Bachelor of Science in Computer Science & Engineering

Smart Water Quality Monitoring and Controlling System

by

Md. Jahirul Islam

ID: 1404092

Department of Computer Science & Engineering

Chittagong University of Engineering & Technology (CUET)

Chattogram-4349, Bangladesh.

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Submitted in partial fulfilment of the requirements for
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by

Md. Jahirul Islam
ID: 1404092

Supervised by

Dr. Asaduzzaman
Professor
Department of Computer Science & Engineering

Chittagong University of Engineering & Technology (CUET)
Chattogram-4349, Bangladesh.

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Abstract

The Internet of Things is a revolutionary concept in the world of technology. It solves complicated issues by collecting, exchanging and analysing data through the Internet, and linking computers around the globe. Automation in the industry, driver-less cars, and surveillance systems are the revolutionary deployment of the internet of things.

In this thesis we proposed a water quality monitoring and control system based on internet of things (IoT) technology, which monitors the quality and quantity of water and cleans the dirty water. The system automatically collects water data using various water sensors and transfers it to remote servers via the Internet. Depending on the volume of water it automatically opens the water pump and if the water purity value falls below a certain level it notifies the owner and cleans the water tank and disposes of the wasted water.

Android devices can automatically download and display data from the server via the Internet. The main function of this system is to verify whether the water is dirty through real time analysis of water data and to clean the water tank by removing the dirty water from the water tank. We collected water data from many samples, we processed those data and we plotted data to visualize the correlation among those water parameters. Also the performance of this project is evaluated and we found 93% accuracy.

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Chapter 1

Introduction

1.1 Introduction

Clean drinking water is the most valuable resource for humans. 71 percent surface of the world is covered with water but only 2.5 percent is considered fresh water. Any imbalance in water quality would seriously affect the health condition of humans. Now a day's drinking water utilities are facing various challenges in real-time due to limited water resources, global warming, growing population, and pollution. Drinking water sources are also contaminated during frequent disasters such as floods, landslides, and cyclones. Hence there is a need for better methodologies for real-time water quality monitoring. The UN and World Health Organization (WHO). Studies by WHO There are now 844 million people without a pure supplier of drinking water with a population of 159 million dependents on surface water. For pollution surface water can get contaminated by arsenic, various chemicals, imbalance of water quality parameter and micro bacteria. Unclean, potable water causes many diseases including diarrhoea, cholera, dysentery, typhoid and polio, which can result in life-threatening diseases. Even for contamination of water, the aquatic life gets a problem. Also, many people face these diseases every year in Bangladesh as well as other countries. This is estimated annually by the studies alarmingly. Recently, the challenges of water due to climate change, natural disaster, confined water, growing population, etc. have been encountered. However, the criteria of water quality must be seen in real time by higher methodologies in the future. Hence there is a need for better methodologies for real time water quality monitoring and controlling.

1.2 Framework/Design Overview

We developed a water quality monitoring and a controlling system where various physical and chemical sensors like pH sensor, turbidity sensor, flow sensor, ultrasonic sensor, waterproof temperature sensor are used. These sensors gather data from water and send data to Arduino UNO microcontroller. After internal data processing, Arduino sends data to NodeMCU and the wifi module sends these data to the google cloud server. we developed an android application to view these sensor data in real-time and it can download the previously stored data. Here is a cleaning brush that is used to clean the water tank and servo that opens the gate to flush the tank when water gets polluted and it sends an early alert by SMS to the owner with the tank location. Figure 1.1 shows the block diagram of the proposed system.

1.3 Difficulties

In this water project, various electronics are used. Many chemicals are dissolved in water at a tiny ratio. To calculates, the quantity of specific chemical perfectly is quite challenging. Water is harmful to electronics. Again any problem occurs in the mechanical component then the water will be licked. In this project NEO-6m GPS device is used which does not get location from satellite all the time. so at the time of sending a message to mobile phone if the location is unavailable then a message will be sent without location. To send data to the cloud server continuous internet connection is needed and to run the whole system and continuous supply of electricity is needed. The following also several challenges:

- Higher quality sensor should be used otherwise the system will behave wrongly.
- For flushing water higher quality non-return gate valve should be used otherwise it will not be able to capable of resisting high water pressure.
- Keeping the whole system simple thus it can work perfectly.
- Making the application interface user friendly.

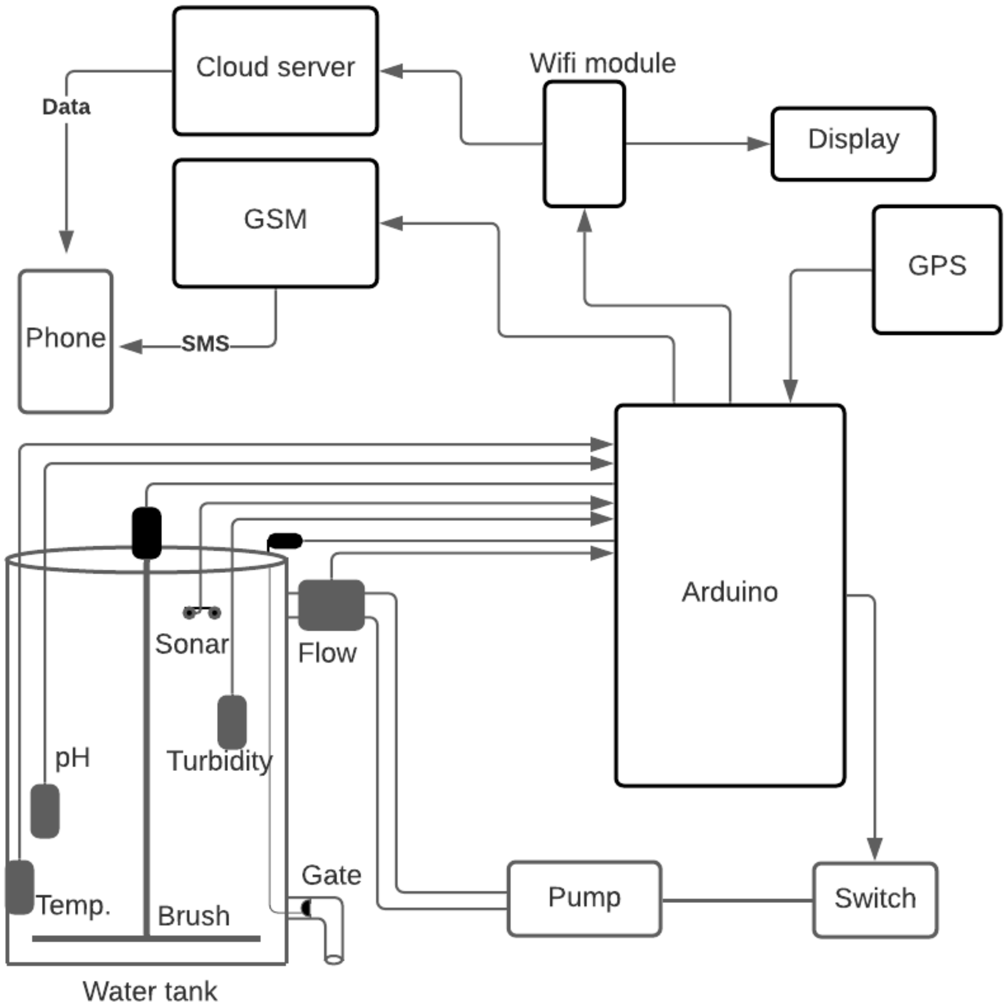


Figure 1.1: Block diagram of the proposed system.

- It should be cost-effective.

1.4 Applications

This project can be used in many cases such as:

- Water quality monitoring and the controlling system can be used in urban and rural area water supply area.
- In agricultural and industrial applications, this system can also be introduced.

- This project can also be used for treating water of WASA and home water tank.
- This method can also be used for treating and managing wastewater before discharging it into a freshwater cell.
- This method can also be used for aquaculture.

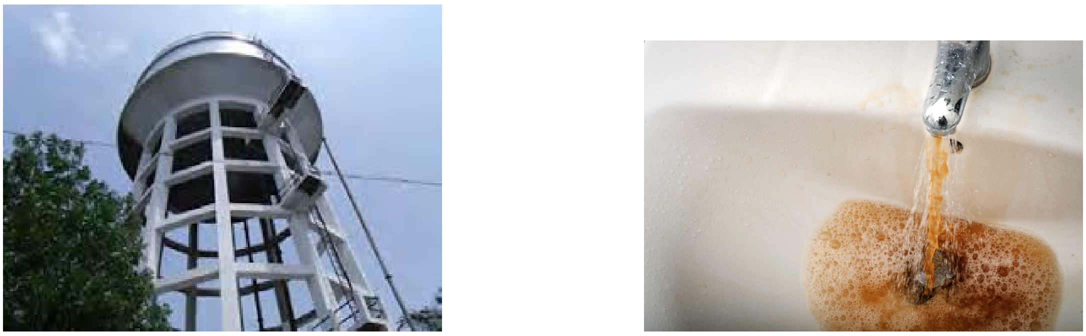
1.5 Motivation

Nowadays in city and village, people use the tank as a reservoir. Again day by day the surface water level is undergoing and the water layer gets damaged for many natural and man-made reason. For getting the very deep layer of water people depends on the supply of water. Those tanks are so big and placed at the top of the house or city. So generally for a long period tank does not get cleaned. So dissolved iron and dirt get dissipated at the bottom of the tank. So often WASA and home water tank supply dirty water. Again water is used continuously so generally tank does not make clean. Most people in urban use supply water for all the purposes, so unbalancing of water quality causes health problem and harmful for aquatic life. And people suffer from many diseases. Till this time many systems developed regarding monitoring the water quality but no system has a quality controlling feature. All those developed systems have many limitations.

By observing those problems, we designed a water quality motoring and controlling system based on internet of things technology as IoT can make a system automated and faster [1] which can monitor water quality parameters and automatically clean tank when water gets unacceptable to use.

1.5.1 Objectives

The main objectives of this thesis is given below:



(a) Water tank (b) Sample dirty water.

Figure 1.2: WASA water

- To make water quality monitoring system automated and better than all the past systems.
- To make the water quality monitoring system easier to WASA as well as people.
- To make the water tank cleaned thus in real life tank cleaning procedure is troublesome.
- To inform the person in charge about water quality.
- To supply fresh water to user.

1.6 Contribution of the Thesis

The contributions of this thesis are given below:

- To calculate daily consumed water in real-time.
- If water pollution occurs, send a warning message with location to the owner using GSM and GPS module.
- Clean and flush the water tank automatically if the water quality goes dirty by analysing water data.

1.7 Thesis Organization

This paper has five chapters. In chapter 1 describes some introductory description, design framework, application, motivation, history, implementation difficulties and contributions of the proposed system. Chapter 2 gives an overview of the literature review and hardware component description, implementation challenges about this proposed system. Chapter 3 discusses the system architecture, methodology, hardware components role, software components role and android application regarding this system. Chapter 4 describes the experimental results, impacts and performance evaluation of the system. Chapter 5 presents the conclusions, limitations and future recommendation regarding this.

1.8 Conclusion

In this chapter, a survey on water quality monitoring system based on IoT is written. Along with the problems, this chapter also describes the necessity of the water quality monitoring and controlling system. The inspiration and the contributions behind this work are also given here. The following chapter provides the context and current state of the issue.

Chapter 2

Literature Review

2.1 Introduction

We will discuss the terminology and technology used in this chapter in our project. We would also look at past work, strengths and limitations in this field. We also study the hardware parts used in this project.

