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PAPER

River Water Quality Analysis Using Arduino-Based Sensor of the Cikapundung River, Indonesia

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ABSTRACT

River water is essential for people's lives and environmental health. There is a need to manage river water to maintain river water quality. This research aims to develop a river water quality analysis system that is practical, easy, and capable of storage and processing using several sensors connected to a computer system. The tools used in this research are Arduino UNO R3 board and sensors. River water samples with various characteristics were taken from four spots of the Cikapundung River. The results showed that river water quality analysis can be done using sensor-based Arduino UNO R3. The temperature at the four spots ranges from 27–32°C and is included in the safe category for sanitation use. Judging from the turbidity factor, the turbidity value of river water is in the high category, namely 49.2–58.1 NTU, which is unsuitable for sanitary use. Regarding the TDS factor, the TDS range in river water is 150–222 ppm, indicating that river water is not polluted. Meanwhile, the pH value shows that the pH range of river water is alkaline and can be used for sanitation with a range of 7.93–8.16. This indicates that the water quality in the Cikapundung River that needs attention is the turbidity factor. It takes awareness of the surrounding community and government agencies to work together to improve the river's environmental health sustainably.

KEYWORDS

river water quality, Arduino, temperature sensor, turbidity sensor, TDS sensor, pH sensor, Cikapundung River

1 INTRODUCTION

River water is the most crucial part and the primary source of water supply for the population for daily use. So, maintaining the quality of river water is very important. River water sources are influenced by several factors, including natural factors and human activities [1], [2]. Natural factors that affect river water quality include climatic conditions (temperature and rainfall) that vary with location and season and extreme weather events such as droughts and floods that affect the capacity of river discharge and the amount of substances in river water [2], [3]. Human activities,

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such as land use, are also significant factors affecting river water quality, which will positively or negatively impact the physicochemical parameters of river water quality [4]. In addition, land clearing, agricultural activities, and livestock waste that can produce sediment, organic matter, nutrients, pathogens, and heavy metals also affect river water quality [5].

River water quality is generally affected by wastewater pollutants or emissions that decrease water quality. Population growth and industrial activities contribute more to the environment and aquatic ecosystems because they can cause emissions and wastewater into the environment [6], [7]. Water pollution and climate change affecting river water quality are the main challenges in better river water management [2], [4]. The difficulties of river water management now target designing a tool that utilizes sensor-based technology using a computer system to analyze river water quality around the population in real-time [8], [9]. One technology that can be developed is the use of Arduino-based sensors.

Arduino has several boards designed to adjust the objectives to be achieved. The Arduino context used in this research is Arduino UNO R3. Arduino UNO R3 is an electronic and coding-based microcontroller board with ATmega328P [10], [11]. Arduino as a device can be used flexibly by integrating various types of sensors according to the needs of river water quality testing [12]. River water quality testing can be done using sensors such as temperature, turbidity, Total Dissolved Solids (TDS), and pH. These tests can produce river water quality parameters in real-time [11], [13]–[15].

Analysis of river water quality using sensor-based Arduino can identify significant changes in several parameters that indicate pollution in river water. Temperature is one of the most important parameters in determining water quality because it influences biotic and abiotic components in the ecosystem [16], [15]. Temperature controls the quality of dissolved oxygen available to organisms in the water. Another parameter that affects river water quality is turbidity. Turbidity is influenced by suspended solids, colloids, algae, dissolved organic matter, and others [17], [15]. The flow velocity of river water also influences turbidity values due to sediment scouring. TDS is also one of the parameters that can affect river water quality [13]–[15]. TDS is the sum of all water-soluble constituents consisting of inorganic anions and cations. The following parameter used to analyze river water quality is pH. pH measures the relative amount of free hydrogen and hydroxyl ions in water. The pH level in river water is influenced by industrial waste, household waste, rainfall, and water hardness [11], [15].

River water in Indonesia has a significant role in supporting the sustainability of ecosystems, population health, and the environment [18], [19]. The quality of environmental health, especially river water used for hygiene and sanitation purposes, must meet the quality standards of environmental health and health requirements described in PERMENKES/No. 32/2017. The quality standards (maximum levels) on the four parameters are temperature (water temperature value = air temperature ± 3^{o}C, turbidity (25 NTU), TDS (1000 ppm), and pH (6.5–8.5). Cikapundung River is the longest river, with 28 KM, that divides Bandung City, Indonesia and empties into the Citarum River [20]. The primary utilization of this river is for drainage in the city of Bandung, tourist attractions, and hydroelectric power plants. The usefulness of the Cikapundung River for the people of Bandung and its surroundings is one of the reasons to continue managing and maintaining the quality of river water [20].

River water quality management is a fundamental issue to ensure water sustainability. Based on this, to optimally develop river water quality management, a design of tool models and techniques that combine technological devices that can be done quickly and obtain results in real time is needed. This research aims to develop a river water quality analysis system that is practical, easy, and capable of storage and processing using several sensors connected to a computer system.

2 LITERATURE REVIEW

River water quality analysis research in the last five years (2019–2024) is spread across various countries. River water quality testing uses various tools and methods and several parameters. This forms the basis for researchers to study river water quality analysis using several parameters integrated with technological devices.

Monitoring river water quality is very important for managing public health and the environment around the river flow. The parameters used to determine river water quality include physical, biological, and chemical parameters in the form of mandatory and additional parameters [15]–[21]. Physical parameters include turbidity, colour, TDS, temperature, taste, and odour. Biological parameters include total coliform and E. coli. Furthermore, chemical parameters include mandatory and additional parameters. Required parameters include pH, iron, fluoride, hardness, manganese, nitrate, nitrite, cyanide, detergent, and total pesticides. At the same time, additional parameters consist of mercury, Arsenic, Cadmium, Chromium (valence 6), Selenium, Zinc, Sulfate, Lead, benzene, and organic substances ($KMnO_4$) [7], [12], [13], [15]–[17].

