© 2022 IJNRD | Volume 7, Issue 7 July 2022 | ISSN: 2456-4184 | IJNRD.ORG

Real-Time Water Quality Monitoring Device

1st Basavprasad Siriyannavar
Dept. Electronics & Communication Engineering
Dayanand Sagar College of Engineering
1DS183EC701@dsce.edu.in

2nd Satyam Kumar Singh
Dept. Electronics & Communication Engineering
Dayanand Sagar College of Engineering
1DS18EC723@dsce.edu.in

3rd Sahir Shrivastava
Dept. Electronics & Communication Engineering
Dayanand Sagar College of Engineering
1DS183EC748@dsce.edu.in

4th Sidharth Sitesh
Dept. Electronics & Communication Engineering
Dayanand Sagar College of Engineering
1DS18EC754@dsce.edu.in

5th Chaitra A.
Assistant Professor
Dept. Electronics & Communication Engineering
Dayanand Sagar College of Engineering
chaitra-ece@dsce.edu.in

***Abstract*—Water pollution has caused a lot of damage to our world in the past few years. The natural resources are depleting, causing a lot of problems for all living organisms. One major problem among them is access to clean, consumable water. We came across this problem while reading a newspaper report on how at a residential township in urban Bangalore, India, due to heavy rainfall, sewage water got mixed up with the drinking water which led to a severe mishap. The objective of this water quality monitoring device is to always keep its user updated about the quality of water they are consuming in real-time whereas the traditional method of analyzing water quality is to collect samples of water manually and send them to the lab for tests and assessments. This method is time-consuming, wastes manpower, and is not economical. The water quality measuring system that we have designed judges the quality of water in real-time through various sensors (one for each parameter: pH, total dissolved solids, temperature, and Turbidity) to measure the quality of water thus creating an integrated system based on Internet of Things. The use of Arduino Uno and Nodemcu as an embedded systems will help in the assembly of sensor devices and the use of firewall communications technology can help the interaction of sending data between things. We can implement our design in residential and commercial water tanks or essentially any water container. This system will keep a strict check on the quality of water supplied in our homes and offices and notify the user on their mobile phone in real-time.**

***Index Terms*—Arduino, NodeMCU, TDS Sensor, pH Sensor, Turbidity Sensor, Temperature Sensor, IoT, Firebase, Kotlin**

I. Introduction

Water safety is a challenge due to the abundance of toxins, most of which are man-made. Over exploitation of natural resources is the primary cause of water quality issues. Water contamination has been caused to a considerable extent by the quick rate of industrialization and increased emphasis on agricultural growth, combined with the latest innovations, agricultural fertilizers, and non-enforcement of laws. Rainfall distribution is not always uniform, which exacerbates the problem. Individual practices play a significant impact in water quality. Point and non-point pollution sources, such as sewage discharge, industrial discharge, agricultural run-off, and urban run-off, all have an impact on water quality. Floods and droughts, as well as a lack of knowledge and education among users, are other sources of water pollution. The importance of user participation in water quality maintenance, as well as consideration of other factors such as hygiene, environmental sanitation, storage, and disposal, are key considerations in preserving water resources. As a result of poor quality water consumption, approximately 40 lakh people died in the world(Water resource info. System of India, 2017). It has a severe impact on the country's economy as well. The river water is often contaminated with fertilizers and pesticides which are washed through the farm soil by rains, other contaminants such as industrial waste also end up in rivers and enter the food chain killing lots of living species. Another concerning practice that affects the quality of water is to use of river water as coolants for factory machinery which increases the river water temperature and reduces its dissolved oxygen content, upsetting the balance of life. Due to all of these factors, some avoidable and some unavoidable, Real-Time Water Quality Monitoring is essential. Our main objective is to include measurement of very important physical, and chemical properties of water and provide a detailed analysis of the same to the user, thus ensuring the user always has Real-time analysis of their drinking water.