2.2 Related Literature Review

In [1] Gubbi et al., proposed a framework that has scalable cloud and capacity for the internet of things. They discussed IoT, ubiquitous computing and wireless sensor network. They showed how various sensors can be connected using a gateway to a cloud with the internet and work together. Cloud has services like analytic and visualization and the security of data. They discussed that computing devices like a computer can be connected to the public cloud-like Microsoft Azure, Amazon AWS, Google and iCloud. This all things can work together using the internet of things technology. This research paper tried to explain the overall architecture of the internet of things. In [2] Geetha et al., proposed a low-cost simple system based on the internet of things concept where they used pH sensor, turbidity sensor, conductivity sensor and a level sensor for getting the quality data of water. They used TI CC3200, a controller with a built-in wiFi module. After collecting data, they send those to a cloud server with the internet. And retrieve those data with the mobile device. They used a message sending system from the cloud to the users mobile when the value exceeds the predefined threshold. In [3] Jianhua dong et al., discussed their survey on various water quality monitoring system till 2014. After the survey, they divided all the system into three subsystem data collection subsystem, data transmission subsystem, and data management subsystem. In the data collection, part data is collected from various sensors like pH, conductivity, turbidity, residual chlorine etc., in the transmission, part data is transferred to the remote cloud using 3G, GPRS, microwave, GSM and satellite. In the management, part data is analysed, based on threshold cloud makes early warning. In [4] Banna et al., discussed in their research paper various chemical parameter for drinking water. They marked that the use of a sensor array for monitoring water quality at distributed system is costly. So they searched for better technology and focused on sensor technology. In the research paper, [5] Lambrou et al., proposed a system based on IoT technology where they focused on low cost, lightweight and reliability. They used analogue to digital converter for converting sensors data. Using Zigbee module data sent to the server and using router those data are received. In research paper [6] Kageyama et al. proposed a dynamic floating system for monitoring water quality. In this system, a solar panel is the main power source and a battery for backup. After receiving data, it sends to the server using the GSM module which uses 3g technology. In [7] Hur et al., developed a monitoring tool for predicting biochemical oxygen demand (BOD) using synchronous fluorescence technique. They found that protein-like fluorescence intensities of the water samples show a positive linear relationship with the BOD values. In paper [8] Silva et al., web-based wireless sensor network application that collects various water quality parameter and send those data through the Zigbee gateway to a web server using WiMax network and users can see the real-time water quality. In [9] Kavi Priya et al., proposed a low-cost system based on IoT technology for monitoring drinking water quality at the distribution system. The sensors are placed in the pipe through which the water passes. If the contamination occurs the Zigbee module sends signals to the solenoid to turn off the water supply and intimates the consumers about drinking water quality through a mobile app. In [10] Prasad et al., designed a system using IoT and remote sensing technology for Fiji. Where they collected sensors data and stored it in local storage and sent it to the cloud using GSM technology. The remote computer can download those data to see. In research paper [11] Zhang et al. proposed a framework where they used IoT and wireless sensor network. The sensor network is the interconnection of many sensors. They used the Zigbee module to send data in the low range of distance and the GSM 3g network to send data to a long-range distance server. A database was to hold all data. By calculating those data if they found contamination then used early alarm system using GSM to notify users.

In [12] Cloete et al., proposed a system in which temperature, turbidity, pH, dissolved oxygen and conductivity is measured and sent to a remote monitoring centre using Zigbee and CDMA (code division multiple access) technologies. And when the quality is under the accepted level then a buzzer makes an alarm. Which is not accessible globally Again there is no flow measurement. In [13] Gopavanitha et al., designed a system where the Temperature, Turbidity, Conductivity, pH and Flow of water is measured. By these sensors, water contaminants are detected. The sensor values processed by Raspberry pi and send to the cloud. In this system, there is no alarm when the quality is going under the accepted level. And no measurement of how much water is used. In [14] De Belen et al., proposed a system where the temperature, flow rate, and pH of water is measured. And a relation between temperature and pH is found. But this system has not any measurement of the volume of water, amount of used water, alarm system and does not send data to the cloud. In [15] Raju et al., proposed a system where dissolved oxygen, ammonia, pH, temperature, salt, nitrates, carbonates are measured but no other features. In [5] Lambrou et al., proposed a system where turbidity, pH, the temperature is measured and sends those data to the local remote centre. Not directly to global server or cloud. And this system has not another feature. In [16] Ramos et al., proposed this system where only electricity conductivity through water and temperature of can be measured. In paper [17] Vijayakumar et al., said that the parameters such as temperature, pH, turbidity, conductivity, dissolved oxygen of the water can be measured. The measured values from the sensors can be processed by the core controller. The raspberry PI B+ model can be used as a core controller. Finally, the sensor data can be viewed on the internet using cloud computing. Multi-parametric sensors are thoroughly tested for water quality and pH values. But this system has no measurement of water flow, used amount of water and alarm system. In the research paper, [18] Ramesh et al., proposed a system where they monitored both soil and water quality. After collecting data, they sent those to the cloud using the Zigbee module, they aggregated data and applied a decision making algorithm if soil or water were considered as contaminated, early warnings and alerts generated. In [19] M. M. Islam et al., developed a system which can find the drinkability of water by calculating temperature, pH and TDS value. They used NodeMCU to send data into firebase database. They used MIT app inventor for android application.

2.3 Hardware Specification

In this section, we will discuss some hardware that we have used in our system. Knowing the functionality of this hardware will give a better understanding of our system.

2.3.1 Arduino Uno R3

The Arduino Uno R3 is a microcontroller board that uses a removable ATmega328 AVR double inline package (DIP). There are 20 input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analogue inputs). The easy-to-use Arduino computer program will load programs to it. Arduino IDE is used for writing, compiling and loading C language-based code into Arduino board. The Arduino has a comprehensive support community, making starting with embedded electronics very simple. The R3 is Arduino UNO's third and most recent revision.

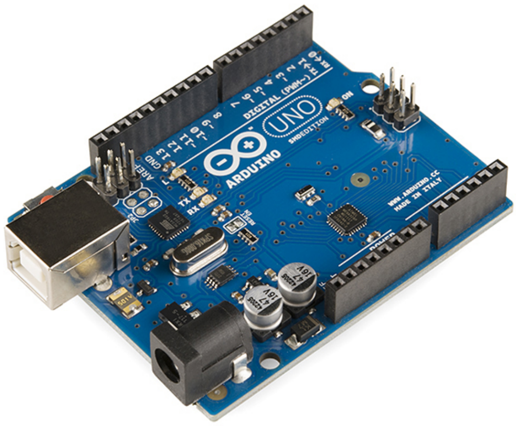


Figure 2.1: Arduino UNO R3.

Figure 2.1 shows the Arduino we have used.

Table 2.1: Specification of Arduino UNO R3

Characteristics	Specification
Chip	ATmega328P
Operating voltage	5V
Digital i/o pin	14
Analogue i/o pin	6
DC current for each pin	20mA
Flash memory	32KB
EEPROM	1KB
Dimension	68.6mm*53.4mm
Weight	25g

2.3.2 GSM Module

A GSM module is a hardware device that uses mobile GSM technology, which provides a data connection with a remote network. In the view of the cell phone network, the basic requirement for a SIM to identify with that network is the same as ordinary mobile telephones. Figure 2.2 shows the GSM Module we have used.

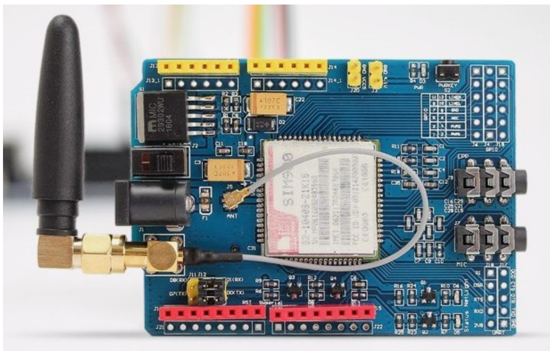


Figure 2.2: GSM module.

Table 2.2: Specification of GSM

Modes	Frequency	Current Consumption
Power down		60 uA
Sleep mode		1 mA
Stand by		18 mA
Call	GSM850	199 mA
	EGSM900	216 mA
	DCS1800	146 mA
	PCS1900	131 mA
GPRS		453 mA
Transmission burst		2 A

2.3.3 LCD Display

Liquid crystal display is the word LCD. It is a type of electric display module used in a wide range of applications such as cell phones, calculators, computers, TV sets and other devices. Mainly for multifaceted light-emitting diodes, these displays are favoured. The key advantages of using these modules are cheap simply programmable, animations and customized characters, unique and even animations etc. are not limited to show. Figure 2.3 shows the 16*2 LCD we have used.

Table 2.3: Specification of 16*2 LCD

Characteristics	Specification
Operating voltage	4.7V-5.3V
Power consumption	1mA
Cell	16*2

Figure 2.3: LCD display.

2.3.4 Flow Sensor

The water flow sensor consists of a nickel, a hall-effect sensor and a rotor for the water. When water flows through the rotor, the rotor rolls, with a different flow rate, the speed varies. The more water flows the rolling speed of the rotor becomes high and generates more electricity. Calculating this voltage of the electricity the flowing rate of water is found. Figure 2.4 shows the water Flow sensor we have

Figure 2.4: Flow sensor.

used.

2.3.5 pH Sensor

The acidity or alkalinity of the water is measured with a pH sensor of a value between 0 and 14. The water is becoming more acidic when the pH value falls

Table 2.4: Specification of flow sensor

Characteristics	Specification
Operating voltage	5V
Power consumption	15mA
Flow rate	1-30L/min
Operating temperature	<80C
Liquide temperature	<120C
Liquid pressure	<2.0MPa

below 7. Any number higher than seven is more alkaline. In order to calculate water quality, each type of pH sensor works differently. Figure 2.5 shows the pH

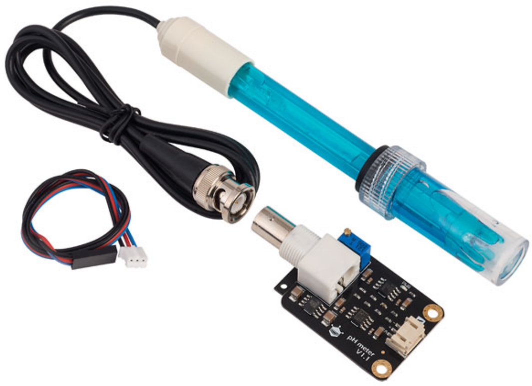


Figure 2.5: pH sensor.

sensor we have used.

Table 2.5: Specification of pH sensor

Characteristics	Specification
Operating voltage	3.3V-5V
Range	0-14pH
Probe	BNC
Operating temperature	<80C
Response time	<1min

2.3.6 Sonar sensor

The 4-pin, ground, VCC, trig and echo HC-SR04 Ultrasound Module. Ultrasound sonar sensor has two different sensors one is for transmitting Ultrasound and the other is for receiving the echoed ultrasound. by calculating the time between transmitting and receiving ultrasound the distance is measured. The module pins of ground and VCC have to be wired respectively to the ground with five volt pins on the Arduino board and to any digital I/O pin on the Arduino board with trig and echo pins. Figure 2.6 shows the Ultrasonic sensor we have used.

Figure 2.6: Sonar Sensor.

Table 2.6: Specification of sonar sensor

Characteristics	**Specification**
Operating voltage	3.5V-5V
Operating current	2mA
Range	2-400cm
Angle	<20
Accuracy	3mm

2.3.7 Temperature Sensor

DS18B20 is a Dallas Semiconductor Corp. One wire interface temperature sensor. For a two-way communication with a microcontroller, the special one wire interface needs just one digital pin. The sensor normally comes in two different shapes. One in TO-92 looks like a common transistor exactly. Another one in waterproof form, which can be more useful when measuring anything far, below or below the floor. The temperature sensor DS18B20 is very accurate and does not require external components. With a precision of ±0.5°C, temperatures range between -55°C and +125°C. Figure 2.7 shows the water temperature sensor we have used.

Figure 2.7: Temperature sensor.

Table 2.7: Specification of waterproof temperature sensor

Characteristics	**Specification**
Operating voltage	3.0V-5V
Operating current	30mA
Range	-55C-125C
Response time	<750ms
Accuracy	0.5C

2.3.8 Turbidity Sensor

By testing turbidity levels and opaqueness, the gravitational Arduino turbidity sensor detects water quality. It uses infrared light to measure the transmission of light and dispersion rates to detect suspended particles in water, which varies with the total suspended solids (TSS) in water. The liquid turbidity level increases as the TSS increases. Sensors for sediment transport and laboratories tests are used for measuring water quality in the streams and rivers, wastewater and effluent measurements, inspection devices for sediment sedimentation pools. Figure 2.8 shows the Turbidity sensor we have used.