Testing these parameters requires the support of devices and testing methods tailored to each parameter's nature. Tools that are often used for water quality testing include a thermometer to test temperature, a pH meter MP220 to test pH, a turbidity meter to test turbidity, a conductivity meter to test Electrical Conductivity (EC) and TDS, a spectrophotometer to test nitrite and phosphate content, BDO meter to test BOD, and several other tools [22]. These tools are ready to use and have the advantage of being able to show the measurement results immediately. The weakness of these tools is their price, which tends to be high and is often owned by agencies or laboratories.

The methods used for river water analysis include the titrimetric method. The titrimetric method is usually used for testing Cl^-, Ca^{2+}, and Total Hardness (TH) content. The dichromate reflux method is also used to test Chemical Oxygen Demand (COD) levels [15]. River water quality testing using some of these methods is conducted on a laboratory scale because it requires a set of test equipment that is not flexible to be carried out and used in a particular place.

Technological devices play an essential role in river water quality testing. Technology is essentially easier to design, modify, and develop according to the needs and availability of tools. One of the technologies used for river water quality testing is using a microcontroller as an Arduino connected to various sensors. The sensors used are DS18B20 (temperature sensor), SEN0189-DFRobot (turbidity sensor), SEN0244-DFRobot (TDS sensor), SEN0161/0169PH (pH sensor), conductivity, and others. Using Arduino-based sensors that are later connected to a computer system is the cheapest, most straightforward way of testing, and it can obtain test results in real-time [12], [17]. Remote sensing and artificial intelligence (AI) are also used in testing water quality. Remote sensing and AI can also be used to determine water quality values in the form of Dissolved Oxygen, Chloride, Fluoride, Arsenic, Alkalinity, pH, Turbidity, Sodium, Potassium, Hardness, Nitrate, Sulfate, and Magnesium. This technology shows test results with high effectiveness and accuracy in determining river water quality.

The tools, methods, and technologies used to conduct river water quality tests are developing from year to year. This makes the awareness and sustainability of river water quality management more widespread. Various parameters, tools, methods, and technologies used by several studies that analyze river water quality are shown in Table 1.

Table 1. A variety of parameters were tested to determine river water quality

Ref. No	Parameters Tested	Tools, Methods, and Technology Used	Year
[22]	Physical (e.g., water temperature and salinity), chemical (e.g., pesticides and pharmaceuticals) and biological parameters (e.g., BOD and faecal coliform)	Termometer, pH meter MP220, Turbidity meter, Conductivity meter, etc	2024
[23]	Oksigen Terlarut, Klorida, Fluorida, Arsenik, Alkalinitas, pH, Kekeruhan, Natrium, Kalium, Kesadahan, Nitrat, Sulfat, dan Magnesium	Remote Sensing and AI Models	2023
[24]	Temperature (Temp), pH, turbidity, EC, TDS, blue-green algae, chlorophyll *A*, and dissolved oxygen	Remote sensing and GIS	2023
[25]	Total phosphorus (TP), permanganate index (COD_{Mn}), and total nitrogen (TN)	Sentinel-2 satellite images	2023
[17]	Conductivity and turbidity	Hydrabot: Arduino-based robot	2023
[26]	Chlorophyll-a (Chl-a), phycocyanin (PC), total phosphorus (TP), TSS, total nitrogen (TN), nitrate-nitrogen (NO_3-N), ammonia nitrogen (NH_4-N), and pH	Ground-based hyperspectral remote sensing	2022
[16]	pH, turbidity, salinity, and Temperature	Arduino	2021
[12]	pH, TDS, turbidity, and Temperature	Arduino UNO R3-based sensor	2020
[15]	Physicochemical (Temperature, pH, EC, turbidity, TDS, Nitrit, Fosfat, etc) and biological parameters	Thermometer, pH meter MP220, Turbidity meter, Conductivity meter, Spectrophotometer, titrimetric method, etc	2020
[27]	pH, DO, TDS, TSS, turbidity, BOD, and conductivity.	Satellite-based remote sensing	2019
[28]	pH, turbidity, and Temperature	Wireless Sensor Network (WSN) (using remote monitoring and Internet of Things (IoT) technology)	2019

3 MATERIALS AND METHODS

3.1 Materials

The study was conducted with water samples from four streams of the Cikapundung River, Bandung, Indonesia. The Cikapundung River, a 28-kilometer-long river, has its headwaters in Bukit Tunggul, North Bandung area, West Java, and empties into the Citarum River in South Bandung area [20]. The four streams are located at different locations, as shown in the map and location points in Figure 1 and Table 1. River water sampling was conducted for four days (one day per river) from October 30 to November 2, 2023. Each river was sampled from 10.10 a.m. to 2.10 p.m. (four hours), as described in Table 2.

Table 2. Time and location of river water sampling

Spot	Date	Time	Location
A	30-10-2023	10.10 a.m–2.10 p.m	6°52'3.81 "S 107°36'48.15 "E
B	31-10-2023	10.10 a.m–2.10 p.m	6°52'3.81 "S 107°36'48.15 "E
C	01-11-2023	10.10 a.m–2.10 p.m	6°52'3.81 "S 107°36'48.15 "E
D	02-11-2023	10.10 a.m–2.10 p.m	6°52'3.81 "S 107°36'48.15 "E

