring these parameters, water quality can be guaranteed to be safe for use [9].

Among the various parameters of water quality, turbidity and total dissolved solids (TDS) are two crucial indicators that can provide valuable information on water quality [10]. Turbidity refers to the cloudiness or haziness of water caused by suspended particles, such as sediments, organic matter, or microorganisms [11]. High levels of turbidity can reduce the effectiveness of water treatment processes, harbor pathogens, and negatively impact aquatic life [12]. On the other hand, TDS represents the concentration of dissolved ions and minerals in water, which can affect its taste, conductivity, and suitability for various applications [13].

Darwito et al. (2019) investigated the lack of access to clean water in Sinan Village, Karangbinnangun, Lamongan, East Java. The study revealed that the villagers, who currently depend on the Bengawan Solo River water mixed with pond water, are exposed to water quality that does not meet WHO and Ministry of Health standards. In response, the researchers proposed a promising clean water treatment system with two stages: precipitation with alum and filtration with stone, sand, charcoal, and palm fiber. Variation in the volume of sand in filtration was found to significantly affect the TDS, turbidity, and pH levels of the clean water produced, indicating the potential of this solution [9]. Mohammed & Massour El Aoud (2021) identified two main issues, degradation of water resources and lack of efficiency in real-time water quality monitoring using conventional techniques. To address these issues, researchers developed a real-time water quality monitoring system with wireless sensor technology and the Internet of Things (IoT), and applied the Naïve Bayes classification algorithm for sensor data analysis. The advantages of this research are the accurate and efficient implementation in water quality monitoring, with the potential for real-time applications to improve response. However, drawbacks include difficulties in real-time decision making, potential unemployment due to automation, significant data loss, and low prototype capacity [14].

This research addresses the critical problem of accurately and reliably monitoring water quality, specifically the levels of turbidity and dissolved solids, which are essential for ensuring safe and sustainable water resources. To address this issue, the study analyzes the effectiveness of using total dissolve solids (TDS) and turbidity sensors for water quality classification by investigating the precision and reliability of these sensors in detecting and quantifying the turbidity level and dissolved solid content in water samples, and to test their applicability in taking precise measurements. It also explored the potential of integrating these sensors into a comprehensive water quality monitoring system. The emphasis on the potential of this research inspires the audience about future possibilities and advancements in water quality monitoring [15]. Using the capabilities of TDS and turbidity sensors, this research is a significant step toward the development of efficient and cost-effective water quality monitoring solutions [16]. The accurate and timely assessment of water quality, as facilitated by these sensors, is not just a theoretical concept, but a practical necessity. Emphasizing the practical necessity of this research makes the audience feel the relevance and applicability of the findings, ensuring sustainable management of water resources, and supporting various industrial processes.

2. METHOD

The main stages of the approach used in this study are as follows. First, a multidisciplinary literature survey on water quality measurement methods, considering sensor analysis, health standards, and measurement technologies [17]. The use of existing theories, methods and approaches, as well as their resulting factors and meanings, was revealed through the literature review [18]. Ultimately, this evaluation stage generated a large number of ideas, interpretations, and concepts regarding the use of TDS and turbidity sensors in water quality monitoring. This research tested the accuracy of the TDS and turbidity sensors using an experimental method.

In the first stage of this investigation, a literature review was conducted. The literature used in this research consists of several previous studies, including Darwito et al. (2019) who addressed clean water access issues in Sinan Village, proposing a treatment system that involves alum precipitation and filtration with sand, charcoal, and palm fiber, significantly affecting TDS, turbidity, and pH levels [9]. Mohammed & Massour El Aoud (2021) developed a real-time water quality monitoring system using wireless sensors and IoT, employing the Naïve Bayes classification algorithm. The study highlighted the efficiency of real-time applications but noted challenges in decision making and data loss [14]. The TDS sensor operates based on electrical conductivity, measuring ion particles in the liquid. It has a measurement range of 0-1000 ppm with ±10% accuracy at 25 ° C, which requires 3.3-5.5 volts input voltage and 3-6 milliamperes operating current [19]. The turbidity sensor detects levels of water turbidity based on the presence of particles, changing the output voltage with increasing turbidity [20]. The ESP32 module, designed with Wi-Fi capabilities, includes a micro USB port for power and programming, making it a comprehensive solution for projects that require internet connectivity [21], [22].

