Mini Project Report

on

Water Quality Monitoring Buoy

Submitted in the partial fulfillment of the requirements

for the degree

Bachelor in Technology

by

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Guide

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Batch 2021 -2025

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(A Constituent College of Somaiya Vidyavihar University)

Certificate

This is to certify that the Mini project report entitled **Water Quality Monitoring Buoy** is bonafide record of the work done by Aditya Pandey (16010321032), Atharva Dalvi (16010321033), Janvi Panwar (16010321034), Jay Patil (16010321035) in the year 2023 - 2024 under the guidance of Dr. Rupali P Patil and Dr. Sandeep R Sainkar in partial fulfillment of requirement for the Bachelor in Technology degree in Electronics and Telecommunication Engineering of Somaiya Vidyavihar University.

SRSainkar (Sandeep R. Sainkar)

Guide 1

02.05.2024

Guide 2

Date: 02/05/2024

Place: Mumbai-77

Somaiya Vidyavihar University

K. J. Somaiya College of Engineering

(Constituent College of Somaiya Vidyavihar University)

Certificate of Approval of Examiners

This is to certify that the Mini project report entitled Water Quality Monitoring Buoy is bonafide record of the work done by Aditya Pandey (16010321032), Atharva Dalvi (16010321033), Janvi Panwar (16010321034), Jay Patil (16010321035) in partial fulfillment of requirement for the Bachelor in Technology degree in Electronics and Telecommunication Engineering of Somaiya Vidyavihar University.

02/05/2024

Expert / External Examiner

02-05-2024

Internal Examiner / Guide

Date: 02/05/2024

Place: Mumbai-77

K. J. Somaiya College of Engineering, Mumbai-77

(Autonomous College Affiliated to University of Mumbai)

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Date: 02-05-2024

Place: Mumbai-77

Abstract

Water is one of the most vital resources for sustaining life on Earth, playing a crucial role in various aspects of human activities, including drinking, agriculture, industry, and recreation. However, ensuring the quality and safety of water sources has become an increasingly challenging task due to environmental pollution, climate change, and human activities. The increasing pollution in marine environments necessitates enhanced monitoring methods to tackle the challenges of water quality and sea weather conditions. Traditional stationary monitoring approaches are limited by high operational costs and manual data collection requirements.

To address this, our project develops a Water Quality Monitoring Buoy equipped with advanced sensors to autonomously assess water quality metrics such as turbidity, temperature, and pH levels, alongside sea weather conditions. This buoy Leverages advancements in sensor technology, wireless communication, and data analytics, the system aims to provide reliable, cost-effective, and scalable solutions for monitoring water quality in various contexts, including freshwater bodies, groundwater sources, and wastewater treatment facilities. By implementing this buoy, we aim to enhance environmental monitoring, contributing significantly to the preservation and management of marine ecosystems.

***Key words*:** Water quality monitoring, Thingspeak, Esp 32, IoT, pH, Data visualization, Real-time Data Acquisition.

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Chapter 1

Introduction

This chapter presents a brief idea of the project, the motivation behind the project and the scope of the project. This also includes organization of project.

1.1 Background

The creation of the Water Quality Monitoring Buoy was motivated by a growing recognition of the urgent environmental challenges posed by water pollution and the limitations of traditional water quality monitoring methods. Water pollution has become a critical environmental issue globally, with pollutants ranging from bacteria and viruses to chemicals, and even radioactive substances. These pollutants which are often invisible significantly alter the composition of water bodies, posing severe health risks to ecosystems and human populations. The World Health Organization highlights the profound impact of these contaminants on water usability, underlining the necessity for effective monitoring and management solutions.

The urgency of addressing marine pollution, coupled with the technological advancements in sensors and IoT, catalyzed the development of the Water Quality Monitoring Buoy. This project aims to revolutionize how water quality is monitored by making the process more accessible, timely, and effective, ultimately contributing to the preservation and protection of global water resources.

1.2 Motivation

Traditionally, water quality monitoring has relied on stationary methods that involve high operational costs and require manual data collection. These methods are not only expensive but also inefficient in providing timely and comprehensive data, especially across vast and remote marine areas. Such limitations hinder the ability to respond promptly to pollution events or environmental changes, making it difficult to implement effective mitigation strategies. In response to these challenges, there has been a significant push towards leveraging advanced sensor technology and IoT platforms. These technologies allow for real-time, continuous, and remote monitoring of water quality and sea weather conditions, which is crucial for understanding and responding to the dynamic nature of marine environments.

