WATER QUALITY MONITORING SYSTEM WITHOUT USING TDS PEN

DIVYA A[1]
School of Information Science and Engineering
Presidency University
Bengaluru, Karnataka, India
divyagowda280101@gmail.com

AMRITHA G S [2]
School of Electronics and Computer Engineering
Presidency University
Bengaluru, Karnataka, India
amrithagbabu@gmail.com

GEETHA D C[3]
School of Information Science and Engineering
Presidency University
Bengaluru, Karnataka, India
geethachanikuppi@gmail.com

SAPNA R[4]
Asst. Professor Computer Science and Engineering
Presidency University
Bengaluru, Karnataka, India
sapnar@presidencyuniversity.in

***Abstract*— A novel method of measuring water quality without the use of pricey equipment is the water quality monitoring system without TDS pens. It is intended to be inexpensive, portable, and precise and uses conductivity to determine the total dissolved solids. This abstract showcases a groundbreaking water quality monitoring system that utilizes the Internet of Things technology and eliminates the need for a TDS pen to test water quality. Creating an inexpensive, accurate, and lightweight system that can determine the safety of drinking water, regardless of its source, whether it is pure water, tap water, groundwater, or seawater, is the primary objective of this project. The Total Dissolved Solids, a crucial factor for establishing the quality of the water, are calculated by the suggested method using conductivity. We test the water's resistance while accounting for the container's length and cross-sectional area in order to determine the water's resistivity. We determine the conductivity from the resistivity, and then the TDS value follows. The Internet of Things-based water quality sensor project is made to be user-friendly, simple to use, and affordable, making it appropriate for usage both indoors and outdoors. The device has the potential to revolutionize the monitoring of water quality and support safe and responsible water use.**

Keywords—Water quality monitoring system, TDS pen, Internet of Things, resistivity, conductivity

I. INTRODUCTION

Water is a highly important component of life. We can't survive with no water. Approximately 71% of the outermost layer of the Earth is covered by water, of which 96.5 percent is in the ocean and only 3% is freshwater. The provision of clean and safe drinking water is one of the new real-world concerns since just 3% of water is fresh. The availability of high-quality drinking water has considerably declined as a result of scarce drinking water resources and an increasing population[1]. The lack of water sources in some parts of the globe and the intake of tainted water by at least two billion people are the primary issues associated with water quality that we are currently facing on a global scale[2].

The laborious collecting of water samples from different places was a part of the conventional ways of monitoring water quality. As a result, the Internet of Things (IoT) is an intriguing as it has the power to make anything "smart". Devices may talk with one another and exchange data online thanks to a technology called the Internet of Things (IoT). It has been used in many different applications, including the monitoring of water quality, Women safety, Drivers' safety, document verification and many more [3,4,5]. Sensors are used in IoT-based water quality monitoring systems to measure factors including pH, turbidity, and conductivity. These sensors can monitor and analyze data on water quality in real-time because they are linked to a central hub via the internet. IoT technology is utilized in water quality monitoring systems to provide more accurate and efficient monitoring, as well as to increase the process's accessibility and affordability. IoT-based water quality monitoring systems can be installed in various locations such as homes, commercial areas, and public spaces to supervise the quality of water sources. It will be possible to quickly address any problems with water quality, such as pollution or changes in water parameters, by using this technology[6] .

Water quality monitoring systems using IoT have the potential to revolutionize the industry and enhance the security and sustainability of water resources. Additionally, it can encourage more judicious use of water resources and raise awareness of problems with water quality.

Monitoring water quality is crucial to ensuring the security and sustainability of water resources. The use of expensive equipment is required by traditional methods of water quality monitoring, which are not always viable or accessible. Researchers have created a revolutionary water quality monitoring device that uses the IoT technology to assess water quality without the use of a TDS pen in order to solve this problem. This portable and affordable technology utilizes conductivity to measure the total dissolved solids (TDS) present in the water being tested.

It can be easier to identify patterns and trends in water quality data using IoT-based monitoring systems, providing crucial information on long-term trends in water quality. Sustainable use of water resources can be achieved by using this knowledge to improve water management practices and influence policy decisions.

In conclusion, the adoption of IoT technology for water quality monitoring holds great promise for enhancing the sustainability and safety of water resources, which would be favorable for the environment and society.

II. BACKGROUND STUDY

Systems for monitoring water quality are essential tools for guaranteeing the security of our water resources. More advanced systems are required to provide more precise and in-depth information on water quality, despite the use of TDS pens in traditional monitoring techniques.