Second, this research used an experimental approach to test the accuracy of Total Dissolved Solids (TDS) and Turbidity sensors in measuring water quality. The test was carried out by taking water samples from various sources, including pond water, coffee solution, Aqua brand drinking water, PDAM water from several regions, and catfish pond water. Each sample was tested using TDS and turbidity sensors and standard measuring devices (TDS and turbidity meter) to compare the results. The data obtained from both methods were processed to calculate the relative error rate and evaluate the accuracy of the sensors [23]. Furthermore, the method also includes water quality classification based on TDS and turbidity parameters, according to the standards set in health regulations. This test provides a deeper understanding of the performance of TDS and turbidity sensors when used together to measure water quality.

The explanation of the operating process of a hardware system encompasses the part that elucidates how the system functions. To facilitate understanding of the system's overall operation, a flowchart is commonly generated to depict the sequence of steps. Presented in the following is a flow chart delineating the operational principle of the system, from the beginning to the end. It serves as a graphical representation of the system's operational steps.

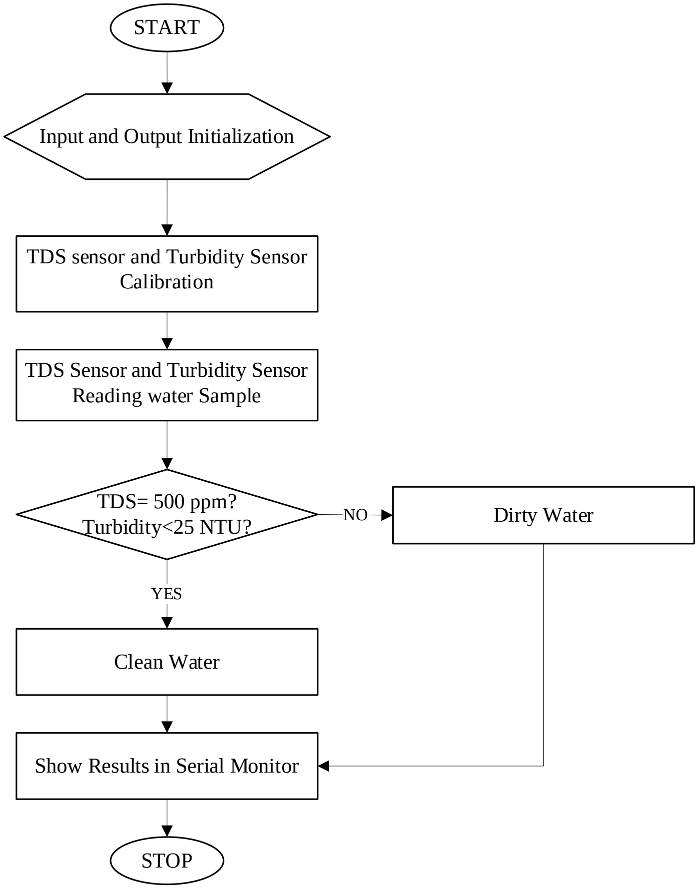

Figure 7. Flowchart of system

Figure 7 is a flow chart of the system. The system starts with the input and output initialization process; then sensor calibration is performed. After calibration, the sensor is inserted into the water sample and then the sensor will read the sample. On the basis of the sample reading, if the TDS value is less than 500 ppm and the turbidity is less than 5 NTU, the water will be classified as clean water. However, if the values exceed these conditions, the water will be classified as dirty water. The classification results will be displayed on the serial monitor, and then the system will stop.