Table 2.8: Specification of turbidity sensor

Characteristics	**Specification**
Operating voltage	5V
Operating current	40mA
Range	-55C-125C
Response time	<500ms
Weight	30g

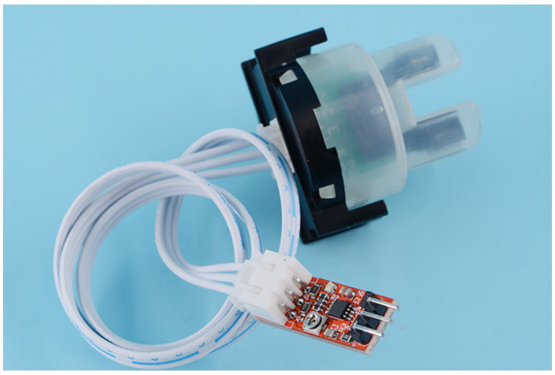


Figure 2.8: Turbidity sensor.

2.3.9 GPS Module

GPS modules contain small antennas and processors which receive direct data from satellites via specific RF frequencies. From there, along with other data bits, it is going to receive timelines from each visible satellite. If an antenna of the module can spot four or more satellites, its location and time can be accurately calculated. Figure 2.9 shows the GPS sensor we have used to get Location.

Figure 2.9: GPS module.

Table 2.9: Specification of Neo 6m GPS module

Characteristics	**Specification**
Operating voltage	3.3-6V
Baud rate	4800-115200
Channel	50
Response time	<1s
Accuracy	2m
Update rate	5Hz

2.3.10 Non Return Valve

A non-return valve can only allow the liquid medium to flow in one direction and is installed to ensure that the medium flows in the correct direction through a pipe, where otherwise the pressure conditions can cause opening the gate for reverse flow. Figure 2.10 shows the non return water gate we have used for

Figure 2.10: Non return valve.

flushing water.

Table 2.10: Specification of non return valve

Characteristics	**Specification**
Size	80mm
Material	Brass
Media	Air, water, gas

2.3.11 Servo Motor

A Servo Motor is a small output shaft unit. By giving the servo a coded signal, this shaft can be located in particular angular positions. The servo retains the angular location of the shaft as long as the coded signal remains on the input side. The angular direction of the shaft changes if the coded signal changes. Servos are used for positioning control surfaces such as elevators and rudders in practice in radio-controlled aircraft. They are also used in boat, motorcycles, marionettes, and of course, robots that are radio powered. Figure 2.11 shows the Servo motor we have used for opening and closing water gate.

Figure 2.11: Servo motor.

Table 2.11: Specification of servo motor

Characteristics	Specification
Operating voltage	4.8-7.2V
Speed	0.16s/60deg
Torque	12kg/cm
Operating temperature	-30C-60C
Gear type	metal
Range	0-180deg

2.3.12 NodeMCU ESP8266

ESP8266 is a wifi module that is low powered devices. It can operate in a 2.4GHz network by which it can easily be connected to any wifi network. It has a library for being connected to a remote server to send and retrieve data. It is very easy to use and to combine with another Arduino. The specifications are given below. Figure 2.12 shows the ESP8266 NodeMCU we have used for internet connection.

Table 2.12: Specification of ESP8266 wifi module

Characteristics	Specification
Chip	32-bit RISC CPU
Operating voltage	3.3V-5V
GPIO pin	16
Analogue i/o pin	1
DC current for each pin	20mA
Flash memory	64KB
Network	2.4GHz(802.11 b/g/n)

2.3.13 Buzzer

It is a light weight frequency making device made of piezoelectric crystal Figure

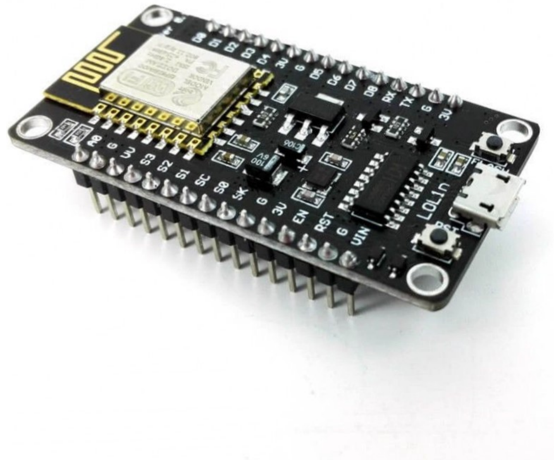


Figure 2.12: Wifi module.

Figure 2.13: Buzzer.

2.13 shows the buzzer we have used for making early alarm.

Table 2.13: Specification of buzzer

Characteristics	Specification
Operating voltage	3.3V-6V
Current	<25mA
Frequency	2300Hz
Operating temperature	-20C-60C
Weight	2.5g

2.3.14 Brush

A Brush made of nylon is used to clean the water tank.

Figure 2.14a shows the Cleaning brush we have used for cleaning the tank.

(a) Brush.

(b) Jug.

Figure 2.14: Brush and Jug

2.3.15 Jug as Water Tank

A Jug is used as a water tank Figure 2.14b shows the Jug we have used as water tank.

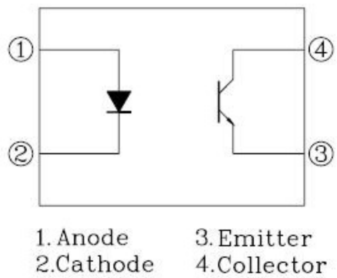
Table 2.14: Specification of water jug

Characteristics	**Specification**
Material	polypropylene
Colour	transparent
Net weight	3.5L
Dimension	22cm*16cm*25.5cm

2.3.16 Optocoupler

An optocoupler is a switching device that can switch another device without triggering electrically. It makes two devices optically isolated.

(a) Optocoupler device



(b) Schematic diagram

Figure 2.15: Optocoupler

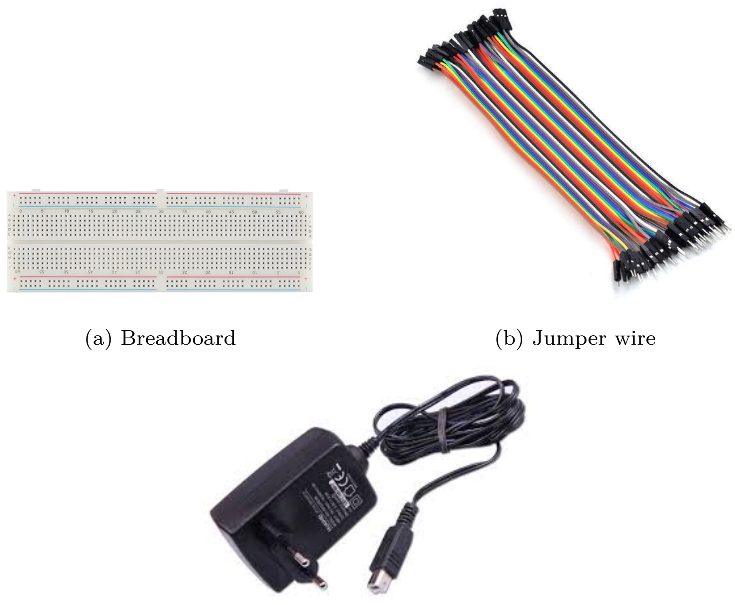
Figure 2.15 shows the Optocoupler we have used.

Table 2.15: Specification of optocoupler

Characteristics	Specification
Current transfer ratio	600%
Voltage	5V
Current	5mA
Temperature	+110C
Type	Switch

2.3.17 Other Equipment

Other passive equipment like a breadboard, adapter, jumper wire, scotch tape, the gum is used. A breadboard is a kind of board that is used to connect components electrically. 5V Adapter is used for the power source. It converts high voltage to low voltage. Jumper wire used to drive electric. Figure 2.16 shows other passive



(a) Breadboard

(b) Jumper wire

(c) Adapter

Figure 2.16: Other components

components we have used.

2.4 Software Specification

In this section we will discuss about some software that we have used in our system.

2.4.1 Arduino IDE

This platform is for writing code for Arduino board. It is a C language base IDE. It has the own compiler and library installed on different Arduino board. Using this IDE code editing, debugging and loading can be done in Arduino board. It has a serial monitor by which any real time value can be seen. It is very easy to learn and use. Figure 2.17 shows Arduino IDE we have used.

Figure 2.17: Arduino IDE Icon

2.4.2 Android Studio

This platform is made by IntelliJ for writing code for android device. It is a java and extensive markup language (XML) language base IDE. it has its own compiler for android device. Many libraries are previously installed for a different version of the Android operating system. From this platform, code can be edited, dubbed and exported into APK software. Figure 2.18 shows Android IDE we

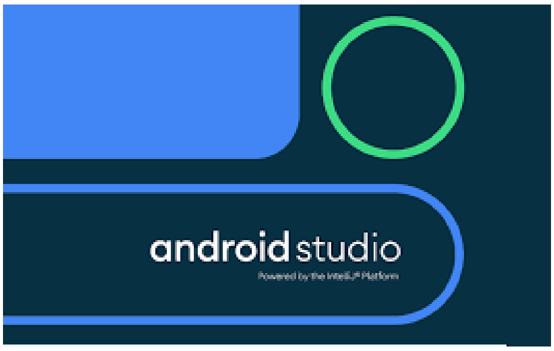


Figure 2.18: Android studio

have used.

2.4.3 Operating System

We used windows 10 home as the operating system of our device. This operating system is very user friendly as it is graphically rich. Figure 2.19 shows Operating

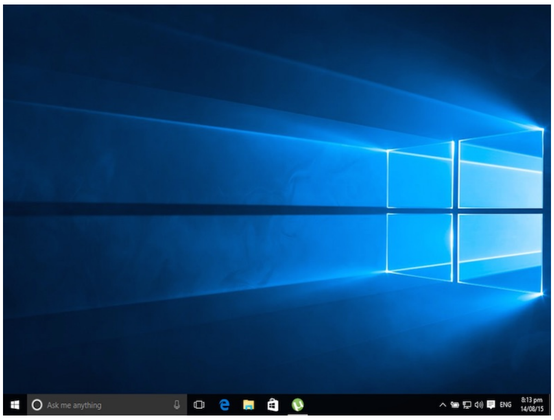


Figure 2.19: Windows 10

System we have used.

2.4.4 Firebase

We used the firebase realtime database as the cloud server of our system's database. This platform is made by google. It is free, fast and easy to use. It has SDK for android code and also API for Arduino code so integration is easy. Figure

Figure 2.20: Firebase

2.20 shows Firebase we have used as realtime database.

2.4.5 Implementation Challenges

- Making this system watertight
- Insulating electronics from water
- Data Storage Challenge.
- Connectivity and Power Management IoT Challenges.
- Data Security Issues.
- Authentication and Identification Issues in IoT.
- Managing all components in this lockdown situation
- Making this system simpler thus it works perfectly and complexity to be minimum

2.5 Conclusion

A systematic analysis of the literature is discussed in this chapter. This topic was conveniently divided into key sections of the monitoring and control segment for water quality. We explained various hardware and software equipment here. The following chapter provides vast explanations of the proposed water quality monitoring and controlling system's methodology.

Chapter 3

Methodology

3.1 Introduction

The architecture of the water surveillance system based on IoT is mentioned in this chapter. This chapter consists mainly of three sections. The device architecture of the proposed model is discussed in this section. The analysis of this method will be covered here. This provides information about the framework built with various diagrams and flowcharts. The diagrams also discussed in this chapter.

3.2 Diagram/Overview of Framework

As seen in the previous figure 1.1, the framework structure of the proposed system is given. This proposed block diagram consists of a wide range of devices with respective sensors, collected by Arduino with statistics and sent to NodeMCU from Arduino. This system has two parts hardware and software. The hardware part also has mainly two parts. Many physical and chemical sensors used in this system to collect water data like pH sensor, temperature sensor, turbidity sensor, sonar sensor and flow sensor. The unit includes these sensors to measure water quality parameters with pH, total suspended solids(TSS). The task with the current gadget is to use sensors in a fully automated water quality monitoring unit. All the sensors have their own computing system to collects data from water. They collect data from water and sends it to Arduino. This processor processes those data and if the tank is empty it makes the water pump active until the tank gets full of water. If the quality of water gets unacceptable it collects location from the GPS module and send this location to the respective people and notify.