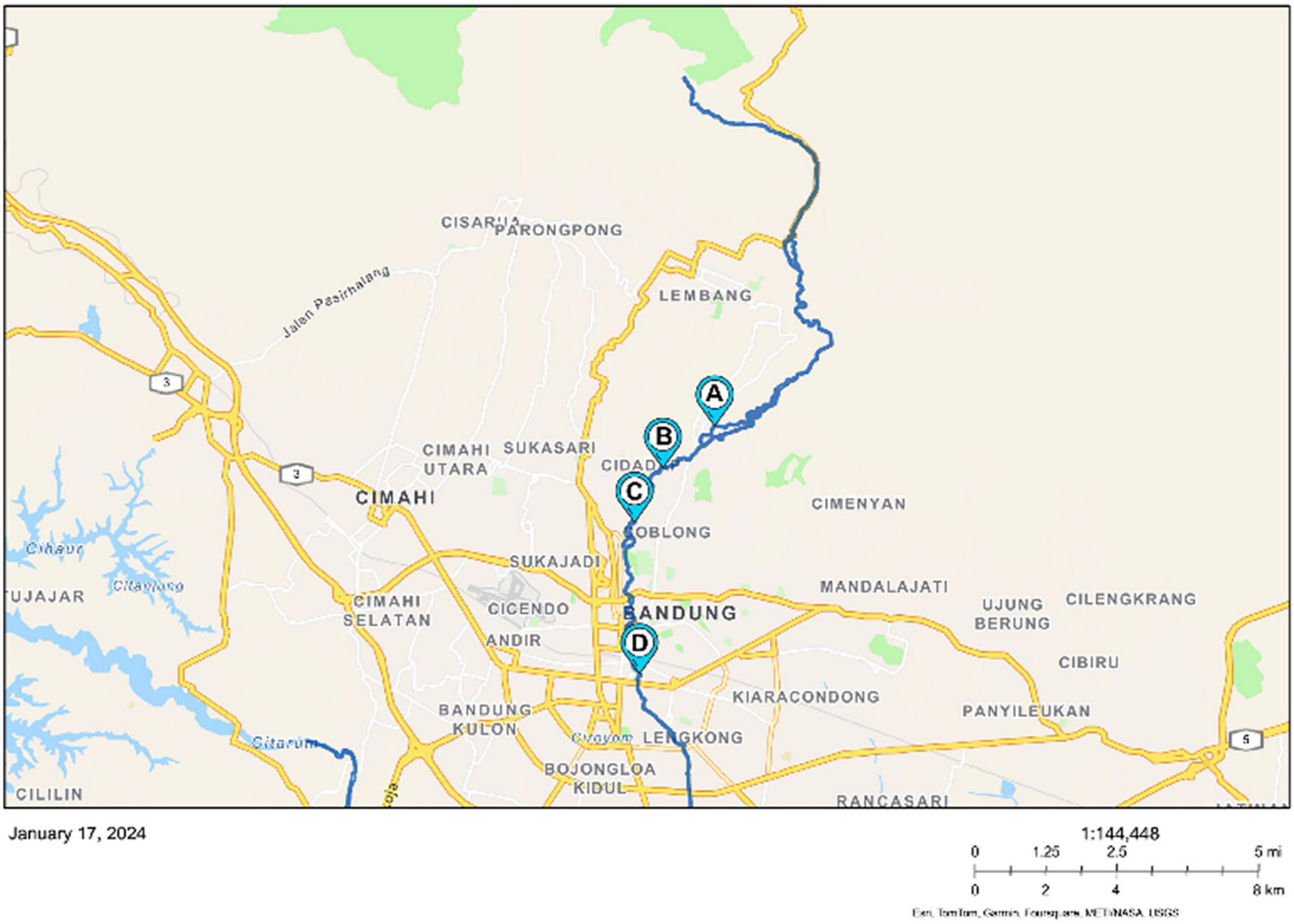

Fig. 1. Sampling location map of Spots A, B, C, and D

Figure 1 shows the four points of the river water sampling location. Spot A is the uppermost point in sampling, where the river is often used as an education centre for residents to preserve the river environment. The river flow at spot A is swift, and the water tends to be quick. Spot B is the second point where the river flows quite fast; there are residential areas around the river. So, river water at this spot is often used for residents' consumption and sanitation needs. Spot C is a river flow near the tourist attractions; the river flow tends to be calm and turbid. While spot D is a river in the city centre, several food vendors are around the river. The river flow in spot D tends to be calm and murky. The condition of river A, B, C, and D can be seen in Figure 2.