1.3 Scope of the Project

This mini project aims to simultaneous measure multiple water quality parameters, including pH levels, turbidity, temperature, and humidity used for assessment of water quality conditions in various environmental settings. The ESP32 microcontroller along with sensors acquires real-time data on water quality parameters. The system is configured to transmit the acquired sensor data to the ThingSpeak server. ThingSpeak provides data visualization, and does analysis of sensor data in real time.

With the ThingSpeak platform, we can remotely monitor water quality parameters in real time via web or mobile applications. The system is designed to be scalable and adaptable to different monitoring scenarios and environments. Additional sensors or functionalities can be easily integrated into the system to monitor additional water quality parameters or expand monitoring coverage.

1.4 Organization of the Report

- In this chapter 1, we provide the background and motivation for our project, explaining why it is important to develop a Water Quality Monitoring Buoy.
- In this chapter 2, we conducted a thorough literature survey, reviewing ten research papers that addresses different methods and technologies for Water Quality Monitoring Buoy.
- In this chapter 3, we discuss many steps involved in making our program and its capabilities. We also discuss the various technologies that we will use in our project.
- In this chapter 4, we implement the various techniques discussed in Chapter 3 and successfully built the buoy. We will test it in different environments and assess the different parameters.
- In this final chapter 5, we conclude our project by analyzing our findings, discussing the limitations of our study, and suggest areas for future research.

Chapter 2

Literature Survey

The literature survey serves as a comprehensive overview of the existing research and developments. This survey not only identifies significant trends and gaps in the different papers but also establishes a foundation for further study and analysis.

In our literature survey, we rigorously reviewed multiple papers, analyzed the different technologies, the trends and patterns, the varying components and the distinct methodologies used. We have summarized the key points of each paper and laid down the foundation for our project by understanding the various advantages and disadvantages present in the current water quality monitoring mechanisms.

"**A Low-Cost AI Buoy System for Monitoring Water Quality at Offshore Aquaculture Cages**" [1] talks about a cost-effective AI buoy system to monitor and predict water quality in aquaculture settings. Developed by a team from National Taiwan Ocean University, the buoy uses simple electronic devices and AI algorithms to measure essential water parameters like dissolved oxygen, salinity, water temperature, and velocity. The data collected by the buoy is transmitted wirelessly to a shore server, where AI techniques are employed to provide real-time water quality information and short-term predictions. This approach aims to improve the management and sustainability of aquaculture operations by providing accurate, real-time data to aquaculture staff, thereby optimizing feeding strategies and reducing environmental impact.

An innovative approach is used to assess water quality using remote-controlled (RC) boat equipped with various other sensors is explained in the paper "**Water Pollution Monitoring RC Boat**" [2]. The RC boat monitors turbidity, pH, and temperature of water bodies, and data is transmitted to a cloud server, which is accessible through a mobile app. The system employs an ESP32 microcontroller, turbidity sensor (SKU SEN0189), pH sensor, and a temperature sensor, chosen for their cost-effectiveness and operational efficiency. The real-time data collected is aimed at helping identify pollution levels in different water sources, making it easier to take timely corrective actions.

This mobile-integrated solution enhances the ease of operation and data accessibility, showcasing a scalable and economical approach to environmental monitoring.

"**Renewable Powered Portable Weather Update Station**" [3] outlines the development of a renewable energy-powered portable weather station. This station employs various sensors to collect environmental data like temperature, humidity, carbon monoxide levels, and more. The data collected by these sensors is processed by Arduino MEGA and displayed on an LCD screen. Additionally, the system can send weather updates via SMS using a GSM module. The device operates on solar power, making it suitable for remote locations without access to the electrical grid. The study highlights the accuracy of the system by comparing its data with national weather service data, showing minimal deviations, thereby proving its reliability for personalized, location-specific weather updates.

In [4], the paper titled "**A GSM Based Water Quality Monitoring System using Arduino**" discusses the development of a water quality monitoring system using wireless sensor network to address water contamination issues accelerated by rapid urbanization. The system is designed to assess water quality using multiple sensors that measure parameters such as pH, conductivity, and temperature, and employs an Arduino microcontroller for data processing. The use of GSM technology facilitates real-time data transmission to a central system, where it can be accessed via smartphones or PCs. This allows for continuous on-site water quality assessment, reducing the need for manual sampling and enabling timely interventions to address water quality issues.