A viable alternative to TDS pens is the use of a system for monitoring water quality based on sensors. The pH, temperature, turbidity, conductivity, and other characteristics can all be measured by this system using cutting-edge sensors. The information gathered by these sensors is then wirelessly transferred to a central data recorder that can be accessed from a distance that anticipates as one part of the entire proceedings, and not as an independent.

This system can include sensors and a real-time monitoring alarm system. With the help of this feature, it is possible to check the quality of the water continuously and to send out real-time notifications if any parameter deviates from the desired range. This guarantees that any possible problems with water quality are handled quickly and successfully.

Additionally, machine learning algorithms that analyze the gathered data and offer predictive insights can be used to improve this system. By doing so, it will be possible to identify potential problems with water quality before they arise and take preventative action [7,8,9].

Because good data helps us make good decisions, semantic interoperability has emerged as a key component of the Internet of Things' development. However, in order for applications for the IoT to function properly, good data understanding is also required. This can be incorporated with inclusion of linked data concepts of Web 3.0 when multi smart devices are used [10,11,12]

For the purpose of guaranteeing the quality of seafood study focused on monitoring the iodide content of sea water[13]. It was suggested to use a multi-sensor approach to gauge the iodate content of saltwater and subsequently the calibre of seafood. Their investigation demonstrated the viability of the suggested proof-of-concept. Nine distinct algorithms for machine learning were examined by [14] while data collection was carried out by an unmanned aerial vehicle (UAV). A map was created to show the locations of polluted water after it was determined that the Catboost regression model provides the best forecast. Akin to this, study created a UAV for Yangtze River air-water quality monitoring tasks[15].

A water intake monitoring system for cattle based on Arduino development boards was reported by Tang et al. in their work [16]. The suggested system can track and identify each animal in order to perform further research on the use of water by animals. It can also check the condition of the water. The study in [17] provided another system based on UAC and IoT for monitoring livestock.

Overall, compared to conventional TDS pens, the adoption of a sensor-based water quality monitoring system can offer an improved and more thorough approach to water quality monitoring. Its cutting-edge technologies, such as machine learning and real-time monitoring, can help guarantee the security and sustainability of our water supplies.

III. PROPOSED WORK

Using conductivity as a substitute for TDS pens, an IoT-based water quality monitoring system is being developed in the proposed work.

The water's resistance will be measured by the sensor, and the resistivity of the water will be calculated by the microcontroller. Using a calibration curve, the TDS value is calculated after converting the resistivity to conductivity. Your mobile device will receive real-time water quality data from the IoT module via a Bluetooth module.

For this, we need to take into account the container's length and cross-sectional area. The equation (1) is about Resistance R, where r is Resistivity, L is Length of container, A is Area of Cross Section of container and c is Conductivity

$$R = r\,L/A \qquad (1)$$

$$\Rightarrow r = R\,A/L \qquad (2)$$

From the resistivity, we can obtain the conductivity as in (2)

$$c = 1/r \qquad (3)$$

Finally, we obtain the TDS from the conductivity

$$TDS = c*7000 \qquad (4)$$

Then the system will be tested and calibrated using various types of water, including tap water, groundwater, and seawater. The system's accuracy and precision will be evaluated.

The TDS value increases with the increase in electrical conductivity. A compilation of TDS values for various water types is presented here in table 1.

Table 1: A compilation of TDS values for various water types

Sample	TDS
Pure water	80-150
Tap water	250-350
Groundwater	500-1000
Seawater	around 30000

To monitor water quality without the need for expensive TDS pens, the proposed work aims to offer a cost-effective, portable, and precise solution. A wide range of applications can benefit from the system's simplicity, accuracy, and ease of use. Demonstrating the potential of IoT technology to revolutionize the monitoring of water quality and support safe and responsible practices will be the main outcome of this study.