A. Overview

In this project, we are going to take four sensors that are necessary to successfully analyze the quality of drinking water. The four sensors are namely; pH sensor, TDS sensor, Turbidity sensor, Temperature sensor All these sensors are connected to the NodeMCU and Arduino UNO, and the code is already dumped into the module. The device can also be powered by a lithium-ion battery, After the device is put in its place by the user, the device accurately displays the data acquired by the above sensors on the user's mobile phone.

B. Literature survey

Due to the fast rise in population and the need to fulfill the demand for agriculture, industrial, and personal usage, existing resources are depleting and water quality is deteriorating. Insecticides and pesticides have an impact on the quality of groundwater. Due to industrial pollution and untreated sewage discharge, India's rivers are becoming contaminated. CPCB aims to go hi-tech and develop a "Real-Time Water Quality Monitoring (WQM)" Network across the Ganga Basin to minimize difficulties associated with manual water quality monitoring. Stephen Brosnan [1], 2007, looked at using a wireless sensor network (WSN) to collect real-time water quality data (WQP). Quio Tie-Zhen [**?**], 2010 created a GPRS/GSM-based online water quality monitoring system. The data was relayed via the GPRS network, allowing the WQP to be checked remotely. Kamal Alameh [2], combining ZigBee and WiMAX networks, proposed a web-based WSN for monitoring water contamination in 2011. Various WQP were measured by the system. To monitor water quality over long distances, it gathered, analyzed, and routed measured data from sensors through a ZigBee gateway to a web server through a WiMAX network. The system may detect water contamination in real-time. Dong He [3], 2012, created a WQM system. The ZigBee network was used to power the remote sensor. WQP was put to the test by WSN.

C. Objectives / Scope / Aim of the project work

Our objective is to use the Internet of Things technology supported by sensors that help in retrieving critical data and displaying the said data on the user's mobile phone application. We can extend the quality of detection by finding other parameters like conductivity, dissolved ions, and salinity.

D. Methodology

The system uses four sensors (pH, TDS, Turbidity, and Temperature), a processing module Arduino Uno, and node MCU(ESP8266). The temperature and pH sensor collect data in the form of analog signals while the TDS and turbidity sensor capture it in the form of digital signals. The Analog signals are converted into digital with the help of an ADC. The microcontrollers will process the digital information and analyze it and the data collected from the sensors will be displayed on the user's mobile app via the Wi-Fi module (node MCU ESP826). Embedded C coding helps to carry out the whole process. We used Arduino IDE software to simulate the code. The data is processed through the Arduino Uno and transferred via NodeMCU to the user. This data can be accessed by the User by logging into their accounts with a User ID and Password. This whole process of collection, analysis, and transmission of data is in Real-Time. Arduino Uno is an ATmega328P-based microcontroller board. It consists of 14 digital input/output pins (6 are capable of PWM), 6 analog inputs, a USB connection, a 16MHz ceramic resonator (CSTCE16MOV53-R0), and an ICSP header, and a reset button. The operating voltage is 5V and the recommended input voltage is 7-12V. It has a flash memory of 32KB of which 0.5 KB is used by the bootloader. [4] The ESP8266 is a low-cost Wi-Fi module that consists of a Wi-Fi chip with a full TCP/IP stack and a micro controller chip manufactured by M/S Espruino. Both the firmware and the board are open source. [5] To communicate between a microcontroller and a Wi-Fi module, only two wires (Tx/Rx) are required. It transfers Wi-Fi-related activities to the module, making the microcontroller code much lighter. Because the Wi-Fi Module can be addressed through SPI and UART, it's simple to create an Internet of Things application.

II. Block diagram, Circuit Diagrams and Working principle, Algorithms, Flow-Charts DFDs

A. Block Diagram

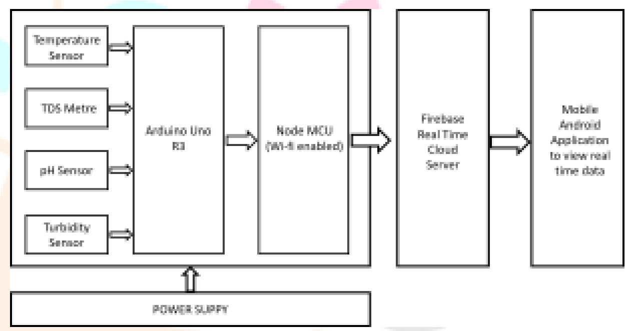

Fig. 1. Block Diagram of the module

The first block depicts the hardware device, it consists of four water quality sensors