3. RESULTS AND DISCUSSIONS

The quality of clean water can be affected by various parameters contained in it. There are many parameters that can be used to measure water cleanliness. In this study, the researchers used two mandatory parameters to classify the water as clean or dirty. The mandatory clean water parameters used in this study are total dissolved solids (TDS) and turbidity. The regulation used is the Regulation of the Minister of Health of the Republic of Indonesia number 492 of 2010 concerning drinking water. In this study, the clean water in question is water that is suitable for consumption, but must also go through several stages. The following is a table of limit values for TDS and turbidity according to the Regulation of the Minister of Health of the Republic of Indonesia number 492 of 2010.

Table 1. Water quality parameters based on The Regulation of The Minister of Health Of The Republic of Indonesia number 492 of 2010

Water Parameters	**Unit**	**Maximum Allowable Level**
TDS	ppm	500
Turbidity	NTU	5

The total dissolved solid (TDS) sensor is used to measure water quality parameters in the form of dissolved solids. This sensor will be connected to the microcontroller to detect the value of the dissolved solids that will be read in water. In testing the TDS sensor, tests were carried out using various types of water, including pond water, PDAM water from the Sukolilo Park Regency housing area, coffee solution, Aqua brand drinking water, and also catfish pond water.

Figure 1. Sample water type for TDS sensor testing

To test the accuracy of the TDS sensor, it is necessary to compare it with a general instrument or measuring instrument that complies with the standard, namely the TDS meter. In this study, the authors conducted a sample test using a TDS meter, where the same sample will also be used to test the validity of the sensor. The following are the results of the sample testing documentation of the value of dissolved solids.

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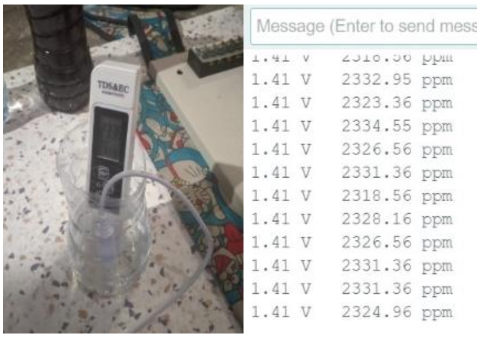

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1.41 V   2332.95 ppm
1.41 V   2323.36 ppm
1.41 V   2334.55 ppm
1.41 V   2326.56 ppm
1.41 V   2331.36 ppm
1.41 V   2318.56 ppm
1.41 V   2328.16 ppm
1.41 V   2326.56 ppm
1.41 V   2331.36 ppm
1.41 V   2331.36 ppm
1.41 V   2324.96 ppm
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Figure 2.TDS meter measurement results and sensor measurements

After testing the sample and taking sensor data, a comparison of the test results on the TDS meter measuring instrument with the TDS sensor can be obtained. A detailed explanation can be seen in the following table by calculating the average percent error as a comparison of the accuracy of the values that have been obtained.

Table 2. Comparison of results on TDS meter and TDS sensor readings

Water Type	TDS meter (ppm)	TDS Sensor (ppm)	Error (%)	Average error (%)
Pool Water	2329	2332.95	0.002	0.002
	2329	2323.36	0.002	
	2329	2334.55	0.002	
	2329	2318.56	0.004	
	2329	2326.56	0.001	
PDAM Water Sukolilo Park Regency residential area	410	409,11	0.002	0.01
	410	406,14	0.01	
	410	406,14	0.01	
	410	407,13	0.01	
	410	407,13	0.01	
Coffee Solution Water	2468	2485.15	0.007	0.004
	2468	2475.97	0.003	
	2468	2469.08	0.000	
	2468	2485.15	0.007	
	2468	2475.97	0.003	
Aqua Drinking Water	332	334.2	0.01	0.01
	332	334.2	0.01	
	332	329.61	0.01	
	332	329.61	0.01	
	332	329.61	0.01	
PDAM water for Gebang Kidul area	413	594.38	0.44	0.44
	413	591.94	0.43	
	413	596.82	0.45	
	413	589.51	0.43	
	413	596.82	0.45	
Total Average Error				0.09