A. Supplies and components

1)Arduino UNO(1)
2) 330 ohm Resistor(1)
3) Jumper Wires Female/Male
4) Diffused Common Cathode RGB(1)
5) generic rotary potentiometer(1)
*6) 16*2 Alphanumeric LCD,(1)*
7) Bluetooth Module(HC-05)(1)
8) kilohm resistor(1)

B. Tools, Machines, Apps and Platforms

Ardutooth, Wire Stripper & Cutter, Solid & Stranded Wires, 26-14 AWG, Arduino IDE(1)

IV. THE CIRCUIT AND COMPONENTS

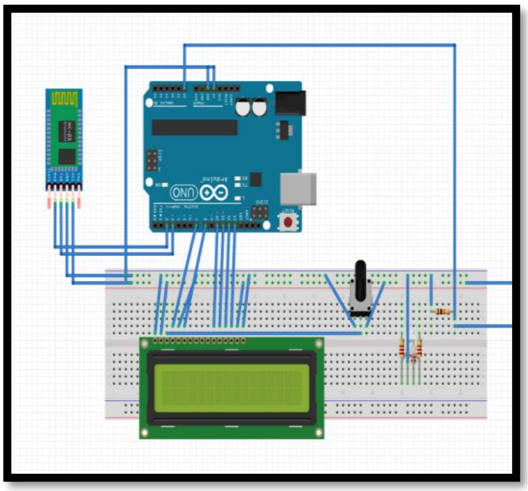

FIG 1: CIRCUIT DIAGRAM COMPONENTS

a) ARDUINO

- Connect the Arduino's 5V to a breadboard power rail.
- Connect the ground of the Arduino to the other power rail of the breadboard.
- The ground should be connected to one end of the 1k-ohm resistor and the other end should be connected to the breadboard. Attach the resistor to pin A0 of the Arduino's analog input. Attach a wire to the resistor and another to 5V, lastly. Connect the crocodile clips to the free ends of these wires.

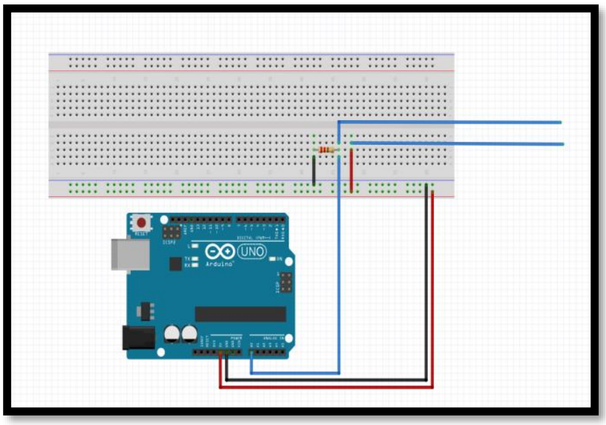

FIG 1.1 : ARDUINO CONNECTION

b) LCD DISPLAY

- Connect the VSS pin to the ground rail.
- Connect the 5V rail and the VDD pin.
- Connect the center pin of the potentiometer to V0.
- Potentiometer ends ought to be linked to the ground and 5 volts.
- Connect the Arduino's RS pin to pin 7.
- The ground rail must be attached to the R/W pin.
- Connect the Arduino pin and the E pin. 8
- Connect D4 to pin 10 of the Arduino, D5 to pin 11, D6 to pin 12, and D7 to pin 13.

VOLUME: 07 ISSUE: 05 | MAY - 2023 IMPACT FACTOR: 8.176 ISSN: 2582-3930

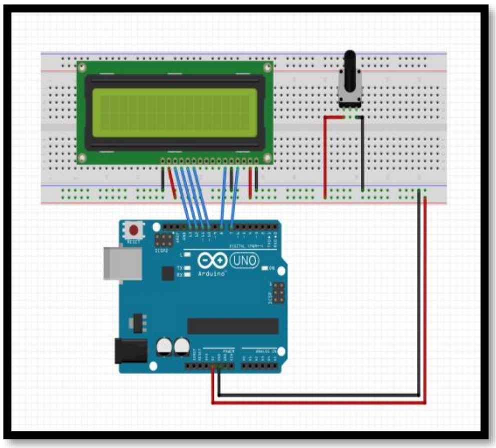

FIG 1.2 : LCD DISPLAY CONNECTION

c) HC-05 BLUETOOTH MODULE

- Connect the 5V rail and the VCC pin.
- Connect the GND pin to the earth.
- Connect Arduino pin 3 (which serves as the RX) to the TX pin.
- RX pin to Arduino pin 2 connector (which serves as TX).