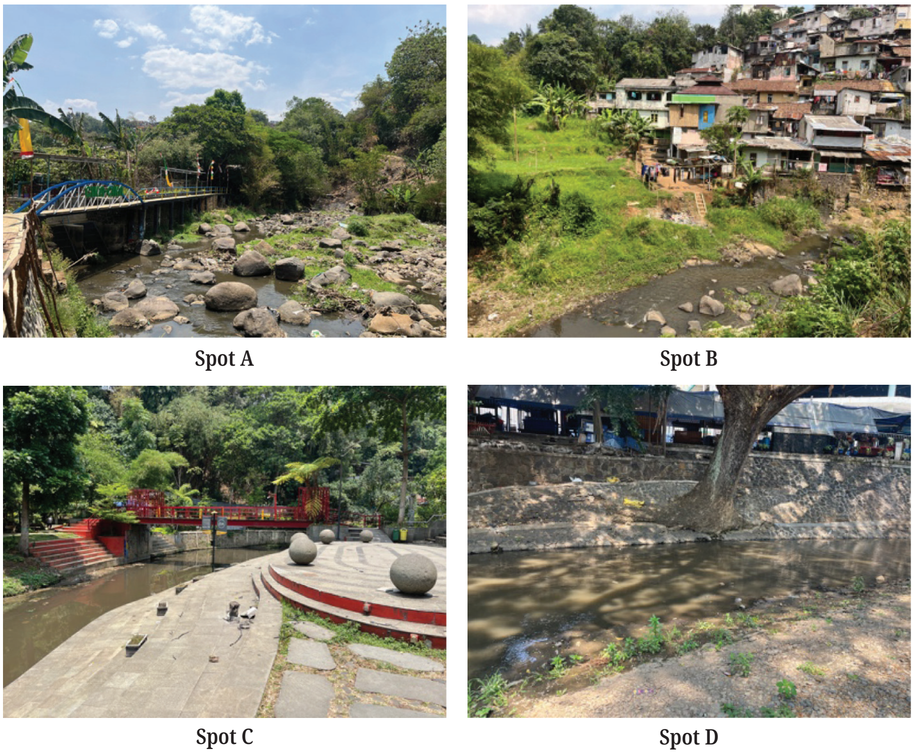

Fig. 2. Overview of river conditions at Spots A, B, C, and D

The primary tool used in this research is a microcontroller with an Arduino UNO R3 Board and several sensors. The Arduino UNO R3 board (Figure 3) is an ATmega328-based microcontroller board that has the following specifications: 1) it has six analogue input pins with labels A0–A5, which serves to maximize the number of sensors, namely six analogue sensors that can be connected directly to Arduino; 2) has two power supply pins with labels 3.3 volts and 5 volts with specific voltage settings that serve to power the sensor; and 3) has a USB plug connected to a USB cable to connect with the microprocessor [10].

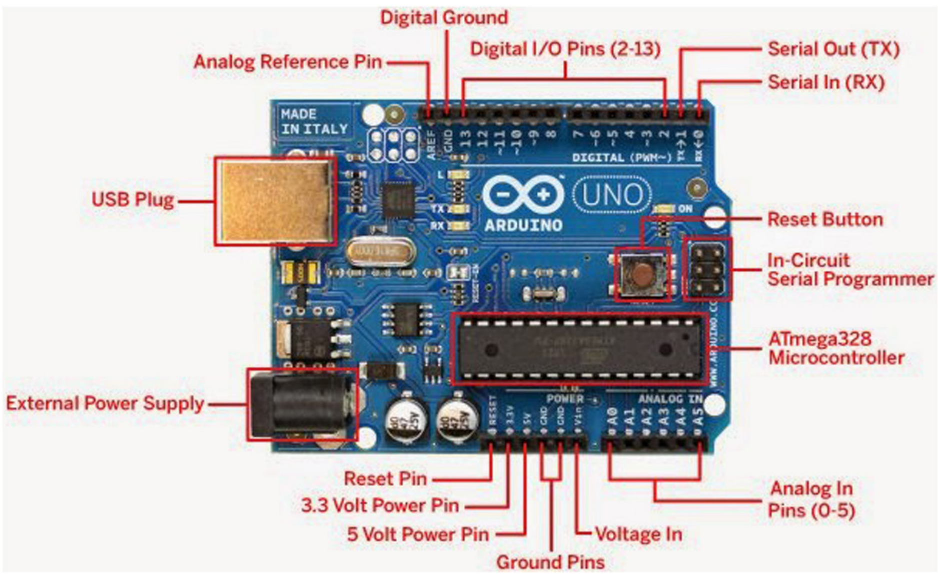

Fig. 3. Board mikrokontroler Arduino UNO R3

The sensors used in this test are DS18B20 (temperature sensor), SEN0189-DFRobot (turbidity sensor), SEN0244-DFRobot (TDS sensor), and SEN0161/0169PH (pH sensor). The sensors were selected based on practicality (can be used in real-time), ease of use, portability, measurability (parameters), cost-effectiveness and economy. Figure 4a shows that the temperature sensor used in this study is DS18B20. The DS18B20 is a digital temperature sensor often used in various electronic projects and applications with a temperature range of –55°C to +125°C. This range makes this sensor suitable for multiple applications that require sub-zero to high-temperature measurements. Figure 4b shows the turbidity sensor using the SEN0189-DFRobot. SEN0189-DFRobot is an Arduino Turbidity gravity sensor from DfRobot that detects water quality by measuring water's turbidity level. It uses light to identify suspended particles in water by measuring light scattering and transmission rates, which change with the amount of total suspended solids (TSS) in water. The higher the TSS, the more turbidity of the liquid. Figure 4c shows the SEN0244-DFRobot sensor, which measures Total Dissolved Solids (TDS). TDS indicates the number of milligrams of dissolved solids in one litre of water. The higher the TDS value, the more solids are dissolved in the water, and the cleaner the water. Therefore, the TDS value can indicate how clean the water is. This sensor has a TDS measurement range of 0–1000 ppm. Figure 4d shows the pH sensor, SEN0161/0169PH. It has fast response, good stability, good reproducibility, and challenging to hydrolyze. It has a pH range of 0–14, making it suitable for long-term monitoring [29].