- Temprature Sensor
- TDS Metre
- pH Sensor
- Turbidity sensor

Analog signal from temprature sensor and digital signal from other three sensors are sent to the Arduino Uno R3 microcontroller. The code for all three sensors at their respective pin is dumped into the microcontroller and then the data is sent to the Node MCU microcontroller which is wifi enabled. It is a gateway for the hardware part which takes the data from arduino board and sends it to the cloud server Firebase which have realtime database encoded. This whole hardware device is powered by a 5V rechargable battery. Firebase project link and database key is dumped in Node MCU microcontroller before connecting the device to the wifi. The Firebase cloud server recieves real time data, it has got 4 input parameters, Temprature, TDS, pH and Turbidity. It then combines 4 different parameters of the hardware sensors making one common scale to measure the quality of the water, real time cloud computing. Then all the 5 different values are sent to the android application which the user have, the api of the firebase database is coded beforehand during app development.

The feature-rich android application has a water quality index text view that rates the water in the scale of 0-100, 0 being the worst and 100 being the best. The user can also click on detailed analysis to see the live readings of each individual sensor, Real Time Water Quality Metre.

B. Circuit Diagram

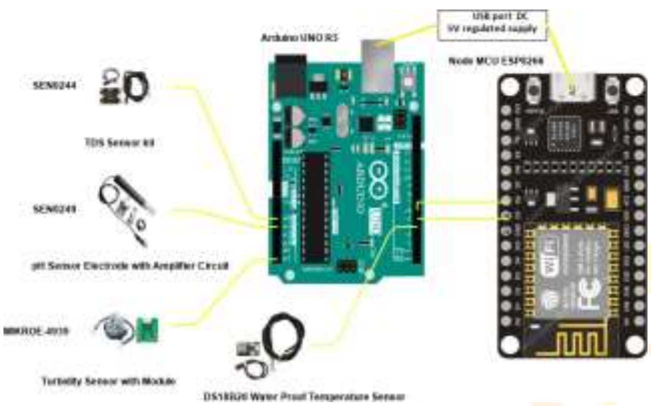

Fig. 2. Circuit Diagram of the module

Here in the above circuit diagram we have four sensors:

- SEN0244 TDS Sensor
- SEN0246 pH Sensor
- MIKROE-4939 Turbidity Sensor
- DS18B20 Temprature Sensor

And two microcontrollers

- Arduino UNO R3
- Node MCU ESP8266

The connections between the various components are made accordingly -

- TDS sensor is connected to the A0 pin of analog input.
- pH sensor is connected to the A1 pin of analog input.
- Turbidity sensor is connected to the A5 pin of analog input.
- Temprature sensor is connected to the 4th pin of digital input.
- To send the data from Arduino UNO R3 to Node MCU ESP8266 we have connected the -5 and -6 digital pin of Arduino UNO to D5 D6 pin of Node MCU.
- Both the microcontrollers are powered by USB port DC 5V regulated supply

C. Water Quality Index Scale

Here we have given equal percentage of 25% to each parameter of Temprature, pH, Turbidity and TDS.

- For Temperature, the lower limit is 5° C and the upper limit is 25° C giving us the range of 20 =¿ 25/20=1.25 So, for each ° Celsius out of this range the index will reduce by 1.25

SCALE OF 100 TO DISPLAYED AS WATER QUALITY INDEX

	25	25	25	25
	Temperature	pH	Turbidity	TDS
DRINKING WATER	6 - 20 C	5.5 - 9	1 - 5 NTU	50 - 150 PPM
SURFACE WATER	5 - 25 C	6.5 - 9.5	1 - 10 NTU	50 - 500 PPM
ERROR FORMULA	1 ~ 1.25	1 ~ 7.14	1 ~ 2.5	1 ~ 0.055