Again makes an early alarm to alert the users. with the arrival of a gadget communication machine leading to IoT, we developed a wise IoT water quality monitoring and controlling machine in residential areas speeds to NodeMCU wifi device through Arduino microcontroller. In the second part, the Arduino sends data to the NodeMCU wifi device. With the use of HTTP (Hypertext Transfer Protocol) protocol to transfer information from the IoT gateway on NodeMCU to the cloud server. In the software, part cloud computing generation provides a non-public server for monitoring the facts stored on the Internet. The private API of the cloud server is used by the mobile application to download those data stored in the cloud server. The user-friendly application which works on Android is delivered to get data from beginning to end.

Here the full logical decision of this system is given below in figure 3.1,

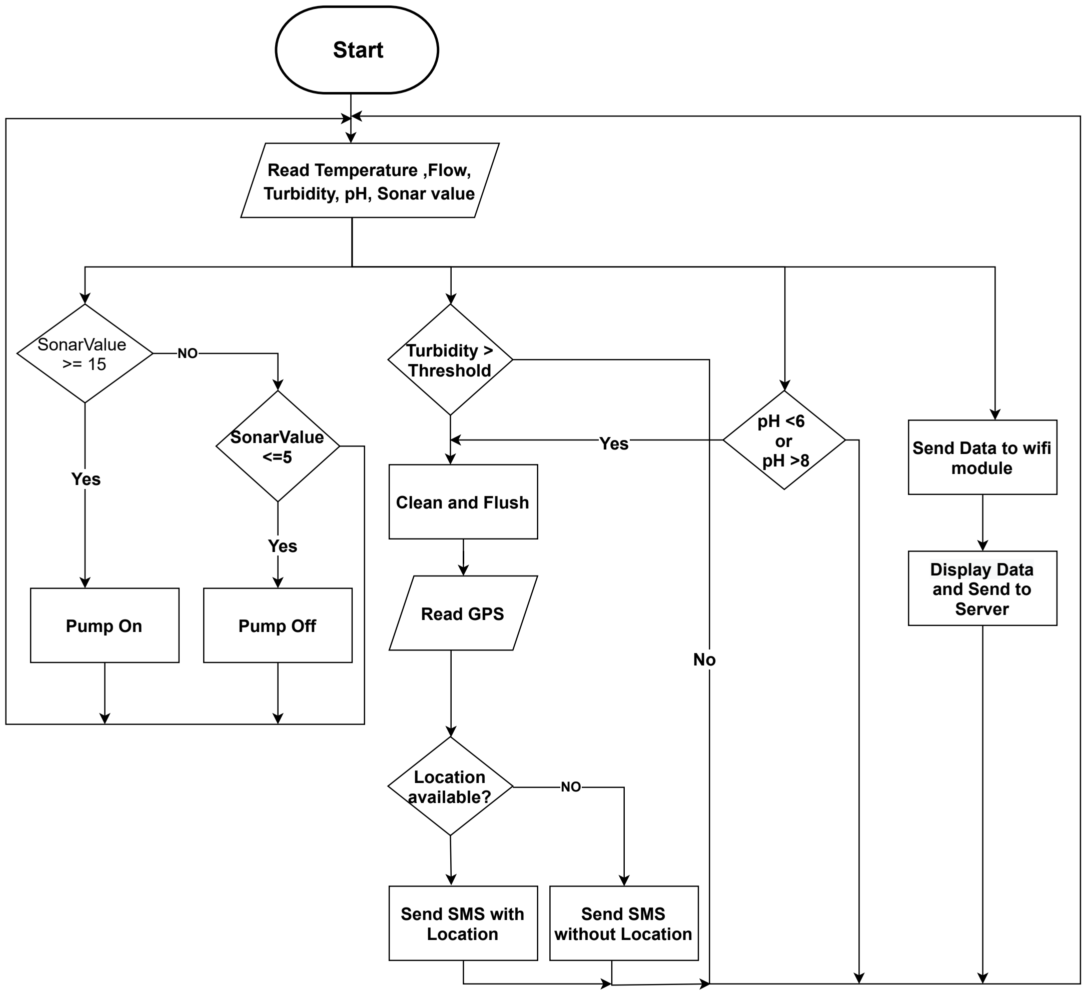


Figure 3.1: Overall flow chart of proposed system.

3.2.1 Features of This System

This system has features that are given below:

- This system can automatically pump water when the tank gets empty.
- This system can collect the pH level of water.
- This system can collect dirt level of water.
- This system can read the water temperature.
- It can analyse data and find that water is drinkable or not.
- It can make an early alarm when the water is contaminated.
- It can clean the water tank and can automatically flush water.
- It can send tank location to the person in charge when the water gets unusable.

3.3 Detailed Explanation

We use different sensors, Google Cloud Storage and an Android app to track the whole device in this IoT based water quality monitoring and control system. 3.2 shows the prototype of the proposed model. In the upcoming section we will describe the schematic diagram, the circuit prototype, and the detailed methodology of the proposed work

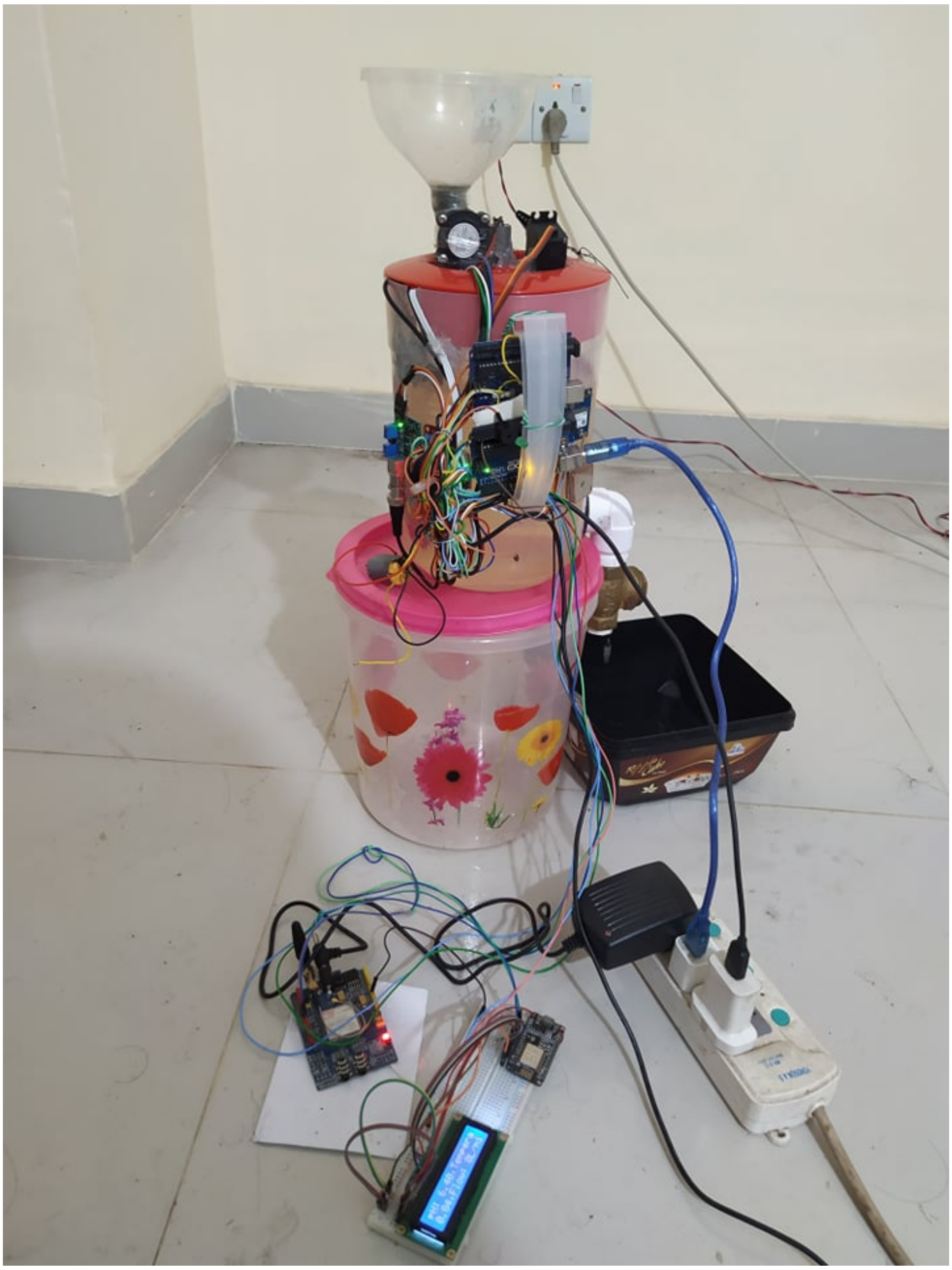


Figure 3.2: Prototype of the proposed model.

3.3.1 Schematic Diagram of the System

The total schematic diagram of the proposed water quality monitoring and controlling system is given below:

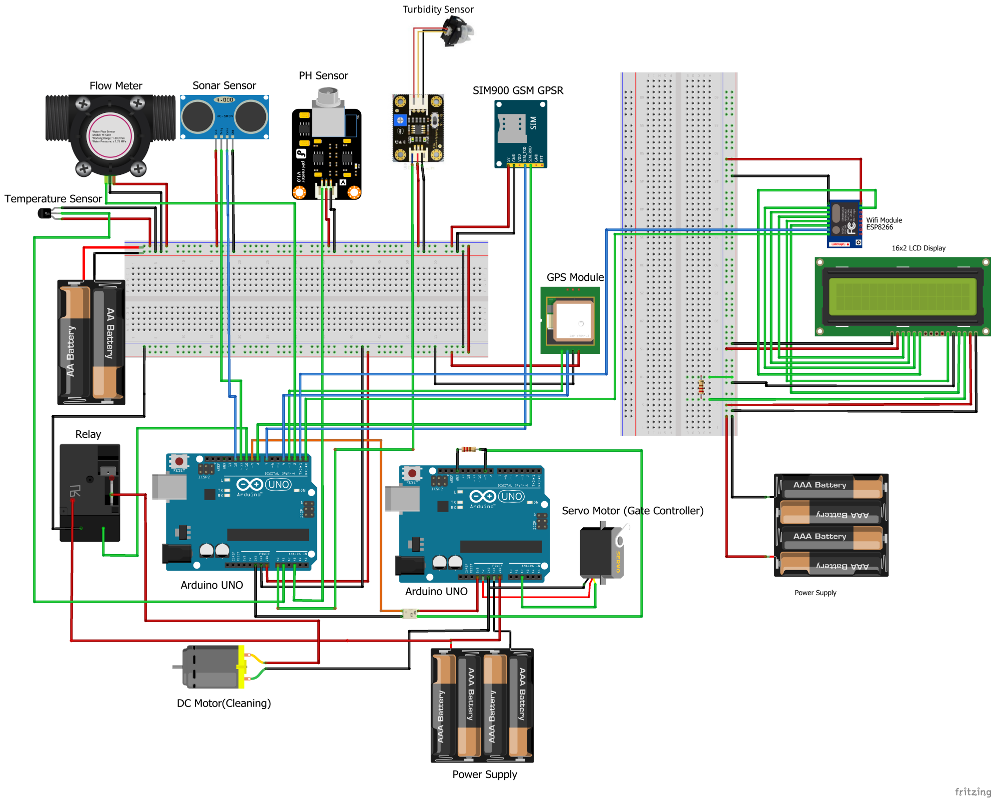


Figure 3.3: Complete schematic diagram of proposed system.

Initially, we connect the pH sensors and turbidity sensors, flow sensors, temperature sensors with the Arduino UNO. The pH data will be received from the pH sensor, temperature from the temperature sensor, turbidity (How much clean) data will be received from the turbidity sensor, the height of the upper surface of the water will be received from the sonar sensor. From the sonar sensor reading the water volume will be calculated. If the total volume of the tank is V, the area of the tank is A and the height of the upper surface from the top of the tank is h then, water volume is = V-(A*h) If the upper surface of water exceeds the lower level of the outlet pipe of the tank, then the pump will start automatically. Until the tank gets full with water pump will remain on. when the tank gets full with water it turns the pump off. Also, the turbidity sensor will check the amount of dirt in the water. If the dirt Level exceeds the prefixed limit then it gives an early alarm by buzzer, cleaning motor starts to clean the tank automatically. After a certain time period of cleaning the non-return water gate is opened by a servo motor for flushing the whole water. After flushing the tank servo will close the non-return water gate. So the storage tank is safe. Then GSM module and

GPS module are also interfaced with the Arduino UNO. At the time of cleaning, Arduino collects location from the GPS module and using the GSM module the water quality state and location sends to The tank owner number. The controller of the circuit i.e. Arduino UNO, NodeMCU convert analogue data into digital form and send these sensor data to google cloud storage. We created an android application for the Android app to view, track the entire system. To do this, we collected and visualized the data from Google Cloud Storage with the Android application. This application can download the whole data stored in the firebase database.