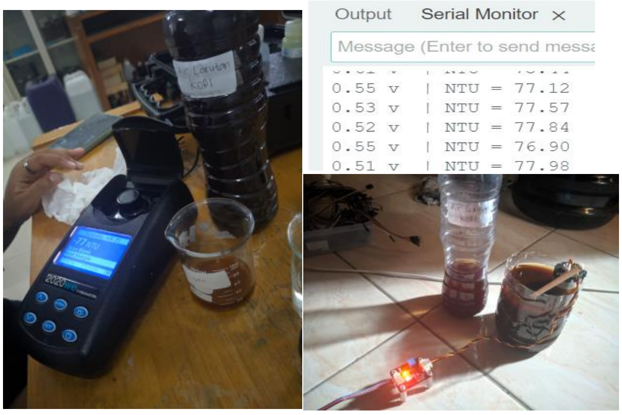
From the comparison results in Table 2, it is concluded that there is no significant difference between the reading of the TDS meter and the TDS sensor measurement of the variation in the total dissolved solids content in water. After a series of tests, it can be concluded that the TDS sensor exhibits a satisfactory level of accuracy, with a relatively small average error rate of approximately 0.09%.

Sensor Turbidity Testing

The turbidity sensor is used to measure water quality parameters in the form of turbidity. This sensor will be connected to the microcontroller to detect the turbidity value that will be read in the water. In the process of testing this sensor, five different types of water were used to test the reliability and performance of the sensor. The types of water used include pond water, coffee water solution, Aqua brand drinking water, PDAM water from the Gebang Kidul area, and catfish pond water. The following is a list of samples that have been used in the test.

Figure 3. Type of water sample for turbidity sensor testing

Testing the accuracy of turbidity sensors requires a comparison with standard calibrated instruments, such as turbidity meters. In this study, the authors conducted a sample test at the Waste Treatment Laboratory. This test aimed to ensure that the turbidity sensor used was capable of providing accurate and valid results. The same sample was tested using a turbidity meter and a turbidity sensor to obtain comparable data. The results of this test would demonstrate how well the turbidity sensor could measure turbidity levels compared to standard measuring instruments.



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0.55 v   | NTU = 77.12
0.53 v   | NTU = 77.57
0.52 v   | NTU = 77.84
0.55 v   | NTU = 76.90
0.51 v   | NTU = 77.98
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Figure 4. Turbidity sensor test

After testing the sample and taking sensor data, a comparison of the test results on laboratory measuring instruments with the sensors could be obtained. The sensor value was taken once every minute for 5 minutes. A detailed explanation can be seen in the table below by calculating the average percent error as a comparison of the accuracy of the values that had been obtained.

Table 3. Comparison of results on turbidity meter and turbidity sensor readings

Water Sample	Turbidity Meter (NTU)	Turbidity sensor(NTU)	Error(%)	Average error(%)
Pond Water	1.65	0.66	0.6	0.6
	1.65	0.66	0.6	
	1.65	0.66	0.6	
	1.65	0.66	0.6	
	1.65	0.66	0.6	
Coffee Solution Water	77	77.12	0.002	0.01
	77	77.57	0.007	
	77	77.84	0.011	
	77	76.9	0.001	
	77	77.98	0.013	
Aqua Drinking Water	0.02	0.16	7	7
	0.02	0.16	7	

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	0.02	0.16	7	
	0.02	0.16	7	
	0.02	0.16	7	
PDAM water for Gebang Kidul area	0.31	0.3	0.032	0.032
	0.31	0.3	0.032	
	0.31	0.3	0.032	
	0.31	0.3	0.032	
	0.31	0.3	0.032	
Catfish pond water	29.2	27.54	0.06	0.176
	29.2	22.15	0.24	
	29.2	20.49	0.30	
	29.2	23.66	0.19	
	29.2	26.42	0.10	
	Error rata-rata			1.563

From the data recorded in Table 3, it can be concluded that some samples have insignificant difference values, but there are also significant sample difference values, namely aqua drinking water. The turbidity meter reads 0.02 NTU, while the sensor reads 0.16. After a series of trials, it can be concluded that the turbidity sensor shows a satisfactory level of accuracy, with a relatively small average error rate of around 1.536%.