Fig. 3. Index scale of water quality according to parameters

- For pH, the lower limit is 5.5 and the upper limit is 9.5 giving us the range of 4 =¿ 25/4=7.14 So, for each pH out of this range the index will reduce by 7.14
- For Turbidity, the lower limit is 0 NTU and the upper unit is 10 NTU giving us the range of 10 =¿ 25/10=2.5 So, for each NTU out of this range the index will reduce by 2.5
- For TDS, the lower limit is 50 PPM and the upper limit is 500 PPM giving us the range of 450 =¿ 25/450=0.055 So, for each PPM out of this range the index will reduce by 0.055

D. Mobile Application

Android application is developed using Kotlin language, it will show the Water quality index in the first page under Water quality meter text. After clicking on Detailed Report button it will take us to the next page which will show the individual value of each sensors that we are using.

1) Flow Chart:

III. Specifications and Working of the Project Module

A. Hardware Specifications

1) Sensory Part: Arduino UNO

The Arduino Uno is a microcontroller board based on the Microchip ATmega328P microcontroller that is open-source. The board features 14 digital I/O pins (six of which are capable of PWM output), 6 analogue I/O pins, and is programmable via a type B USB cable using the Arduino IDE (Integrated Development Environment). It can be powered by a USB cable or an external 9V battery, with voltages ranging from 7 to 20 volts.

In this project, the Arduino UNO acts as the main controller controlling all the sensors(nodes).

DS18B20 Water Proof Temperature Sensor Probe

The temperature range for this sensor is -55°C to 125°C (-67°F to +257°F). It has a resolution range of 9 to 12 bits and works with 3.0V to 5.5V power/data. From -10°C to +85°C, it has a 0.5°C accuracy.

In this project, we have connected to data line of the temperature sensor probe to the digital pin 4 of Arduino UNO for measuring the temperature of the water.

Analog pH Sensor Electrode with Amplifier Circuit (Kit)

The pH probe and sensor board are included in the sensor kit, with the latter being used to signal condition the pH probe