3.3.2 Turning on motor automatically and calculating amount of consumed water

In this section we are going to describe how our system turns on the motor automatically and calculate the amount of consumed water which is explained in figure 3.4

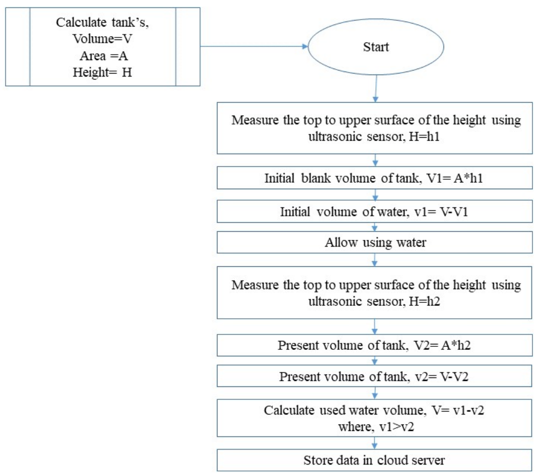


Figure 3.4: Flow chart of calculating used water

In this project, an ultrasonic sonar sensor is used in the tank. A sonar sensor can calculate the distance of an obstacle. The height of the upper surface of the water will be received from the sonar sensor. From the sonar sensor reading the water volume is calculated. If the total volume of the tank is V, the area of the tank is A and the height of the upper surface from the top of the tank is h then, water volume is = V-(A*h). By reading the volume this system can automatically turn the water pump on or off. Again by subtracting present volume from previous volume we got measured the total volume of used water.. Figure 3.5 shows the connection between the sonar sensor and arduino.

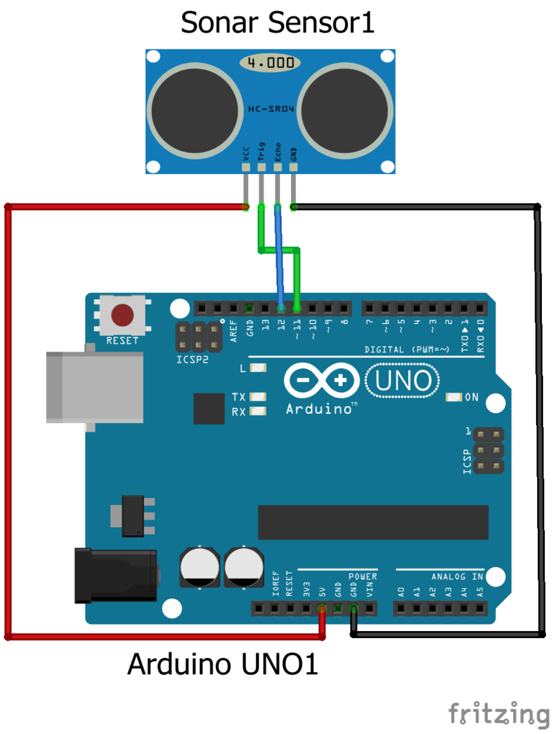


Figure 3.5: Sonar sensor to Arduino connection

3.3.3 Cleaning and flushing the water tank automatically

This system cleans and flushes the water tank if the water quality goes under acceptable range. Figure 3.6 shows the procedure of cleaning and flushing procedure.

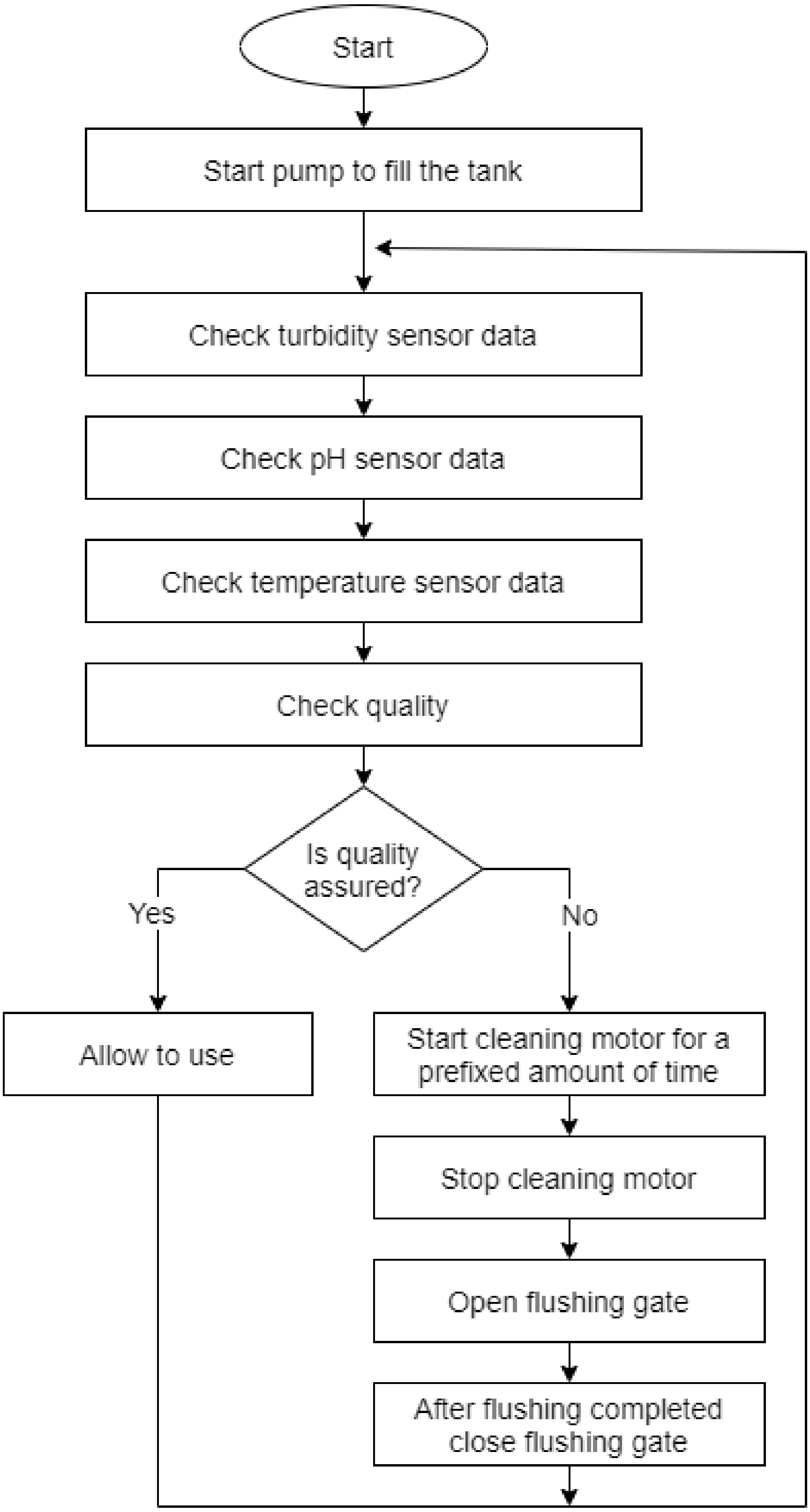


Figure 3.6: Cleaning and flushing water tank

To measure the quality of water good or bad first we calibrated the sensors. After then we read sensors data of water. We compared the sensors value to the standard value of water. The standard range value of pure water according to WHO is given below. If data remains in this range we coincided as good water. And if data exceeds the range we coincided water as bad water.

Table 3.1: Quality parameter value range of pure water provided by WHO

Sensor	Value range	Unit
pH	6.5-8.5	pH
Turbidity	5-10	NTU

The system follows the following steps to clean and flush the water tank.

- Check quality of water
- Clean the tank
- Flush the water
- Fill the tank again

3.3.3.1 Checking the quality of the water

To assure quality the system checks temperature, pH value and turbidity value

Collecting Temperature of Water

In our system DS18B20 waterproof temperature sensor is used inside the tank. Arduino collects supplying voltage from the temperature sensor and calculates water temperature both in Celsius and Fahrenheit.Figure 3.7 shows the connection between the temperature sensor and arduino.

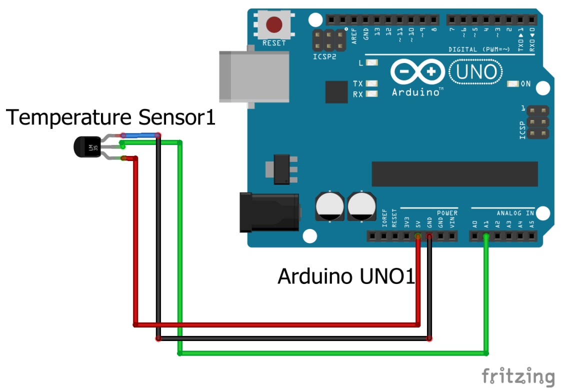
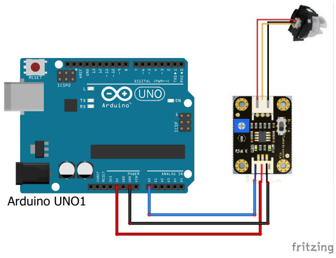


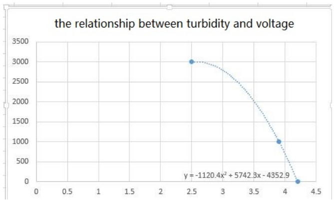
Figure 3.7: Temperature sensor to Arduino connection

Collecting Turbidity Value

In our system turbidity sensor is used to getting the dirt level of water. Turbidity sensor supply electrical voltage to Arduino. Arduino calculates NTU from those voltages.



(a) Turbidity sensor to Arduino connection



(b) NTU vs Voltage

Figure 3.8: Turbidity value calculation

Collecting pH Value

in this section, we will discuss collecting the pH value of water. pH meter can read 0-14 range of value. In our system, it is placed inside the tank. as it reads the real-time acidity value. It is connected to Arduino, based on the supply voltage Arduino calculates the pH value. Figure 3.9 shows the connection of pH sensor with arduino.

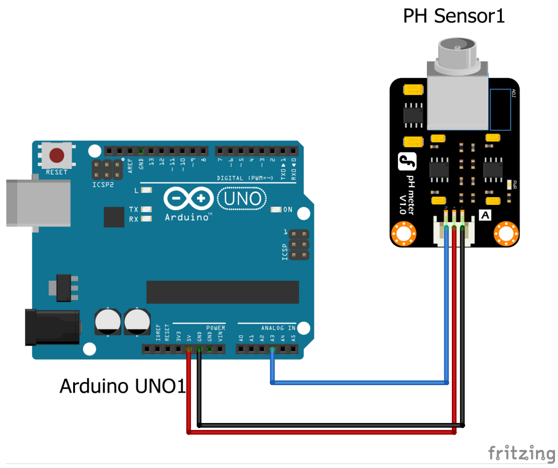


Figure 3.9: pH sensor to Arduino connection

pH value of water can be 0-14 range. Neutral water has pH of 7. If the pH value decreases it becomes acidic and if pH value increases it becomes alkaline.

we According to WHO we consider drinking water pH>6.5 and pH<8.5 .if pH crosses this, limit we recognized it as bad water.

3.3.3.2 Cleaning the Tank

By analysing sensor data when the system detects that water gets dirty it starts the cleaning motor to clean the inner layer of the tank. A nylon brush is used to clean. This motor has high torque and to drive the high current is needed. As this type of motor consumes high power electricity. Thus Arduino cannot supply so much power, the motor is switched by a relay device. A relay switch is an electromagnetic device that can drive high power electricity switched by low power electricity. Figure 3.10 shows the connection between the DC motor and arduino.