Water Quality Classification Results

Water quality testing involves careful measurement of 15 water samples, focusing on total dissolved solids measured in parts per million (PPM) and turbidity in NTU. According to clean water quality standards, water must have a dissolved solids value below 500 PPM and a turbidity of less than 25 NTU to be considered clean. If a sample does not meet these criteria, it is classified as impure and considered unfit for human consumption. In addition to dissolved solids, turbidity is also assessed as an additional indicator of water quality during this process. The test results are essential for assessing the safety and suitability of water for human consumption, and serve as the basis for implementing corrective actions to maintain water quality at acceptable levels.

Table 4. Water quality classification results

Water Type	TDS Sensor	Turbidity Sensor	Water Quality
Unbranded mineral water	276	0.42	Clean Water
Aquades	25	0.33	Clean Water
well water	174	0.44	Clean Water
PDAM water	120	1.54	Clean Water
Aqua water	100	0.31	Clean Water
Le mineral water	100	0.31	Clean Water
Water	85	2.44	Clean Water
Rice field water 1	434	19.03	Dirty Water
Rice field water 2	354	15.67	Dirty Water
Rice field water 3	362	16.23	Dirty Water
Rice Field Water 4	321	11.56	Dirty Water
pond water	657	87.33	Dirty Water
Catfish pond water 1	568	65.34	Dirty Water
Catfish pond water 2	322	15.12	Dirty Water
Catfish pond water 3	587	67.87	Dirty Water

Based on the water quality testing in Table 4, of 15 samples tested, 7 were classified as clean water and 8 as dirty water. The samples classified as clean water included unbranded mineral water, distilled water, well water, PDAM water, Aqua water, Le mineral water and water. These samples met the standards for total dissolved solids and turbidity, making them suitable for human consumption. However, samples categorized as dirty water included rice field water 1, rice field water 2, rice field water 3, rice field water 4, pond water, catfish pond water 1, catfish pond water 2, and catfish pond water 3. These samples exceeded the established limits for total dissolved solids and turbidity, rendering them unsuitable for human consumption. This testing provides important information on the safety and suitability of water for consumption needs and serves as a basis for the corrective actions to maintain water quality.

4. CONCLUSION

Based on the test results of the Total Dissolved Solids (TDS) sensor and the turbidity sensor, this study found that the TDS sensor achieved a satisfactory level of accuracy with an average error of 0.09%, while the turbidity sensor also showed good accuracy with an average error of about 1.536%. When used for water monitoring, these sensors effectively classify water samples into clean and polluted categories, which is very important for assessing water safety. Clean water samples meet the standards for total dissolved solids and turbidity, including unbranded mineral water, distilled water, well water, PDAM water, Aqua water, Le Mineral water, and water. Polluted water samples, such as paddy field water and catfish pond water, exceeded these limits, making them unfit for human consumption. These findings underscore the importance of accurate monitoring of water quality and suggest implementing corrective measures to maintain safe water resources. For future research, exploring advanced sensor technologies can improve accuracy and expand monitoring capabilities. Furthermore, the integration of data analysis and machine learning algorithms can improve the ability to assess and predict water quality in real time. Addressing these issues can advance the development of a robust and reliable water quality monitoring system, which is critical to sustainable management of water resources.

REFERENCES

[1] S. Syahputra, H. Santosa, and F. Hadi, “Perancangan Sistem Pengontrolan Water Treatment Menggunakan Kontrol PID,” *J. Amplif. J. Ilm. Bid. Tek. ELEKTRO DAN Komput.*, vol. 9, no. 1, pp. 26–31, May 2019, doi: 10.33369/jamplifier.v9i1.15398.

[2] N. Anwar, A. M. Widodo, V. Tundjungsari, A. Ichwani, and Yulhendri, “Sistem Pemantauan Level Keasaman dan Total Dissolved Solids Limbah Cair Berbasis Internet of Things (IoT),” *Pros. SISFOTEK*, vol. 5, no. 1, pp. 21–26, 2021.