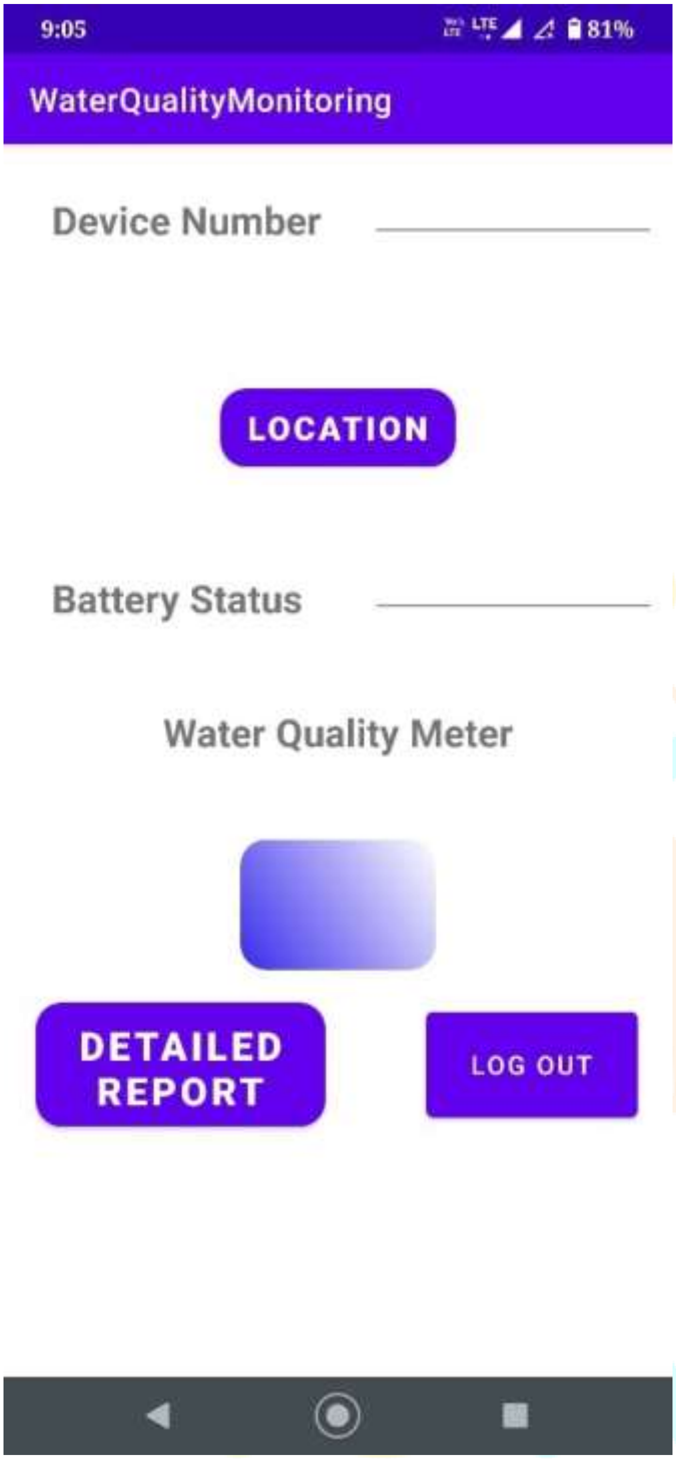

Fig. 4. The Layout of the Mobile App

output to 0-5V. The pH probe can detect pH levels ranging from 1 to 14. The glass electrode and the reference electrode are the two electrodes that make up a conventional pH sensor.

In this project, we have connected the pH analog output (PO) to analog input pin A1 of Arduino UNO for measuring the pH of the water.

Turbidity Sensor with Module

Fig. 5. The various parameters considered while testing and their ranges

The turbidity sensor has a 5VDC operating voltage and a 30mA minimum current. It can detect particles suspended in water and determine water quality at temperatures ranging from -30 to 80 degrees Celsius. It measures light transmittance and scattering rate, which fluctuates with the amount of total suspended solids (TSS) in water, to identify suspended particles in water. The level of liquid turbidity rises as the TTS rises.

In this project, we have connected the turbidity sensor kit's output pin to analog input pin A5 of Arduino UNO for measuring the turbidity of the water in NTU (Nephelometric Turbidity unit).

TDS Sensor Kit

A TDS metre is essentially an electrical charge (EC) metre

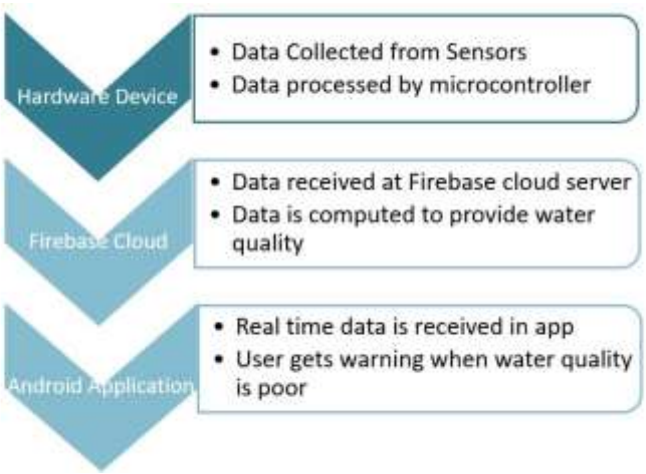

Fig. 6. Flowchart of the entire process

Fig. 7. The structure of an Arduino UNO

that measures charge by inserting two electrodes evenly spaced into water. The TDS metre interprets the result and converts it to a ppm value. This kit accepts 3.3–5.5V broad voltage input and outputs 0–2.3V analogue voltage, making it suitable for use with 5V or 3.3V control systems or boards.

In this project, we have connected the TDS sensor kit's output pin to analog input pin A0 of Arduino UNO for measuring the TDS (Total dissolved solids) of the water in ppm (parts per million).