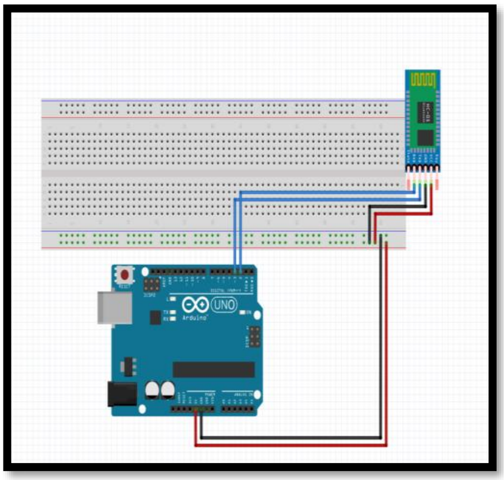

FIG 1.3 : HC-05 CONNECTION

c) RGB LED

- The common cathode (longest pin) should be connected to the ground.
- Attach the red pin (located to the right of the cathode pin) to Arduino's PWM pin 9 through a 330-ohm resistor.
- Using a 330-ohm resistor, connect the green pin (located to the left of the cathode pin) to PWM pin 6 of Arduino.
- Using a 330-ohm resistor, connect the far left blue pin of the Arduino to PWM pin 5.

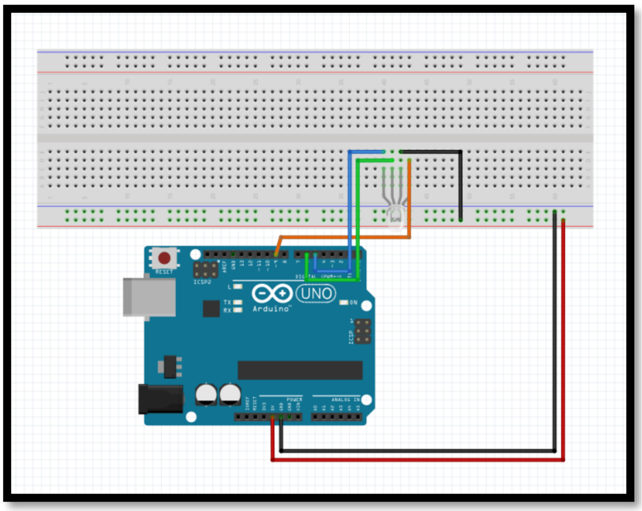

FIG 1.4 : RGB LED CONNECTION

V. FORMULA FOR DETERMINING THE RESISTANCE BETWEEN OPEN WIRES

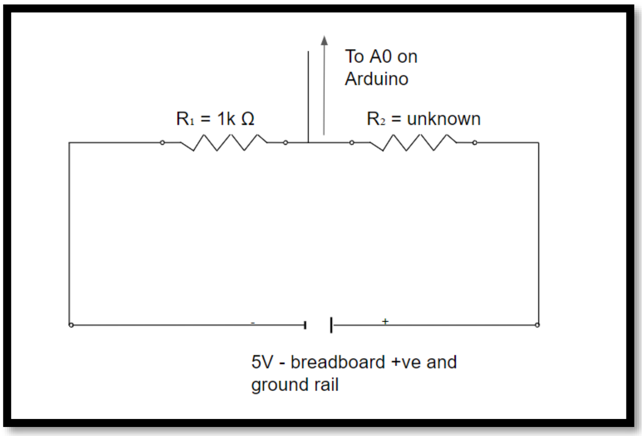

FIG 2 : Resistance system diagram

Although there is a wire connecting the two resistors (R1 being a 1000-ohm resistor, and R2 being between the free wires) to the Arduino's Analogue pin A0, its resistance can be ignored, so we can conclude that only a small amount of current flows through the wire. Therefore, R1 and R2 are coupled in series.

It can be stated that V1 equals IR1 and V2 equals IR2.

Therefore, it can be concluded as in (5)

R2/R1 = IR2/IR1 = V2/V1. (5)
However, we are not aware of V2.
We are aware that
V1+V2 = V, (6)
where V is equal to 5 Volts, in a series configuration of resistors. This leads to the equation (7)
V2 = 5V1 (8)
Finally, we may create a variable buffer to be 5-V1/V1 instead of V2/V1 by inserting the value we obtained for V2 in V2/V1 = R2/R1.

Finally, (8) can be stated.
R2 = buffer * R1 (8)
First, we will calculate the resistance of the water being tested in order to determine its resistivity. To do this, we must consider the length and cross-sectional area of our container.

So, R A/L equals r. (9)

The resistivity allows us to obtain the conductivity, which is equal to 1/r.

Finally, we calculate the TDS using the formula (10)

TDS = c*7000. (10)

VI. RESULTS AND DISSCUSSION

Water quality monitoring systems without TDS pens have become increasingly popular in recent years due to their ability to provide accurate and reliable measurements of various water quality parameters. Cutting-edge sensors and analytical techniques are used to analyze and detect a variety of water quality indicators, including pH, dissolved oxygen, turbidity, and conductivity, by these systems.
These technologies have produced highly encouraging findings, demonstrating the capacity to precisely detect and quantify a variety of toxins and pollutants in water bodies. This has been very helpful in locating the origins of pollution and putting in place efficient cleanup techniques.