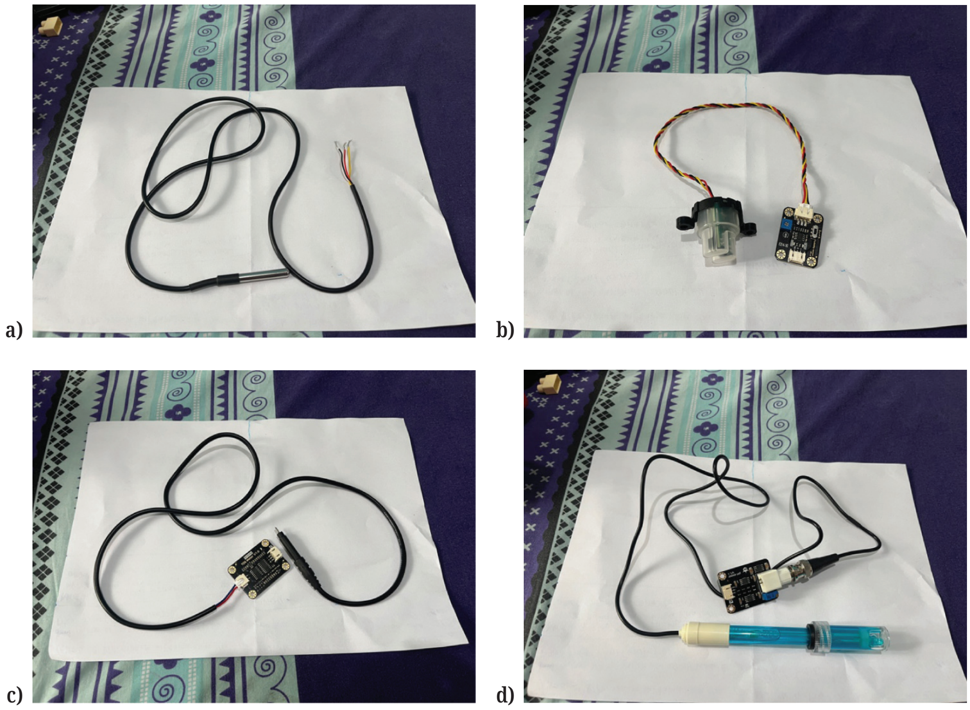

Fig. 4. 4a: Temperature sensor, 4b: Turbidity sensor, 4c: TDS sensor, 4d: pH sensor

3.2 Methods

River water quality was analyzed by observing temperature, turbidity, TDS and pH changes. The temperature measurement process is shown in Figures 5 and 6, the DS18B20 sensor is first connected to the Arduino UNO R3 board connected to digital pin 2, then the positive pole (+) to 5V, and the negative pole (–) to GND.

The temperature probe is then immersed in the river water sample. The code is entered into the Arduino Uno software after the temperature sensor is connected to the Arduino UNO R3 [12], [29].

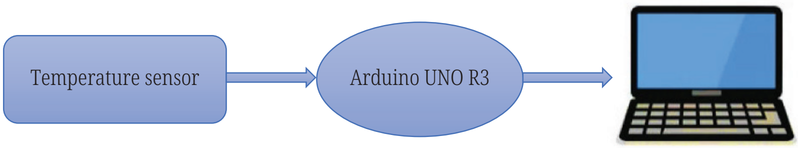

Fig. 5. Temperature sensor linkage circuit to Arduino and computer system

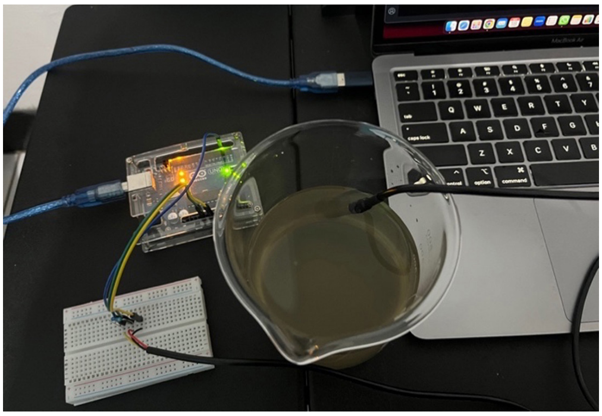

Fig. 6. Actual circuit of the temperature sensor to Arduino and computer system

The turbidity measurement process is shown in Figures 7 and 8; the SEN0189-DFRobot sensor is first connected to the Arduino UNO R3 board through the configuration of SIGNAL (AC signal) to analogue A0, VCC to 5V, and GNS|D to GND. The turbidity probe is then immersed in the river water sample. Enter the code into the Arduino Uno software after connecting the turbidity sensor to the Arduino UNO R3 [12], [29].

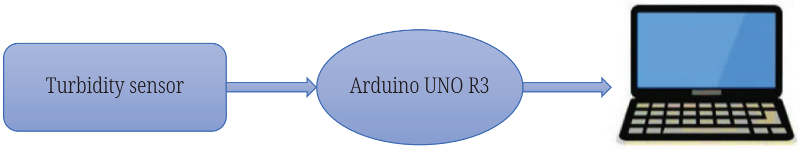

Fig. 7. Turbidity sensor linkage circuit to Arduino and computer system

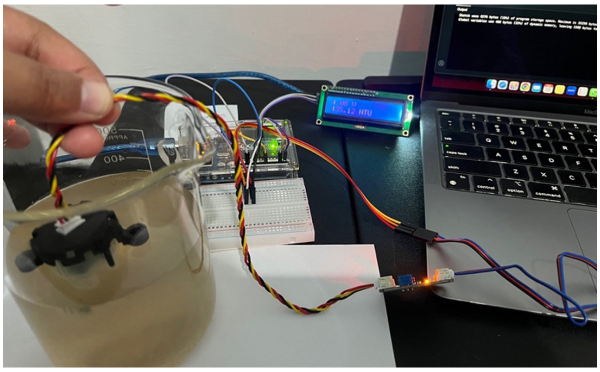

Fig. 8. Real circuit of turbidity sensor to Arduino and computer system

The TDS measurement process is shown in Figures 9 and 10, the SEN0244-DFRobot sensor is first connected to the Arduino UNO R3 board via configuration A (AC signal) to analogue A1, positive pole (+) to 5V, and negative pole (–) to GND. The TDS probe is then immersed in the river water sample. Enter the code into the Arduino Uno software after the TDS sensor is connected to the Arduino UNO R3 [12], [29].