2) Gateway Part: Node MCU ESP8266

Node MCU is an open-source Lua-based firmware and development board developed exclusively for Internet of Things (IoT) applications. It provides firmware that operates on Espressif Systems' ESP8266 Wi-Fi SoC and hardware based on the ESP-12 module. The Node MCU/ESP8266 features 17 GPIO pins that may be programmatically allocated to functionalities like I2C, I2S, UART, PWM, IR Remote Control, LED Light, and Button.

In this project, Node MCU ESP8266 is used as gateway device that receives the sensors' output data from Arduino UNO and transfers it to Firebase real-time database via internet

Fig. 8. DS18B20 Water Proof Temperature Sensor Probe

Fig. 9. Analog pH Sensor Electrode with Amplifier Circuit Kit

(Wi-Fi). The digital PWM pins of Arduino UNO 5(taken as Tx) and 6(taken as Rx) are connected to digital pins of Node MCU D5(taken as Rx) and D6(taken as Tx) respectively for serial data transfer.

B. Software Specifications

*1) **Arduino IDE**:* The Arduino integrated development environment (IDE) is a Java-based cross platform application (for

Fig. 10. Turbidity Sensor with Module

Fig. 11. TDS Sensor Kit

Microsoft Windows, macOS, and Linux). It emerged from the IDE for the Processing and Wiring programming languages. It comes with a code editor that enables text cutting and pasting, text finding and replacement, automated indenting, brace matching, and syntax highlighting, as well as one-click compiling and uploading to an Arduino board. A message area, a text terminal, a toolbar with common function buttons, and a hierarchy of operation menus are also included. The GNU (General Public License), version 2 is used to license the IDE's source code.

In this project, the Arduino IDE is used program the Arduino UNO to fetch the sensors' outputs, manipulate them

Fig. 12. Node MCU ESP8266

Fig. 13. Arduino Integrated Development Environment

and transfer them to the gateway device (Node MCU). The Arduino IDE is also used to program Node MCU ESP8266 to fetch data from Arduino UNO and transfer the same to firebase real-time database via internet (Wi-Fi).

*2) **Firebase Cloud Server**:* Firebase is a Google Cloud Platform-based Backend-as-a-Service (BaaS) that began as a YC11 business and has evolved into a next-generation app development platform. It is platform which allow to build web and mobile applications without server side programming language. You can store users data on its real-time database which sync data among users data in no time. Firebase is a google product which offers so many useful features. Like 1. Real time database. 2. Push notification. 3. Firebase Analytics. 4. Firebase Authentication. 5. Firebase Cloud Messaging. 6. Firebase Storage. 7. Firebase Hosting. A cloud-hosted database, the Firebase Real-time Database. Data is saved in JSON format and synchronized in real time with all connected clients. When you use our Apple, Android, and JavaScript SDKs to create cross-platform apps, all of your clients share a single Real-time Database instance and are automatically

Fig. 14. Firebase

updated with the most recent data.