These systems have also demonstrated to be quite adaptive and versatile, making them suited for a variety of applications, from monitoring water quality in natural bodies of water to monitoring the efficiency of industrial operations and water treatment systems.

The results are tabulated as shown in the below figures and table 2.

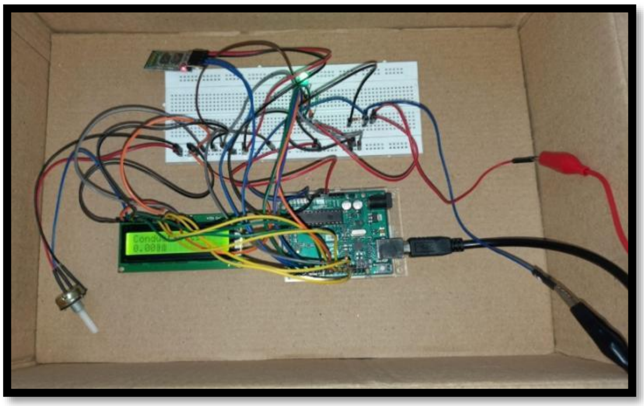

FIG 3 : WORKING MODEL

The complicated operation of our project, which has been painstakingly created and built to satisfy the particular criteria of our objectives, is depicted in the figure that is presented. The project's numerous parts have all been meticulously and precisely attached to one another and organized in line with the circuit diagram, as shown.

The project's parts have all been carefully chosen to assure their best performance and functionality. The complicated interplay between each component and the crucial role they play in attaining the desired results are highlighted by the intricate network of wires and connections.

A. RESULTS ON DIFFERENT TYPES OF WATER

I. TAP WATER

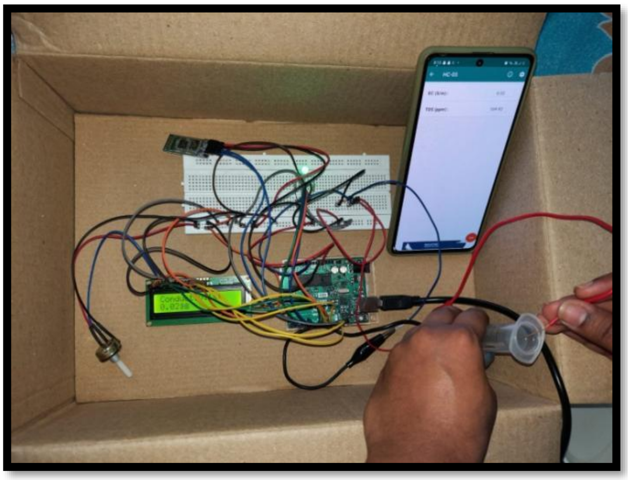

FIG 3.1 : Conductivity and TDS readings for Tap Water Sample1

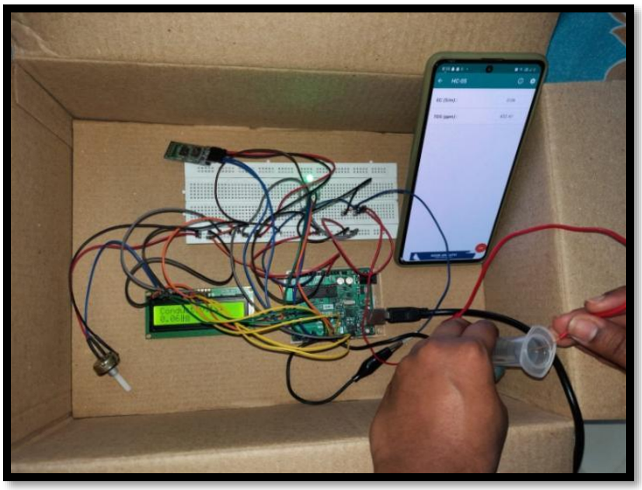

FIG 3.1.1 : Conductivity and TDS readings for Tap Water Sample2

The tap water sample's conductivity was measured using our water quality monitoring system, and a value of 0.06 S/m was determined. The anticipated TDS value for the tap water sample would be 250 to 350 ppm using the generally used conversion ratio of 0.7 (0.06 S/m x 0.7 ~ 350 ppm).