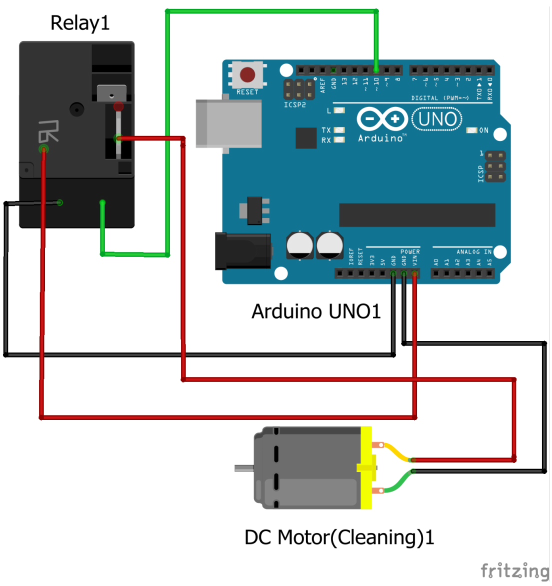


Figure 3.10: DC cleaning motor to Arduino connection

3.3.3.3 Flushing the water tank

By switching servo motor using optocoupler and arduino the syste, flush the water tank. A Servo motor is used to open the gate when it needs to flush water. But servo motor needs a data signal to rotates at a fixed angle. In this project many sensors and computation is used so for fluctuation of electricity sometimes servo behaved wrongly so we needed to switch it optically. we used an optocoupler to switch to another Arduino. In the following diagram, it is shown. when the second Arduino gets a switching pulse it sends rotating signals to the servo motor and the servo motor starts to rotate for opening or closing water flushing gate.

(a) Arduino connection to Arduino with optocupler

(b) Servo to Arduino connection

Figure 3.11: Driving servo motor

3.3.4 Sending a warning message with location to the in charge if water pollution occurs.

After collecting all sensors data it checks the quality. If quality is not good then it sends SMS with GSM module after trying to collect location info from GPS module. Figure 3.12 shows the flow chart of sending alert SMS.

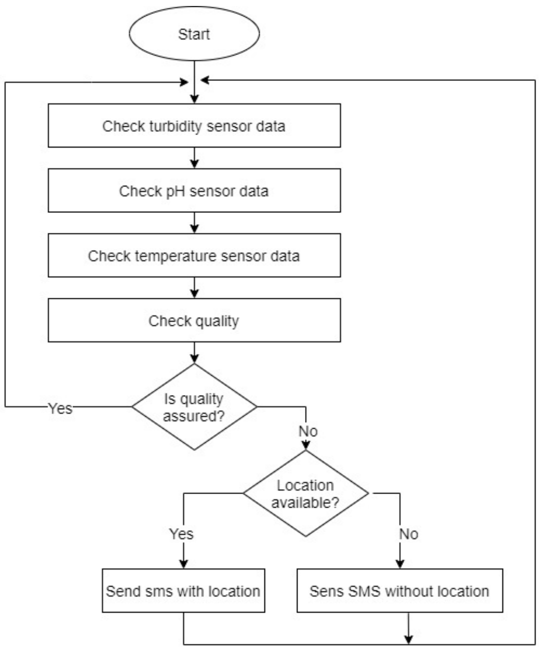


Figure 3.12: SMS sending flow chart

Collecting GPS Location

We used a GPS module in our system to get the tank location. When the water gets unacceptable to use the location will be sent to the responsible person. Figure 3.13 shows the connection between the Gps module and Arduino.

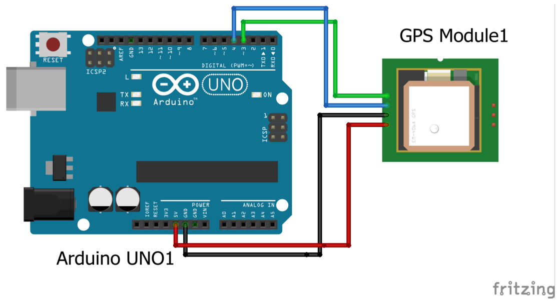


Figure 3.13: GPS module to Arduino connection

Sending SMS

We used GSM GPRS module to send location and notification message to respective person when water gets dirty.Figure 3.14 shows the connection between the sonar sensor and Arduino.

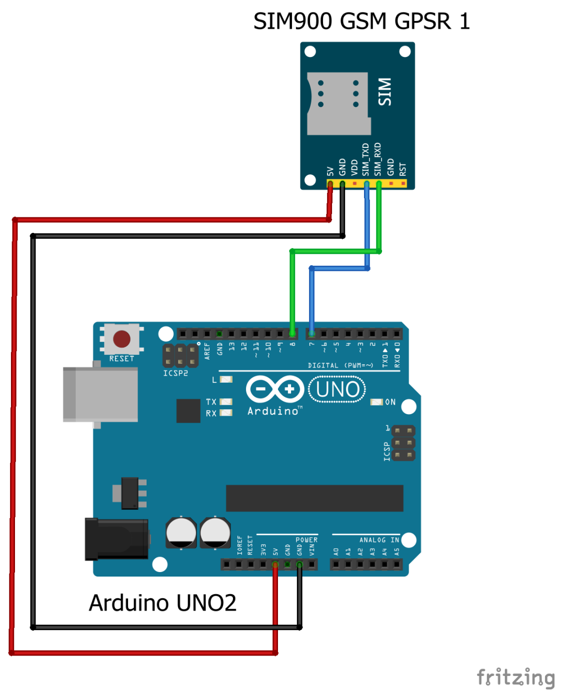


Figure 3.14: GSM module to Arduino connection

Android Application as Output Interface

We developed an android interface to visualize the data. Firebase realtime database SDK is provided by Google to make the application accessible to the database. We used that SDK as API in the application. This application is very easy to use and simple to understand. It has two interfaces in the first interface displays the latest condition of the water. We see the pH, Temperature, Turbidity, Flow, Used, volume value in the app interface.

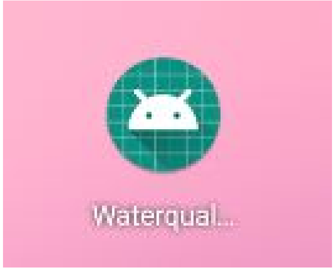


Figure 3.15: Android application Icon

Updated data image is given below:

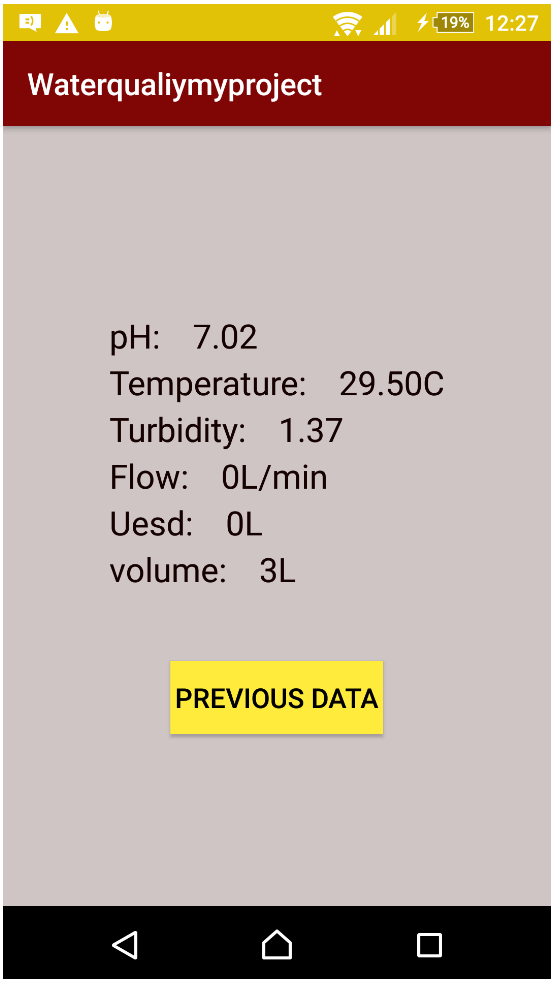


Figure 3.16: Android app updated data.

In the app interface, a button called "PREVIOUS DATA" is added. By pressing this button, we can go to second interface which shows us all the data from beginning to end.

"Previous data" interface image is given below:

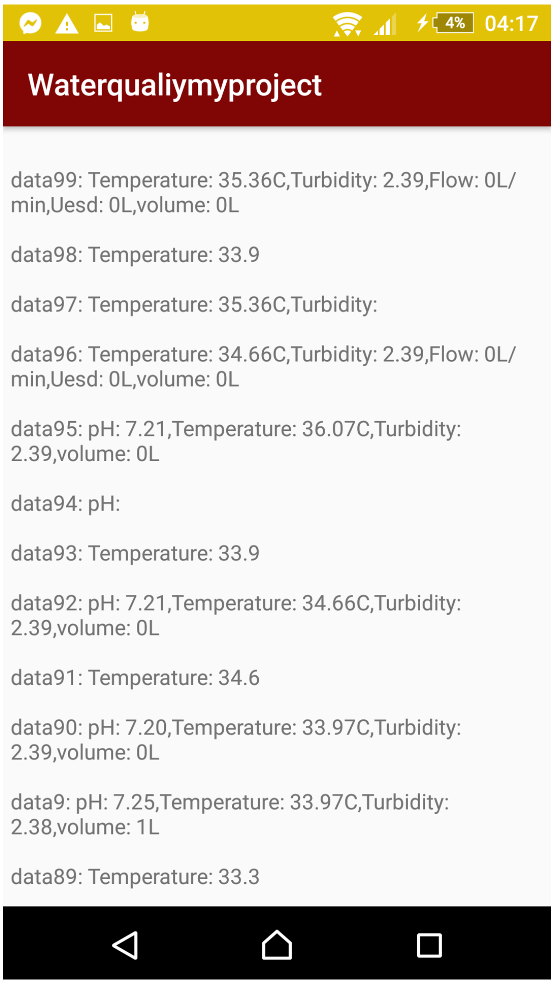


Figure 3.17: Android app previous data.

Incoming SMS with Location

We included the SMS sending process in our system. when the water gets dirty, it sends SMS with location to respective person as an alert.

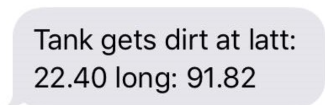


Figure 3.18: Alerting message with tank location

3.3.5 Showing water flow rate on LCD display

Collecting Flow Rate of Water

In our system flow meter used at the inlet pipe thus the rate of entering the water can be measured. Arduino collects generated voltage from the flow sensor and calculates the rate of passing water from this voltage. Figure 3.19 shows the connection between the flow sensor and arduino.

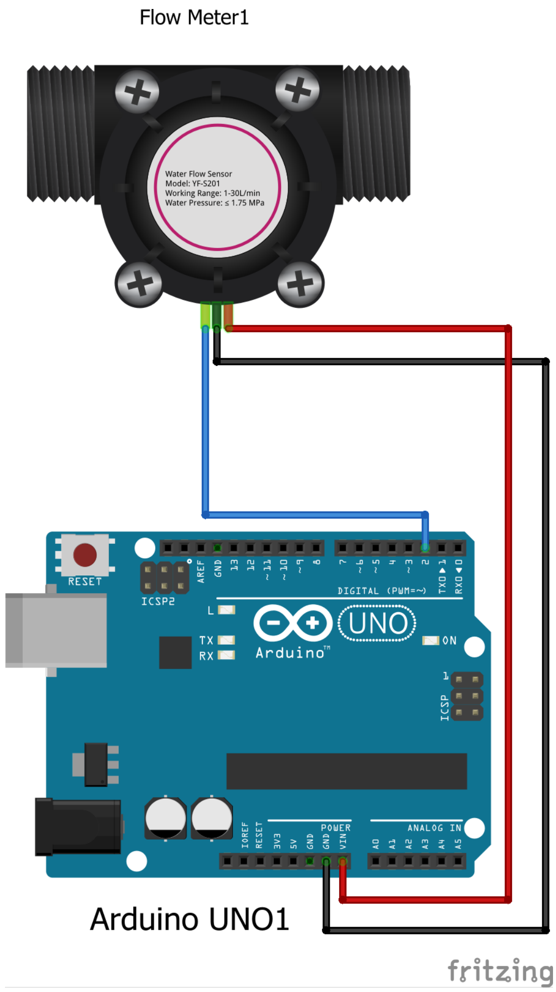


Figure 3.19: Flow sensor to Arduino connection

Interconnecting NodeMCU with Arduino

Two Arduino can communicate to each other by universal asynchronous receiver transmitter(UART). Where one Arduino's Tx and Rx pin is connected to another one's Rx and Tx. Here Rx is for receive data and Tx is for transfer data. Transferring and receiving data is like master-slave relation. Arduino can send data to the wifi module asynchronously and NodeMCU can receive those data and if the internet is available it can through data to firebase real-time database.Figure 3.20 shows the connection between the Node MCU and arduino.