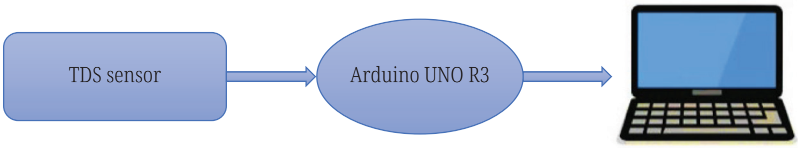

Fig. 9. TDS sensor linkage circuit to Arduino and computer system

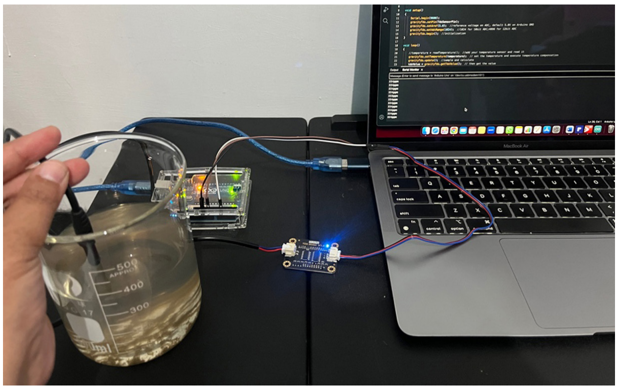

Fig. 10. Real circuit of TDS sensor to Arduino and computer system

The pH measurement process is shown in Figures 11 and 12, the SEN0161/0169PH sensor is first connected to the Arduino UNO R3 board via configuration A (AC signal) to analogue A1, positive pole (+) to 5V, and negative pole (–) to GND. The pH probe is then immersed in the river water sample. Enter the code into the Arduino Uno software after the pH sensor is connected to the Arduino UNO R3 [12], [29].

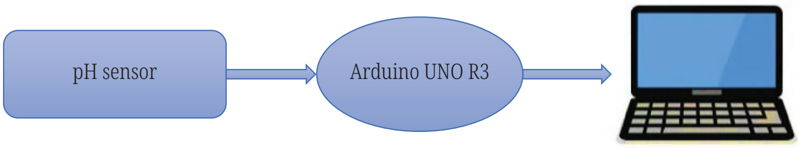

Fig. 11. pH sensor linkage circuit to Arduino and computer system

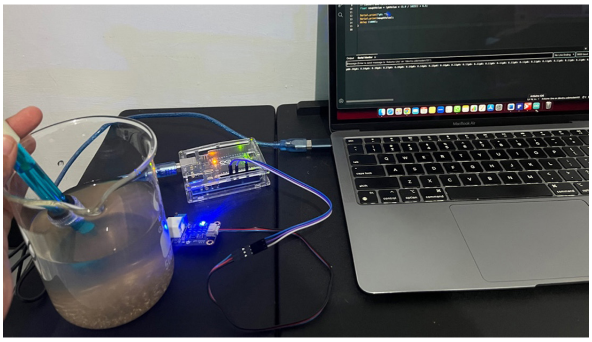

Fig. 12. Real circuit of pH sensor to Arduino and computer system

4 RESULTS

Analysis of river water quality in this study was carried out using Arduino-based sensors and compared using laboratory tools to determine the accuracy of the results. The EZO turbidity sensor and pH TDS Temperature Meter Tester-KT-686 are laboratory tools used. The results of the two tests are then calculated based on the percentage error using the formula:

$$Percentage\,error = \frac{actual\,value\,observed - expected\,value}{expected\,value} \times 100\%$$

The results of the river water quality analysis test using laboratory tools as the "expected value" are shown in Table 3.

Table 3. Measurement results using laboratory tools

Water Sample	Time	Temperature (°C)	Turbidity (NTU)	TDS (ppm)	pH
Spot A	10.10 am	26.2	52.7	168	7.24
	11.10 am	26.9	52.5	164	7.35
	12.10 pm	27.2	52.0	159	7.59
	1.10 pm	27.4	51.2	155	7.82
	2.10 pm	27.9	50.1	149	7.90
Spot B	10.10 am	26.0	53.0	191	7.78
	11.10 am	26.5	52.6	182	7.81
	12.10 pm	27.2	52.3	175	7.84
	1.10 pm	27.9	51.8	172	7.86
	2.10 pm	28.3	51.6	163	7.87
Spot C	10.10 am	26.6	55.0	199	8.09
	11.10 am	27.2	55.6	201	8.12
	12.10 pm	27.6	57.1	205	8.18
	1.10 pm	27.7	57.6	209	8.22
	2.10 pm	27.8	58.4	212	8.29
Spot D	10.10 am	26.9	52.2	193	8.04
	11.10 am	27.2	52.8	201	8.09
	12.10 pm	28.2	53.1	212	8.10
	1.10 pm	28.4	53.4	219	8.12
	2.10 pm	28.8	56.7	230	8.19

Table 3 shows the results of analyzing river water quality using Arduino-based sensors designed by researchers. The value obtained from the results is expressed as "actual value observed".

Table 4. Measurement results using Arduino-based sensor

Water Sample	Time	Temperature (°C)	Turbidity (NTU)	TDS (ppm)	pH
Spot A	10.10 am	26.9	53.7	166	7.94
	11.10 am	27.2	53.3	161	7.95
	12.10 pm	27.6	51.5	155	7.99
	1.10 pm	28.4	51.2	150	8.02
	2.10 pm	29.5	49.2	152	8.11
Spot B	10.10 am	25.6	51.8	185	8.09
	11.10 am	27.1	53.4	180	8.10
	12.10 pm	28.2	54.1	176	8.12
	1.10 pm	28.3	54.5	171	8.12
	2.10 pm	29	54.9	169	8.12
Spot C	10.10 am	27	55.5	205	8.14
	11.10 am	27.9	56.4	202	7.93
	12.10 pm	28.2	57.4	197	8.14
	1.10 pm	28.4	57.8	195	8.08
	2.10 pm	28.3	58.1	193	8.09
Spot D	10.10 am	26.9	51.2	197	8.06
	11.10 am	27.6	51.6	207	8.12
	12.10 pm	28.5	52.8	217	8.14
	1.10 pm	28.9	53.8	221	8.14
	2.10 pm	29.1	57.9	222	8.16

Furthermore, Table 5 shows the results of the percentage error calculated based on the formula using both data in Tables 3 and 4.