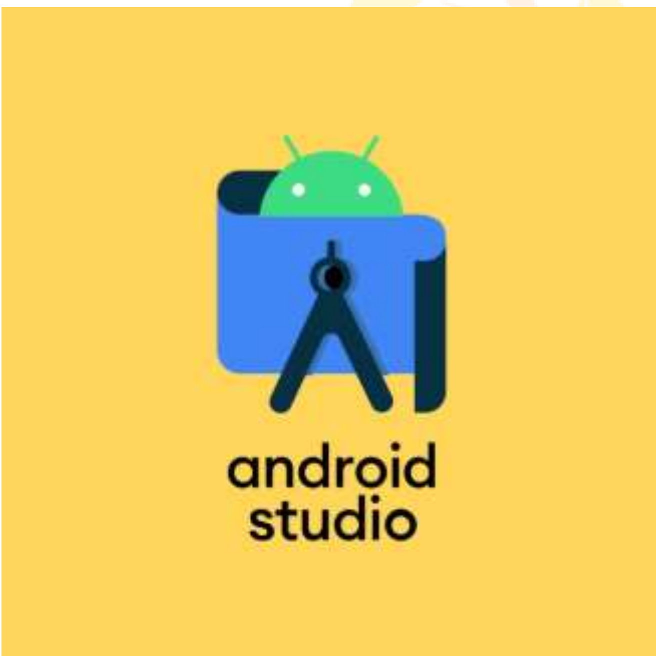

Fig. 15. Android Studio

*3) **Android Studio**:* The official integrated development environment (IDE) for Android application development is Android Studio. It's based on IntelliJ IDEA, a Java integrated development environment for software development which includes code editing and developer tools. Android Studio uses a Gradle-based build system, emulator, code templates, and Github integration to support application development on the Android operating system. Every Android Studio project has one or more source code and resource data types. Android app modules, Library modules, and Google App Engine modules are one of these modalities. To push code and resource changes to a running application, Android Studio uses its Instant Push functionality. A code editor helps programmers write code by providing code completion, refraction, and analysis. Android Studio applications are subsequently compiled into the APK file and submitted to the Google Play.

IV. Results and Discussion

Registered users can access the data by logging on to our mobile application. On successfully entering the user credentials, it opens a window where the parameters are displayed in real-time in the form of numerical values. To demonstrate the quality of water all the sensors are put into a container filled with tap water, the W.H.O approved guidelines for safe drinking water are as follows:

- pH – 6.5 to 8.5
- Total Dissolved Solids – 500mg/l
- Turbidity – Ideally should be below 1, and shouldn't be more than 5
- Temperature - Best temperature for drinking is approximately 200 C

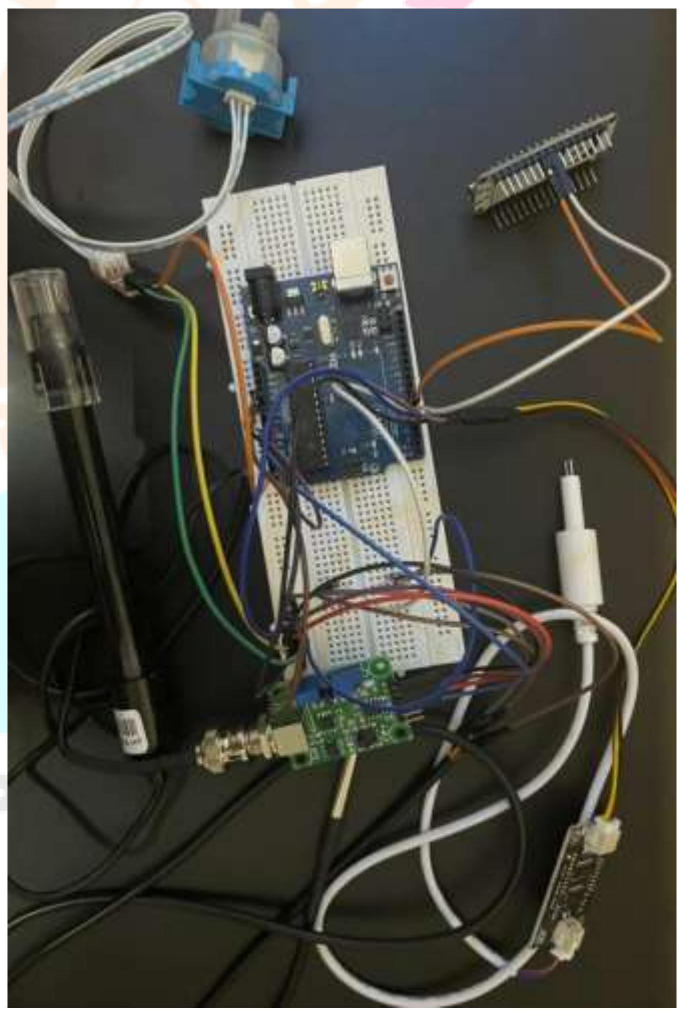

Fig. 16. Final design of the Water testing module

If we add a few drops of acid to the water container, we can notice the value of the pH of water is around 3 to 4.5, highlighting its acidic nature. The temperature remains constant throughout at around 300 C. The turbidity of the water is below 1 NTU and the TDS is below 500mg/l. The TDS sensor can also be replaced by a conductivity sensor. Total Dissolved Solids is be obtained by the equation – TDS = 0.67*electrical conductivity