[3] Y. A. Akhmad, F. Fathoni, and M. Luqman, “Sistem Kendali Penjernih Air Klinik Gigi & Mulut Dengan Metode Filtrasi,” *J. Elektron. dan Otomasi Ind.*, vol. 8, no. 3, p. 179, Oct. 2021, doi: 10.33795/elk.v8i3.314.

[4] M. Anshori, N. Sari, and A. Vijai, “Rancang Bangun Alat Ukur Kekeruhan Air Layak Pakai Berbasis Arduino Uno R3 Pada Sungai Martapura,” *J. Ilm. Fis. FMIPA Univ. Lambung Mangkurat*, vol. 19, no. 1, 2022, doi: https://doi.org/10.20527/flux19i3.12959.

[5] S. Setiowati, R. N. Wardhani, S. Danaryani, and R. Riandini, “Desain Sistem Monitoring Cerdas Kualitas Air Keramba Budidaya Teripang Berbasis IoT,” *J. Ilm. Matrik*, vol. 24, no. 1, pp. 28–39, Apr. 2022, doi: 10.33557/jurnalmatrik.v24i1.1648.

[6] F. Chuzaini and D. Dzulkiflih, “IoT Monitoring Kualitas Air dengan Menggunakan Sensor Suhu, Ph, dan Total Dissolved Solids (TDS),” *J. Inov. Fis. Indones.*, vol. 11, no. 3, pp. 46–56, 2022.

[7] A. Dwicahyo, H. A. Widodo, and A. T. Nugraha, “Purwarupa Monitoring Fresh Water Tank pada Kapal Berbasis Mikrokontroler,” *Elektriese J. Sains dan Teknol. Elektro*, vol. 11, no. 01, pp. 12–19, Jul. 2022, doi: 10.47709/elektriese.v11i01.1623.

[8] F. Febrianti, S. Adi Wibowo, and N. Vendyansyah, “IMPLEMENTASI IoT(Internet Of Things) MONITORING KUALITAS AIR DAN SISTEM ADMINISTRASI PADA PENGELOLA AIR BERSIH SKALA KECIL,” *JATI (Jurnal Mhs. Tek. Inform.*, vol. 5, no. 1, pp. 171–178, Feb. 2021, doi: 10.36040/jati.v5i1.3249.

[9] P. A. Darwito, H. Sa’diyah, and M. Raditya, “Rancang Bangun Sistem Pengolah Air Bersih Standar WHO dan Kemenkes Bagi Warga Dusun Sinan - Desa Gawerejo - Kecamatan Karangbinangun - Kabupaten Lamongan Jawa Timur,” *J. Pengabdi. dan Pengemb. Masy.*, vol. 2, no. 1, p. 167, May 2019, doi: 10.22146/jp2m.48346.

[10] H. Priyatman, S. Supriono, and A. Irwanto, “Aplikasi Teknologi Iot Pada WTP(Water Treatment Plant) Sistem Pendingin Air Pada Mesin Pembangkit Guna Menjaga Nilai Ph Dan TDS Untuk Kualitas Air,” *Transmisi*, vol. 24, no. 3, pp. 106–113, Aug. 2022, doi: 10.14710/transmisi.24.3.106-113.

[11] Anggara Trisna Nugraha and D. Priyambodo, “Design of Pond Water Turbidity Monitoring System in Arduino-based Catfish Cultivation to Support Sustainable Development Goals 2030 No.9 Industry, Innovation, and Infrastructure,” *J. Electron. Electromed. Eng. Med. Informatics*, vol. 2, no. 3, pp. 119–124, Oct. 2020, doi: 10.35882/jeeemi.v2i3.6.

[12] faizal Fatturahman and I. Irawan, “Monitoring Filter Pada Tangki Air Menggunakan Sensor Turbidity Berbasis Arduino Mega 2560 Via Sms Gateway,” *J. Komputasi*, vol. 7, no. 2, Oct. 2019, doi: 10.23960/komputasi.v7i2.2422.