Table 5. Percentage error results

Water Sample	Time	Percentage Error			
		Temperature	Turbidity	TDS	pH
Spot A	10.10 am	2.7%	1.9%	1.2%	9.7%
	11.10 am	1.1%	1.5%	1.8%	8.2%
	12.10 pm	1.5%	1%	2.5%	5.3%
	1.10 pm	3.6%	0%	3.2%	2.6%
	2.10 pm	5.7%	1.8%	2%	2.7%
Spot B	10.10 am	1.5%	2.3%	3.1%	4%
	11.10 am	2.3%	1.5%	1.1%	3.4%
	12.10 pm	3.7%	3.4%	0.6%	3.6%
	1.10 pm	1.4%	5.2%	0.6%	3.3%
	2.10 pm	2.5%	6.4%	3.6%	3.2%

(Continued)

Table 5. Percentage error results *(Continued)*

Water Sample	Time	Percentage Error			
		Temperature	Turbidity	TDS	pH
Spot C	10.10 am	1.5%	1%	3%	0.6%
	11.10 am	2.6%	1.4%	0.5%	2.3%
	12.10 pm	2.2%	0.5%	3.9%	0.5%
	1.10 pm	2.5%	0.3%	6.7%	1.7%
	2.10 pm	1.8%	0.5%	9%	2.4%
Spot D	10.10 am	0%	1.9%	2.1%	0.2%
	11.10 am	1.5%	2.3%	3%	0.4%
	12.10 pm	1.1%	0.6%	2.3%	0%
	1.10 pm	1.8%	0.7%	1.4%	0.7%
	2.10 pm	1.0%	2.1%	3%	0.9%

Based on the percentage error results shown in Table 4, it is known that the percentage error obtained is below 10% in each test performed. This shows that the Arduino-based sensor used by researchers to test river water quality can be used as a standard in monitoring river water quality.

5 DISCUSSION

One of the most important resources to support the life of living things is water. As a maritime country, Indonesia has various regions with flowing waters, one of which is the river. River water has many uses for household needs, drinking, irrigation, fisheries, etc. This shows that river water quality is important to consider so that the use of river water can be maximized. River water quality analysis can be tested in real-time so that the results can be quickly known. River water quality can be reviewed from several factors, including temperature, turbidity, TDS, and pH.

5.1 Analysis of river water quality as seen from the temperature factor

Based on the results of field tests, it is known that the air temperature in the first hour (10.10 a.m.) at the four river points ranged from 27–29°C, then as the afternoon progressed, the air temperature increased in the fourth hour at 2.10 p.m. to 31–32°C. The air temperature affects the temperature changes in river water. Figure 13 shows that the temperature of river water in the four river points in the first hour (10.10 a.m.) varies between 25.6–27°C after one hour, the temperature in all rivers has almost the same range of 27.1–27.9°C, the next hour the temperature range in all rivers is also almost the same, namely 27.6–28.5°C, and in the last hour, 2.10 p.m., the temperature increased further, namely 28.3–29.5°C. The increase follows the increase in air temperature because the standard water temperature, when compared to air temperature based on water quality standards, is ± 3°C compared to air temperature.

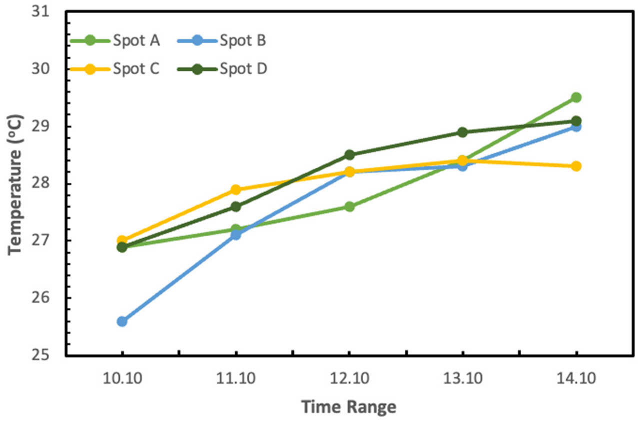

Fig. 13. Temperature measurement results in river water

Water quality in terms of temperature is seen from physical characteristics. Temperature measurement is an important thing to do to determine the quality of river water because geographical location and environmental temperature contribute to the growth of bacteria on the surface of river waterways [30], [31]. Temperature in river water is strongly influenced by the weather around the river and the location of the river. Figure 12 shows that the river water temperature is within standard temperature conditions, so it is stated that the four river points are not polluted in terms of the temperature factor.

5.2 Analysis of river water quality as seen from the turbidity factor

Fluctuations influence river water turbidity in river flow. The turbidity level of the river in the upstream area is lower than in the middle and downstream areas of the river. Table 3 shows that the turbidity of the upstream river water is lower than the downstream. Figure 14 shows that there are variations in the turbidity level of each river. The daytime turbidity value increases in spots B, C, and D, while in spot A, the daytime turbidity value decreases. Spot A and B turbidity values show different results between measurements using laboratory tools and Arduino-based sensors. Based on observations, river water samples at spots A and B experienced a decrease in turbidity from morning to afternoon testing. So, the turbidity value from morning to afternoon should decrease.