It's crucial to keep in mind that this TDS number is an estimate based on the conductivity test and the conversion factor, and could not be as precise as a direct measurement using a TDS pen. The particular conversion factor can also change based on the make-up of the dissolved solids in the water.

II. SALT WATER

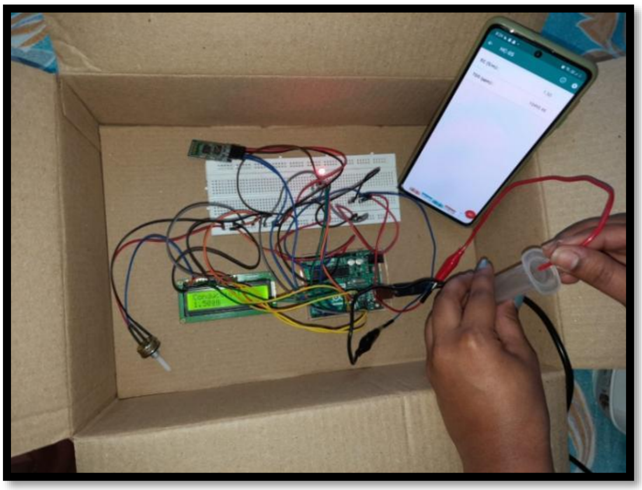

FIG 3.2 : Conductivity and TDS readings for Salt Water Sample1

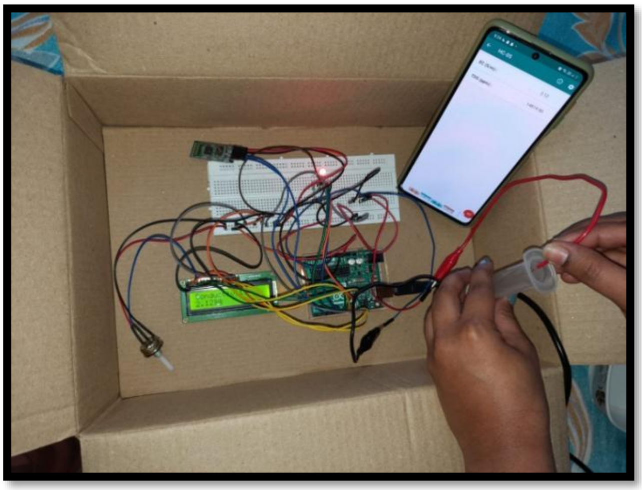

FIG 3.2.1 : Conductivity and TDS readings for Salt Water Sample2

Our water quality monitoring system's conductivity measurement of the salt water sample revealed a conductivity value of 1.50 S/m. It is expected that the conductivity value would be higher since salt water has a larger concentration of dissolved solids than tap water.

The anticipated TDS value for the salt water sample would be around 3000 or more using the generally used conversion ratio of 0.7 (1.50 S/m x 0.7 ~ 10495.48 ppm).

It's crucial to keep in mind that this TDS number is an estimate based on the conductivity test and the conversion factor, and could not be as precise as a direct measurement using a TDS pen. Additionally, the dissolved solids' composition can affect the precise conversion factor.