[13] U. Syafiqoh, S. Sunardi, and A. Yudhana, “Pengembangan Wireless Sensor Network Berbasis Internet of Things untuk Sistem Pemantauan Kualitas Air dan Tanah Pertanian,” *J. Inform. J. Pengemb. IT*, vol. 3, no. 2, pp. 285–289, May 2018, doi: 10.30591/jpit.v3i2.878.

[14] M. Mohammed and M. Massour El Aoud, “Modeling of reverse osmosis process at a brackish water desalination station,” in *2021 7th International Conference on Optimization and Applications (ICOA)*, IEEE, May 2021, pp. 1–7. doi:

.

10.1109/ICOA51614.2021.9442632.

[15] E. SETIAWAN, G. ANINDITA, A. SYAHID, and I. RACHMAN, “Monitoring Keseimbangan Distribusi Beban Transformator untuk Meminimalisasi Terjadinya Rugi Energi,” *ELKOMIKA J. Tek. Energi Elektr. Tek. Telekomun. Tek. Elektron.*, vol. 7, no. 2, p. 297, May 2019, doi: 10.26760/elkomika.v7i2.297.

[16] A. T. Nugraha, “Dirty Air Filter System Using Boxed Equalizer Mq-8 And Mq-9 Wheeled Robot,” *JEEMECS (Journal Electr. Eng. Mechatron. Comput. Sci.*, vol. 1, no. 1, Jul. 2018, doi: 10.26905/jeemecs.v1i1.2301.

[17] . P., “Analysis of Mechanical Water Filtration Systems for River Water Quality,” *Int. J. Sci. Technoledge*, vol. 7, no. 10, Jan. 2019, doi: 10.24940/theijst/2019/v7/i1/ST1901-005.

[18] Sulistiyanto, R. Setyobudi, and Tijaniyah, “Utilization of tds sensors for water quality monitoring and water filtering of carp pools using IoT,” *EUREKA Phys. Eng.*, no. 6, pp. 69–77, Nov. 2023, doi: 10.21303/2461-4262.2023.002865.

[19] Y. Irawan, A. Febriani, R. Wahyuni, and Y. Devis, “Water quality measurement and filtering tools using Arduino Uno, PH sensor and TDS meter sensor,” *J. Robot. Control*, vol. 2, no. 5, pp. 357–362, 2021, doi: 10.18196/jrc.25107.

[20] A. T. Nugraha and R. Arifuddin, “Water Purification Technology Implementation Design,” *JEEMECS (Journal Electr. Eng. Mechatron. Comput. Sci.*, vol. 3, no. 2, Aug. 2020, doi: 10.26905/jeemecs.v3i2.4583.

[21] R. Oktaviana, P. Rusimamto, E. Endryansyah, and M. Zuhrie, “Rancang Bangun Sistem Kendali Water Level Berbasis IoT dengan Metode PID Controller,” *J. Tek. ELEKTRO*, vol. 11, no. 3 SE-Vol 11 No 3 (2022): SEPTEMBER 2022, Jul. 2022, doi: 10.26740/jte.v11n3.p361–370.

[22] Ghilman Ahmad Faza, Muhammad Fikri Fathurrohman, Purwidi Asri, Anggara Trisna Nugraha, and Perwi Darmajanti, “Prototype Sistem Oily Water Separator Otomatis Pada Kapal Menggunakan Metode Decision Tree Berbasis Mikrokontroler,” *J. 7 Samudra*, vol. 8, no. 2, pp. 1–6, Nov. 2023, doi: 10.54992/7samudra.v9i1.128.

[23] G. Anindita, E. Setiawan, and A. Syahid, “Optimasi Energi pada Motor Induksi 3 Fasa dalam Memproduksi Kebutuhan Air (Studi Kasus di PDAM Karang Pilang Surabaya),” *Semin. MASTER PPNS*, vol. 1, no. 1, 2016.