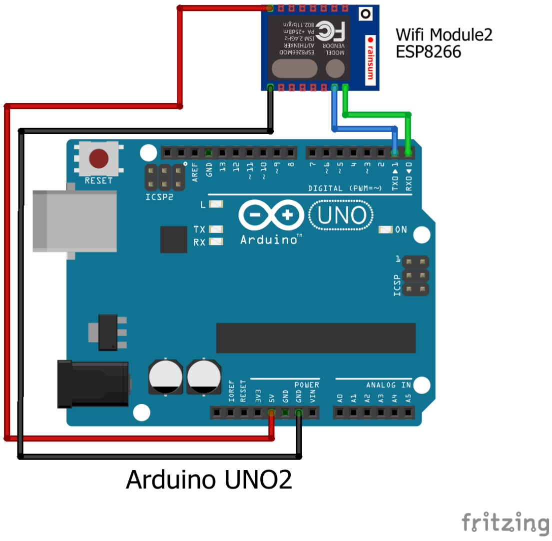


Figure 3.20: NodeMCU to Arduino connection

Showing Data to Display

A 16*2 liquid crystal display is used to showing sensor data. after receiving data from the Arduino wifi module display the data.Figure 3.21 shows the connection between the LCD display and Node MCU.

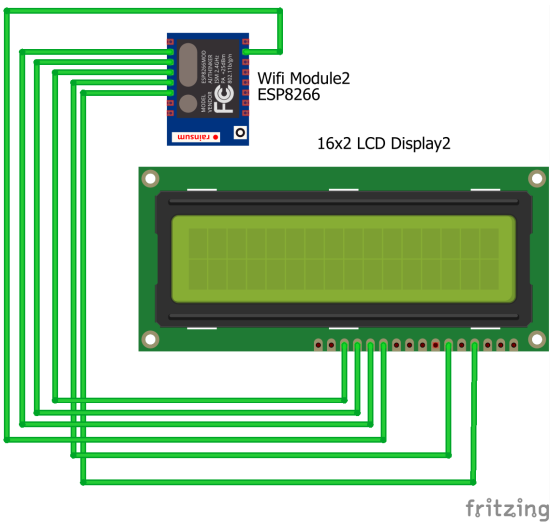


Figure 3.21: 16*2 liquid crystal display to NodeMCU connection

3.4 Implementation

In this section, we will discuss the implementation procedure of our water quality monitoring and controlling system with more detail which is given below.

3.4.1 Required Hardware

In our system, we used the following hardware components. In the following section, we discussed the application of these components to our project. We have selected these hardware components because they are comparatively cheaper than other chemical sensors. At experimental implementation, we can effectively find the feasibility of our proposed system using these components.

- pH sensor
- Turbidity sensor
- Ultrasonic sensor
- Digital temperature sensor
- Flow sensor
- NodeMCU
- Arduino UNO
- GSM module
- GPS module
- Servo motor
- Cleaning motor and brush
- Display
- Buzzer
- Power adapter

3.4.2 Required Software:

- Arduino IDE
- Android Studio
- Google cloud server (Firebase)
- Windows 10 Home
- Water quality monitoring android application

3.4.3 Required Programming Language:

- Java
- C
- Extensive markup language (XML)

3.4.4 Collecting water volume and use Water

Figure 3.22 (a) shows a tank filled with water and figure 3.22 (b) shows that app is showing that the water has not been used.

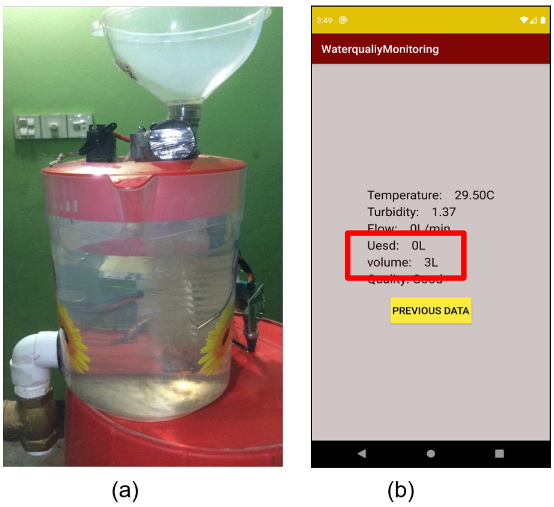
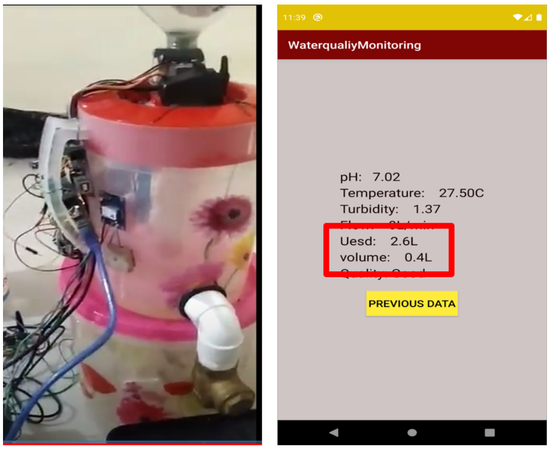


Figure 3.22: Tank status (a) tank filled with water (b) app shows no used water

Figure 3.23 (a) shows an empty tank and figure 3.23 (b) shows that app is showing that the water has been used.

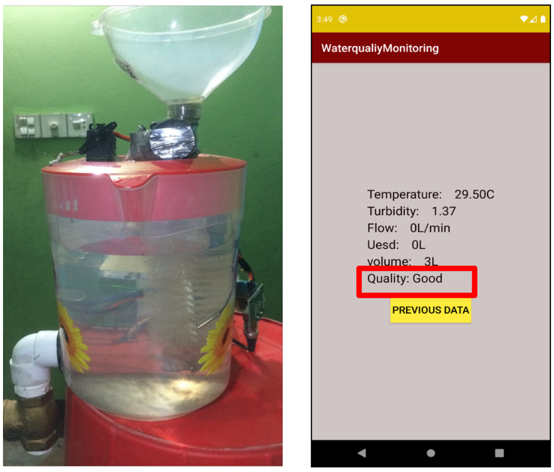


(a) (b)

Figure 3.23: Tank status (a) empty tank (b) app show the used water is 2.6 L

3.4.5 Cleaning and flushing tank

The system check if the quality of the water is good or not. Figure 3.24 (a) shows the tank full of clean water, 3.24 (b) shows the result that the water quality is good.

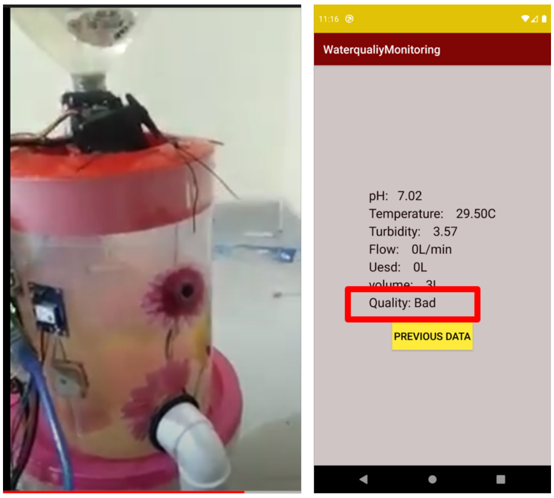


(a) (b)

Figure 3.24: Water quality (a) clean water (b) app showing water quality good

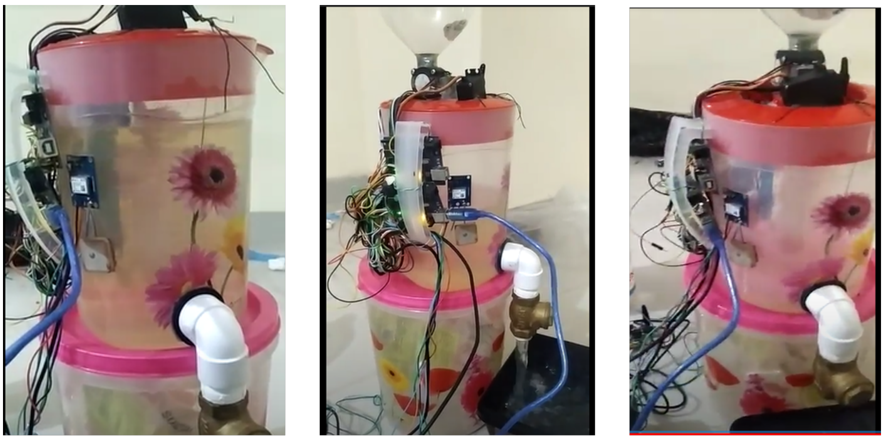
Figure 3.25 (a) shows the tank full of impure water, 3.25 (b) shows the result that the water quality is bad.

After getting impure water the system starts rotate the brush installed inside the tank which is shown in figure 3.26 (a). Figure 3.26 (b) shows that the water is flushed out from the tank and figure 3.26 (c) shows the empty tank after the flush which means it is ready to fill again.



(a) (b)

Figure 3.25: Water quality (a) impure water (b) app showing water quality bad



(a) (b) (c)

Figure 3.26: Water quality (a) cleaning the tank (b) flushed (c) empty tank

3.4.6 Sending alert messages

After calculating quality parameter data if water considered as impure water, A warning SMS with location is sent to tho respective person indicating that water gets dirty. And the geological location of the tank. A screenshot image is given below.

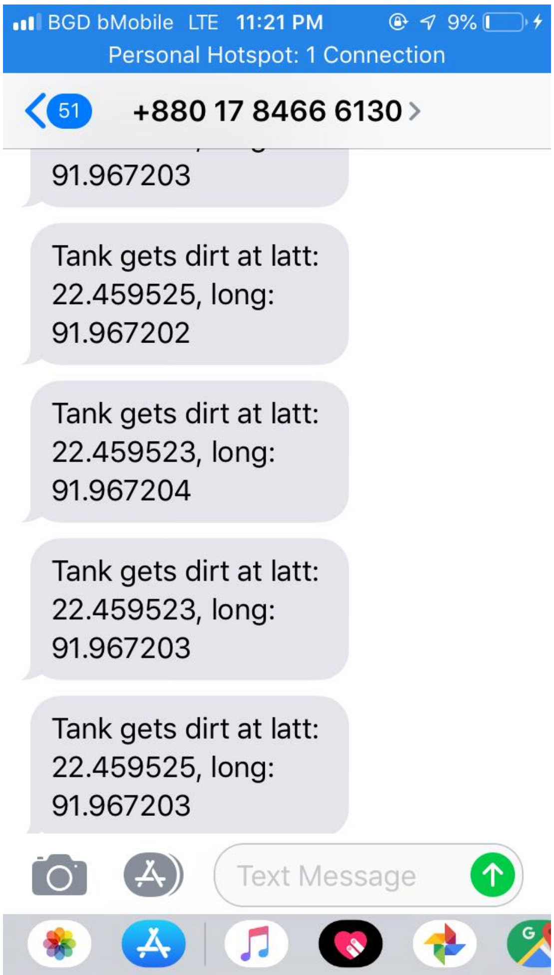


Figure 3.27: Alert messages in mobile device

3.5 Conclusion

We explained how our designed system works in this section. The outline of the project structure is discussed. The required hardware components, software and programming languages are also discussed. We presented observations and discussions according to the approach.

Chapter 4

Results and Discussions

4.1 Introduction

This chapter includes the experimental result, evaluation and performance of this system. We tried to find out the performance of our developed system and we discussed it.