III. PURE WATER

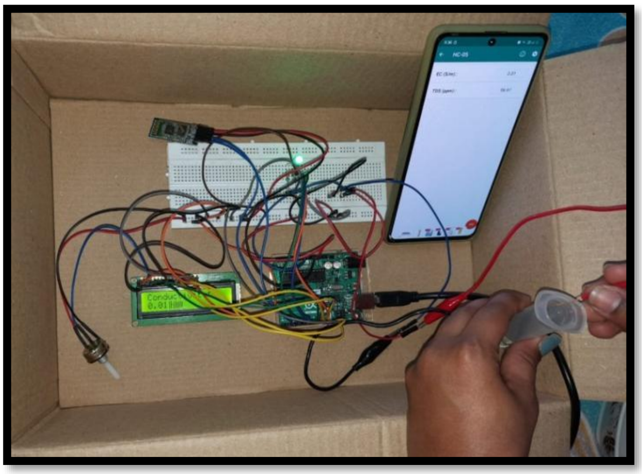

FIG 3.3 : Conductivity and TDS readings for Pure Water Sample1

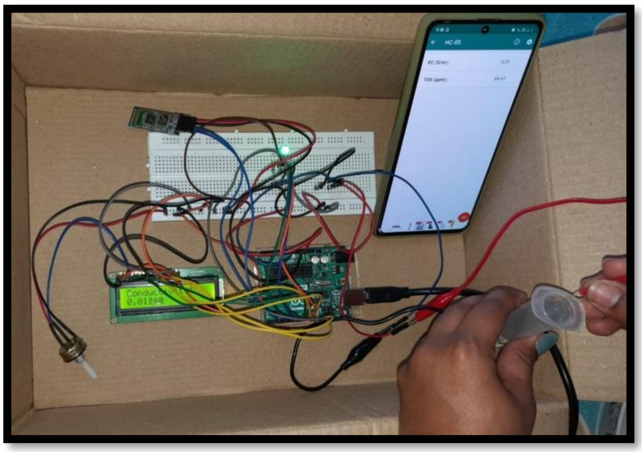

FIG 3.3.1 : Conductivity and TDS readings for Pure Water Sample2

Typically, pure water has a low concentration of dissolved solids, which results in a low conductivity rating. Our water quality monitoring system determined the conductivity value of the pure water sample to be 0.01 S/m, which is within the normal range for pure water. This value was determined based on the conductivity measurement of the sample.

The anticipated TDS value for the clean water sample would be between 80 to 150 ppm using the generally used conversion ratio of 0.7 (0.01 S/m x 0.7 ~ 96.61 ppm).

It's crucial to remember that getting an accurate TDS estimate from conductivity alone might be difficult because pure water has a low concentration of dissolved solids. The particular conversion factor can also change based on the make-up of the dissolved solids in the water.

In concise, here are the values in tabulated format.

TABLE 2 : Conductivity and TDS values of different water types.

Water Type	Conductivity (S/m)	TDS (ppm)
Tap Water	0.02	169.92
	0.06	432.41
Salt Water	1.50	10495.48
	2.12	14819.90
Pure Water	0.01	96.61
	0.01	99.47

Our non-TDS pen water quality monitoring system has several advantages over conventional TDS pen approaches, in conclusion. By eliminating the need for a TDS pen, our technology reduces the cost of monitoring water quality while maintaining accurate readings. Various studies explain a water quality monitoring system that utilizes a TDS pen [18-22]. The survey was conducted solely on a sample of pure water. We also analyzed the quality of water from three distinct sources: tap water, salt water, and pure water. This research expands on past studies that only examined pure water samples. Table 1's findings from our analysis demonstrate how effectively our technology can identify the water quality of various types of samples of water. Overall, our work significantly advances the field of water quality monitoring and has the potential to improve the accuracy and accessibility of water quality measurements in a variety of settings.

VII. CONCLUSION AND FUTURE WORK

Last but not least, the proposed IoT-based water quality monitoring system that determines total dissolved solids using conductivity offers a cheap, portable, and accurate option for water quality monitoring. Using a simple and user-friendly method of measuring the water's resistance and converting it to conductivity, this device can determine whether or not the water being tested is safe to drink. Additionally, the device's accessibility and usability make a variety of uses, both indoors and outdoors, possible. The findings of this study show how IOT technology has the potential to revolutionize water quality monitoring, promoting safe and responsible water use. The suggested system may have substantial effects on the water sector and increase access to clean water in places where limited access to pricey testing equipment. An essential component of our present project is measuring conductivity in order to determine Total Dissolved Solids (TDS). TDS alone, however, cannot be used to evaluate the water's quality. As a result, we intend to improve our project by taking measurements of additional important water characteristics like pH, turbidity, and temperature. By including these characteristics, we will have a more thorough picture of the water quality and be better able to spot any possible problems. This will provide us the ability to take the required steps to guarantee that the water is safe for eating and other uses.

REFERENCES

[1] Chen, Yiheng, Han, Dawei, (2018). Water quality monitoring in the smart city: a pilot project. Automat. Construct. J. 89, 307–316

[2] World Health Organization. Guidelines for Drinking Water Quality, Recommendations; WHO Library Cataloguing-in-Publication Data: Geneva, Switzerland, 2017; Volume 1.

[3] Raja, S. P., Rachel, S. S., & Sapna, R. (2021, December). Women's Safety with a Smart Foot Device. In *2021 4th International Conference on Computing and Communications Technologies (ICCCT)* (pp. 570-573). IEEE.

[4] Preetham, M., Raja, P., Sapna, R., Banu, V., & Sivaraju, S. S. (2022, September). Investigations on Improving Drivers' Safety using Artificial Intelligence and Internet of Things. In *2022 4th International Conference on Inventive Research in Computing Applications (ICIRCA)* (pp. 404-409). IEEE.