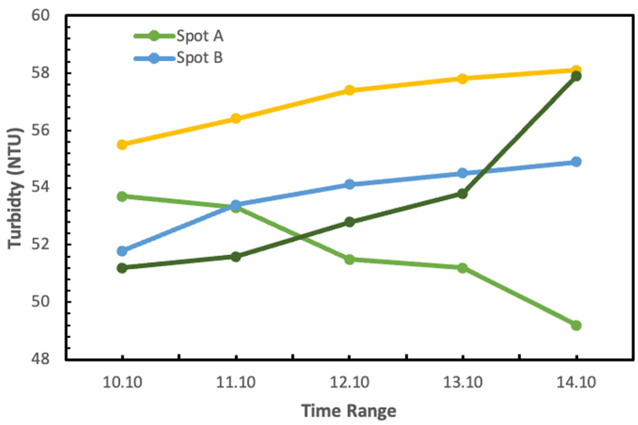

Fig. 14. Turbidity measurement results in river water

Turbidity values are influenced by river water flow. Kinetic energy possessed by high-speed river flow can re-suspend solids at the bottom of the river and then carry suspended solids and cause high turbidity values [16], [17]. In the morning conditions, which are usually calm waters, suspended solids will settle to the bottom of the river, resulting in low turbidity. Waters in spots A and B in the morning tend to be swift, based on observations showing that the morning's turbidity level is higher than during the day. Whereas waters C and D are calm waters, the observation results show that the turbidity level in the morning is lower than during the day. The results of all tests show that the turbidity value is in the range of 49.2–58.1 NTU. This value shows a number above the water quality standards used for sanitation, which is < 25 NTU, so water at the four river points cannot be used for sanitation. Real action is needed from the government and the surrounding community to reduce turbidity values to improve river water quality.

5.3 Analysis of river water quality as seen from the TDS factor

The TDS value is related to the salinity of river water caused by the separation of dissolved ions from water use or other highly saline water activities. Figure 15 shows the variation in the trend of dissolved solids values at all river spots during the four hours of sampling. Spots A, B and C show a decrease in dissolved solids values, but spot 4 shows an increase in dissolved solids values. TDS values are influenced by conductivity and temperature. Temperature affects conductivity by increasing ion activity and the escape of salts and minerals [13], [14]. As the temperature value increases, so does the TDS value. This statement does not follow the results of the analysis shown in Table 3, where spots A, B and C show higher temperatures from morning to afternoon. Still, the TDS value decreases from morning to afternoon. While in spot D, the results follow this statement: when there is an increase in temperature, there is also an increase in TDS.

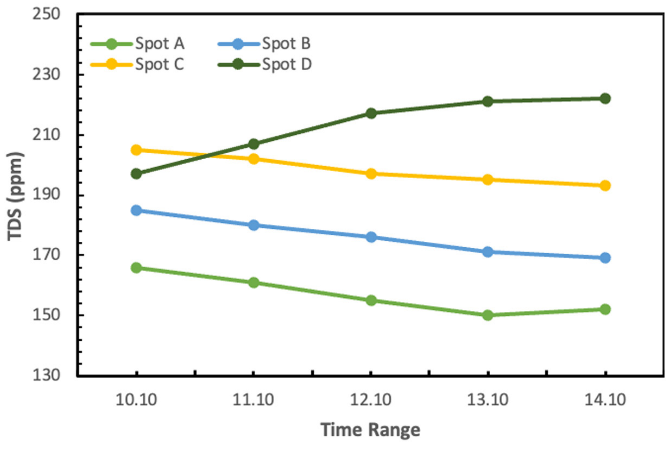

Fig. 15. TDS measurement results in river water

Waters in the Cikapundung River is a source of fresh water. Based on the results of the analysis obtained, TDS data at the four river points range from 152–222 ppm. This result follows the standard TDS value that can be used for sanitation, which is < 500 ppm, and following the standards set, freshwater sources should have a low TDS value of < 500 ppm.

5.4 Analysis of river water quality as seen from the pH factor

Analysis of pH value in river water is one of the chemical parameters that must be known to determine river water quality. Several factors affect the pH value of river water, namely rainfall, water hardness, discharges from industrial processes, and household waste into river water [11], [15]. Figure 16 shows that the pH value at the four river points ranges from pH = 7.93–8.16, which indicates that the PH of the water has an alkaline nature (> 7). This value follows river water quality standards for sanitation, which is in the range of pH = 6.5–8.5.

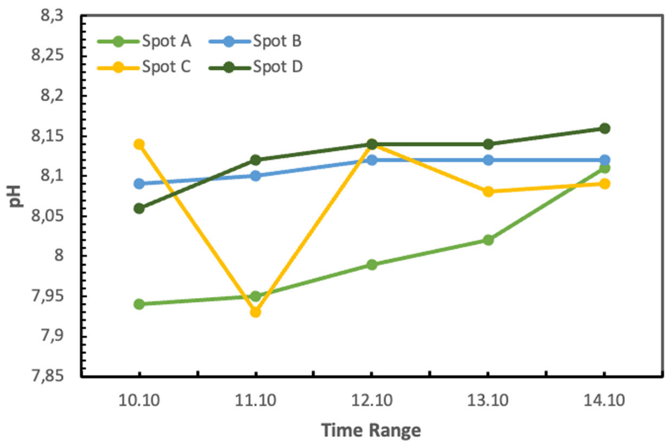

Fig. 16. pH measurement results in river water

6 CONCLUSIONS

This research shows the success in designing, developing, and testing river water quality using an Arduino UNO R3 microcontroller board with several sensors. The sensors used in this research are DS18B20 (temperature sensor), SEN0189-DFRobot (turbidity sensor), SEN0244-DFRobot (TDS sensor), and SEN0161/0169PH (pH sensor). The four sensors successfully tested the river water quality with a percentage error below 10% for all treatments. The test results show that the Cikapundung River, in terms of temperature, TDS, and pH factors, is in a safe condition. However, the turbidity value is quite high, in the 49.2–52.2 NTU range. These results provide recommendations for the community, policymakers, and related parties to work together to manage river water quality more optimally. Thus, river water quality will be better and can be managed and maintained sustainably.

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