4.2 Impact Analysis

In our water quality monitoring and the controlling system can be some impact such as social impact, environmental impact and ethical impact. A brief description of these impact analysis is given below:

4.2.1 Social and Environmental Impact

- It violates privacy,
- It is in violation of privacy, technology deployment and causes job losing for employees.
- IoT system consumes energy continuously.
- reducing the usage of IoT make the world safer.
- If total water gets flushed, a large quantity of water will be wasted
- IoT creates web links to remodel the interaction between human beings and things [20].
- If electricity gets leaked into water, then it will be dangerous

- If any sensor gets damaged it will give the wrong result by which people might be confused.
- people will be dependent on automated device.

4.2.2 Ethical Impact

Technologies generally have no question of ethics. Many devices may be used for both positive and bad purposes. For example, a video inspection can be extremely helpful for elderly people who stay at home longer and for the parents to watch their new-born child. They will reveal dishonest viewers and unexpected injury to private behaviour [21]. Some ethical impacts are discussed below:

- Internet of things technology deployment makes a system automated and causes loss of job for employees.
- People can apply IoT for destructive purposes.

4.3 Evaluation of Performance

4.3.1 Google Cloud Realtime Data Representation

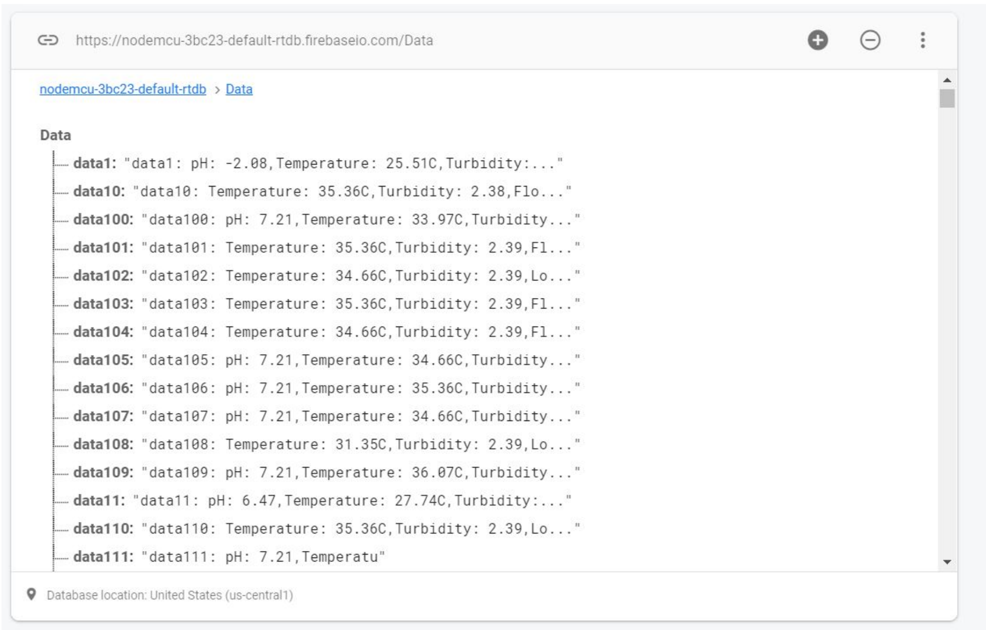


Figure 4.1: Google cloud realtime database.

4.3.2 Data Stored in Excel file

We have collected sensor data from seven hundred samples at different temperature. We got all combined data from the pH sensor, temperature sensor and turbidity sensor. We stored all the data in an excel file

B	C	D	E	F	G	H
temp	tur	ph_acid	ph_base	pH_acid	pH_base	sample
17.18	1849	3505	3810	7.01	7.62	0
18.94	1875	3500	3650	7	7.3	1
18.94	1985	3365	3710	6.73	7.42	2
18.94	2275	3225	3905	6.45	7.81	3
19.55	1846	3525	3515	7.05	7.03	4
19.55	1851	3505	3650	7.01	7.3	5
19.55	1856	3515	3565	7.03	7.13	6
19.55	1858	3510	3540	7.02	7.08	7
19.55	1975	3405	3665	6.81	7.33	8
20.17	1850	3510	3560	7.02	7.12	9
20.17	1975	3505	3655	7.01	7.31	10
20.17	1866	3445	3655	6.89	7.31	11
20.17	1803	3440	3720	6.88	7.44	12
20.17	1866	3445	3745	6.89	7.49	13

Figure 4.2: Data stored in excel file

4.3.3 Relation Between Turbidity and Temperature

We tried to find out the relation between incremental turbidity at incremental temperature. Here the relation is plotted and given below:

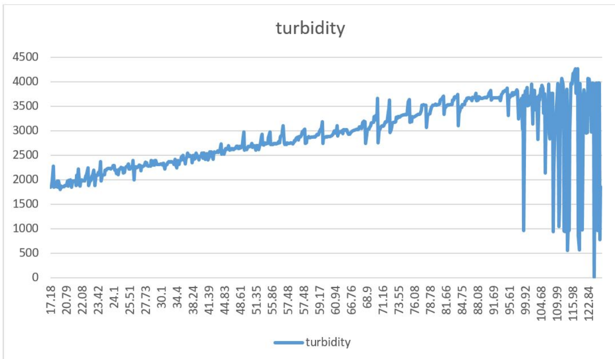


Figure 4.3: Turbidity vs temperature

we found that at low to moderate temperature turbidity value is linearly increased but at high temperature, it gave the wrong result. So we stopped collecting any more data.

4.3.4 Relation Between pH and Temperature

We tried to find out the relation between incremental pH value of both acid and base at incremental temperature. Here the relation is plotted and given below:

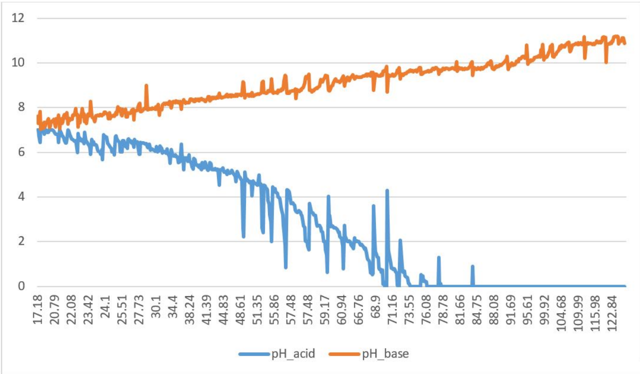


Figure 4.4: pH value vs temperature

We found that at incremental temperature pH value at the base was incremented linearly but the pH value at acid falls more quickly. At high temperature, water becomes more acidic.

4.3.5 Relation Among all Sensor Data at Incremental Temperature

We tried to find out the relation between incremental turbidity data and the pH value of both incremental acid and base at incremental temperature. Here the relation is plotted and given below:

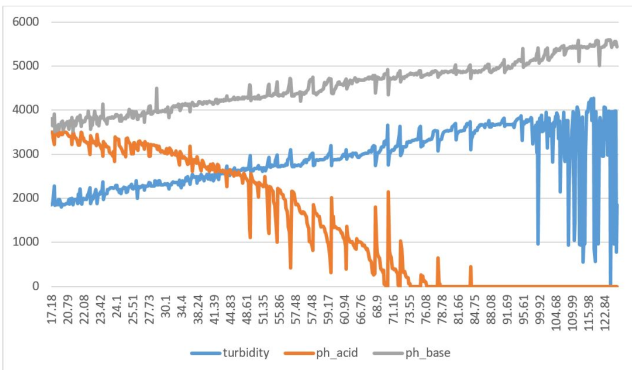


Figure 4.5: Turbidity vs temperature, pH at acid vs temperature, pH at base vs temperature

We found that there is no notable relation between turbidity and pH value.

4.3.6 Accuracy Calculation

We tested total process for thirty times and we stored the activity of every segment. We found this result, which is given below:

Table 4.1: Performance of System

Test case No.	pH	Temp	Tur	Sonar	Flow	Update to server	Quality found	Actual quality	Match	Clean and Flush	SMS with location
1	1	1	1	1	1	1	Good	Good	Yes	No	
2	1	1	1	1	1	0	Good	Good	Yes	No	
3	1	1	1	1	1	1	Good	Good	Yes	No	
4	1	1	1	1	1	1	Good	Good	Yes	No	
5	1	1	1	1	1	1	Bad	Good	No	Yes	
6	1	1	1	1	1	1	Good	Good	Yes	No	
7	1	1	1	1	1	0	Good	Good	Yes	No	
8	1	1	1	1	1	1	Bad	Good	No	Yes	
9	1	1	1	1	1	1	Good	Good	Yes	No	
10	1	1	1	1	1	1	Bad	Bad	Yes	Yes	No
11	1	1	1	1	1	0	Bad	Bad	Yes	Yes	No
12	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
13	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
14	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
15	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
16	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
17	1	1	1	1	1	1	Bad	Bad	Yes	Yes	No
18	1	1	1	1	1	1	Bad	Bad	Yes	Yes	No
19	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
20	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
21	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
22	1	1	1	1	1	1	Bad	Bad	Yes	Yes	No
23	1	1	1	1	1	1	Bad	Bad	Yes	Yes	No
24	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
25	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
26	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
27	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
27	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
28	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
29	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
30	1	1	1	1	1	1	Bad	Bad	Yes	Yes	Yes
Result						(30-3) /30 * 100 =90%			(30-2) /30 * 100 = 93%	(30-2) /30 * 100 =93%	(20-6) /20 * 100 =70%

In table 4.1 Shows the result of thirty cases.

So, the Success rate is = 93%. Cleaning and flushing accuracy is 93%. Data updating accuracy is 90% and location found on sending message is about 70%. In the following section we will discuss on the result.

4.3.6.1 Result Analysis

From this result, we found that all the sensors are working well. Data updating accuracy is 90% it is due to internet latency. Again for the two times we found wrong result, the system considered good water as bad water. We got 93% accuracy due to the low quality of sensors. If we could use industrial graded sensors, we would be able to get a more accurate result. We got the accuracy of alert message with location is 70%. This is because the GPS module cannot find satellite signals all time. If the sky gets cloudy, the satellite signals get unavailable.

4.4 Conclusion

Finally, a water quality monitoring and controlling system based on internet of things technology is developed to retrieve water quality parameters with excellent precision. The system established shows brilliant results that flow, pH, turbidity and temperature and tank cleaning are expected to meet the exacting requirements of water quality. The work has been compared with past literature, and a water quality monitoring system based on IoT can also be used as a low-cost method for local water system quality which can solve a wide range of problems in any water quality measurement guide in the real life.

Chapter 5

Conclusion

5.1 Conclusion

Monitoring of water quality is nowadays extremely important as it's widely fed by the public. IoT has faced difficulties in the field of traditional water quality tracking and water testing, mostly centred in the period. Similarly, the current water quality tracking for assessment does not contain any intelligence. Now with the arrival of the machine to communicate with other machines which include items to communicate to each other and can be used in large geographical areas in comparison to the small area as seen in the previous device. As a result, a wise water quality monitoring machine based on IoT was advanced right here. This proposed system can solve a large number of problems regarding this topic. The sensor data is sent serially to Arduino UNO, where the Arduino learns the logic used to calculate water quality. Cloud servers have stored the documents and projected results. This has led to IoT technology being used in the automatic water monitoring system, where the sensors can interconnect to measure residential water quality. This shows that there is no human interference to automatically regulate water safety. This device should be implemented not only in the supply tank but also in a river, lake and wetlands. For predicting and future operation the data should be stored carefully.

5.2 Limitation and Future Work

A cost-effective, real-time monitoring system for water quality has been implemented and tests performed. Here an experimental setup is performed. This system allows administrative staff to monitor the levels of contamination inside water systems. In the future notifications can be sent to every user when the water gets dirty. In this experimental setup, low-cost components are used so an Industrial graded waterproof sensor should be used. The structure can be designed in such a shape that it can be used anywhere. Due to Covid, it was not possible to set this device at the real supply line. If possible then real data would get and use that data machine learning algorithms could be applied. Thus we could predict the water quality at a different place at different time. We did not use individual chemical sensor due to the high price. Again we flushed thee total dirty water. In future, we can make an automated process to refine dirty water. Internet of Things (IoT) and its services are becoming part of our life, ways of running, and business. High-quality studies are being conducted on the development of essential building blocks and modes to support a range of relevant technology network solutions.

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