V. Applications, Advantages, Limitations and Outcomes

A. Applications and Advantages

- Clean drinking water is a basic human necessity, which is often taken for granted. Rather than being dependent on the authorities to perform regular checks on the water supply, our water quality monitoring device can be installed in any water tank and provides its user with a detailed analysis of the quality of water they are drinking or using for any other purpose.
- The whole device is designed to be very economical. Since there are no moving parts in our device, there is less chance of wear and tear. We are using high durability, low-cost sensors which can be replaced individually if necessary. Low keep-up.
- The conventional method of water quality testing is manual collection of water samples and then lab analysis. However, this process is very time-consuming and can take approximately 3-7 days for a detailed analysis. Our water quality monitoring device works on IoT technology and notifies its user about the quality of water in "real-time". Therefore, a lot of time and expense are saved in this process.
- Our WQM device can be powered by a rechargeable lithium-ion battery attached to the Arduino Uno board. Portable design
- Our Water quality monitoring smart device can be deployed in big storage tanks used for water supply and also individual water tanks used in big organizations. It can also be used in fish tanks, aquariums, and organic farming.

The applications for such a convenient, economic device are endless. These can be employed in all possible locations where the quality of water needs to be monitored before use. This could extend from people employing such devices in their water tanks for household applications, to large corporations using it to test the purity of various components of their manufacturing process to ensure the best formulations. The diverse range of applications along with it's user-friendly applications makes it suitable for a wide range of applications.

B. Limitations

- We require a fully waterproof enclosure for our WQM device which would certainly increase the price of the device.
- Since our device is meant to be underwater for its operation, there is a risk of water leaking inside the enclosure and damaging the micro controller.
- Our WQM device requires a stable Wi-Fi connection at all times for its proper operation, in case of a power cut or internet failure, our device would fail to operate.

VI. Conclusion and Further Scope of Work

The real-time water quality monitoring system has been implemented and evaluated at a cheap cost. The user may keep track of contamination levels with this approach.

A sensor node with a temperature, turbidity, pH, TDS Sensor was designed and constructed on a Arduino Uno-board. The microcontroller then transmitted the measurements wirelessly to the notification node via the NodeMCU module. The accuracies of the different sensors and other findings are as follows. Temperature sensor: 2.5∘C. TDS sensor: 14.71% . Turbidity sensor: 6.28%(unverified). pH sensor: ±0.51.. The raw sensor data was processed successfully. Wireless communication between the device and mobile application with a non-line-of-sight wireless rnge of 13 m was achieved. The water parameters were displayed clearly on the mobile screen and visible warnings were displayed from the application when the parameter is at an unsafe level.

Future work could include the design and implementation of an ORP sensor, flow sensor, and conductivity sensor as these are also important quality monitoring parameters. The present design can display the parameters in real-time, but there is no way to see a history of the values, therefore data logging of the sensor measurements may be explored.

This use of this device can be extended to monitor the water quality of large water bodies such as rivers, lake and ponds. We can add a GPS module to always keep a track of the device's location in dynamic environments.

The system is simple to set up and any individual with minimum training can operate the device.

Internet of Things Technology and its services are easily becoming a part of our lives, work place environment and businesses. Presently, there is a lot of research and development is going on in this domain to building blocks and models for the upcoming generation of internet services which will have support by a slew of connected devices.

IoT has altered the globe thanks to the effective and clever use of mobile networks. It is reshaping the future of technology. IoT lets the user operate any object with just a touch of their fingertips.

References

[1] Tuan Le Dinh, Wen Hu, Pavan Sikka, Peter Corke, L. Overs, Stephen Brosman.
[2] S. Silva, H. N. G. Nguyen, Valentina, Tiporlini, and K. Alamehe.
[3] L.-X. Z. Donge He.
[4] [Online]. Available: https://docs.arduino.cc/hardware/uno-rev3
[5] [Online]. Available: https://www.nodemcu.com/index$_e$n.html