[5] Pavithra, N., Manasa, C. M., & Sapna, R. (2022, July). Smart Vehicle Document Verification System Using IoT. In *2022 IEEE International Conference on Data Science and Information System (ICDSIS)* (pp. 1-5). IEEE.

[6] Singh, M., & Singh, R. K. (2021). Internet of Things Based Water Quality Monitoring System. In Proceedings of the 3rd International Conference on Computer Networks, Big Data and IoT (pp. 117-123). Springer, Singapore

[7] Hussein, E.A.; Thron, C.; Ghaziasgar, M.; Bagula, A.; Vaccari, M. Groundwater Prediction Using Machine-Learning Tools. Algorithms 2020, 13, 300.

[8] Huangfu, K.; Li, J.; Zhang, X.; Zhang, J.; Cui, H.; Sun, Q. Remote Estimation of Water Quality Parameters of Medium- and Small-Sized Inland Rivers Using Sentinel-2 Imagery. Water 2020, 12, 3124

[9] Eldesouky, E.; Bekhit, M.; Fathalla, A.; Salah, A.; Ali, A. A Robust UWSN Handover Prediction System Using Ensemble Learning. Sensors 2021, 21, 5777.

[10] Amara, F. Z., Hemam, M., Djezzar, M., & Maimour, M. (2022). Semantic web technologies for internet of things semantic interoperability. In *Advances in Information, Communication and Cybersecurity: Proceedings of ICI2C'21* (pp. 133-143). Springer International Publishing.

[11] Sapna, R., Monikarani, H. G., & Mishra, S. (2019, February). Linked data through the lens of machine learning: an Enterprise view. In *2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)* (pp. 1-6). IEEE.

[12] HG, M. R., & Mishra, S. (2018, October). An investigative study on the quality aspects of linked open data. In *Proceedings of the 2018 International Conference on Cloud Computing and Internet of Things* (pp. 33-39).

[13] Zompanti, A.; Grasso, S.; Sabatini, A.; Vollero, L.; Pennazza, G.; Santonico, M. A Multi-Sensor System for Sea Water Iodide Monitoring and Seafood Quality Assurance: Proof-of-Concept Study. Sensors 2021, 21, 4464.

[14] Lu, Q.; Si, W.; Wei, L.; Li, Z.; Xia, Z.; Ye, S.; Xia, Y. Retrieval of Water Quality from UAV-Borne Hyperspectral Imagery: A Comparative Study of Machine Learning Algorithms. Remote Sens. 2021, 13, 3928.

[15] Liu, H.; Yu, T.; Hu, B.; Hou, X.; Zhang, Z.; Liu, X.; Liu, J.; Wang, X.; Zhong, J.; Tan, Z.; et al. UAV-Borne Hyperspectral Imaging Remote Sensing System Based on Acousto-Optic Tunable Filter for Water Quality Monitoring. Remote Sens. 2021, 13, 4069.

[16] Tang, W.; Biglari, A.; Ebarb, R.; Pickett, T.; Smallidge, S.; Ward, M. A Smart Sensing System of Water Quality and Intake Monitoring for Livestock and Wild Animals. Sensors 2021, 8, 2885.

[17] Behjati, M.; Mohd Noh, A.B.; Alobaidy, H.A.H.; Zulkifley, M.A.; Nordin, R.; Abdullah, N.F. LoRa Communications as an Enabler for Internet of Drones towards Large-Scale Livestock Monitoring in Rural Farms. Sensors 2021, 21, 5044.

[18] Ahmed, S., Ahmed, S., & Alam, M. M. (2019). Design and implementation of an automated water quality monitoring system using IoT. International Journal of Electrical and Computer Engineering (IJECE), 9(2), 1227-1234.

[19] Singh, M., & Singh, R. K. (2021). Internet of Things Based Water Quality Monitoring System. In Proceedings of the 3rd International Conference on Computer Networks, Big Data and IoT (pp. 117-123). Springer, Singapore.

[20] Chen, S., & Shih, Y. (2019). Development of an IoT-based Water Quality Monitoring System. Journal of Marine Science and Engineering, 7(12), 457.

[21] Goyal, N., Kumar, V., & Goyal, P. (2020). IoT based water quality monitoring system. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 5(1), 20-26.

[22] Kaur, M., & Singh, J. (2020). IoT-based Water Quality Monitoring System. International Journal of Innovative Technology and Exploring Engineering, 9(5), 1695-1700