Tarlochan Kaur and colleagues, discuss the design and development of an innovative, low-cost solar-powered battery charging system intended for Rural Solar Home Systems (SHS) in their paper titled "**Arduino Based Solar Powered Battery Charging System for Rural SHS**" [5]. Utilizing an Arduino Uno microcontroller, the system features a Maximum Power Point Tracking (MPPT) system for efficient energy harvest from photovoltaic cells, a user interface LCD for displaying system statuses, and a Wi-Fi module for remote data monitoring and management. This system is particularly tailored to improve the accessibility and sustainability of electric power in remote rural areas by allowing individual SHS to connect and form a low voltage DC microgrid.

The paper titled "**IOT Based Water Quality Monitoring System**" [6] by Jayti Bhatt and Jignesh Patoliya, presents a real-time water quality monitoring solution utilizing IoT technology. The system integrates sensors to measure critical water parameters like pH, turbidity, conductivity, dissolved oxygen, and temperature. These sensors' data are processed by a microcontroller and transmitted via Zigbee protocol to a core Raspberry Pi controller. The processed data is then uploaded to the cloud, allowing remote monitoring through a web-based application. This IoT system aims to provide a cost-effective, efficient, and user-friendly approach to maintaining water safety and quality, addressing the significant need for ongoing monitoring due to the challenges posed by global warming and pollution.

"**Real time, low power, high data rate and cost effective transmission scheme for coastal buoy system**" [7] discusses the implementation of a real-time, low-power, high data rate, and cost-effective data transmission scheme using GPRS for a coastal buoy system. By leveraging GPRS technology, the buoy system achieves efficient data management with higher data rates at reduced costs. The data collected includes various meteorological and oceanographic parameters, which are transmitted in real-time to a shore station for immediate processing and use in forecasting and scientific research. The paper highlights the technical specifications, system design, and operational effectiveness of the buoy system, demonstrating its advantages over traditional satellite-based systems in terms of cost, power consumption, and data throughput.

In "**IoT Based Smart Water Quality Monitoring System**" [8] the system uses various sensors to measure parameters like pH, turbidity, conductivity, and more, providing real-time data on water conditions. This information is sent to a cloud server, allowing for immediate analysis and action if needed. The system aims to improve water safety and is particularly significant for areas where water quality is a persistent issue. It leverages advancements in sensors and communication technology to offer a cost-effective, efficient solution for ongoing water quality monitoring, which is crucial for public health and environmental protection.

Authors - Sathish Pasika and Sai Teja Gandla, discuss the development of an affordable and efficient water quality monitoring system utilizing IoT technology in their paper. The paper titled "**Smart Water Quality Monitoring System with Cost-Effective Using IoT**" [9] by the authors incorporates sensors to measure key parameters such as pH, turbidity, water level, temperature, and humidity. These parameters are crucial for assessing the quality of drinking water. The collected data is processed by a microcontroller and transmitted to a cloud platform via IoT for real-time monitoring. This setup allows for continuous and automatic water quality assessment, which is vital for preventing waterborne diseases and ensuring the safety of water supplies.

S Gupta and colleagues in "**IoT Based Underwater Robot for Water Quality Monitoring**" [10] describe the development of an autonomous underwater vehicle designed to monitor and evaluate the quality of water in terms of pH, turbidity, and temperature using IoT technology. The robot uses an ESP32 module for underwater communication due to its low power consumption and in-built Wi-Fi capabilities. It employs machine learning algorithms to analyze water quality against predefined standards. This model serves as a low-cost, effective solution for real-time water quality monitoring, aiming to reduce manpower, enhance operational efficiency, and minimize human errors. The robot is particularly useful for continuous monitoring of water bodies such as lakes, rivers, and ponds, providing significant advancements over traditional methods which are often time-consuming and labor-intensive.

S. No.	Title	Methodology	Limitations	Components used
1	**A Low-Cost AI Buoy System for Monitoring Water Quality at Offshore Aquaculture Cages** **Publication Year** -27.05.2022 **Citation** – [1]	✓AI ✓WCN ✓ML ✓ water quality ✓Zigbee	✓Limited to Aquaculture cages ✓Expensive (overall cost 2015 US Dollars)	✓LoRa module ✓GPS module ✓Solar controller
2	**IoT Based Water Pollution Monitoring RC Boat** **Publication Year** –May 2022 **Citation** – [2]	✓Remote Controlled boat ✓Data Logging as well as IOT Online Transmission	✓Limited operating time ✓Low range operation ✓Safety issues	✓ Rudder ✓ Propeller ✓ NRF transreceiver ✓ Sensors. ✓ Motor, Servo Motor
3	**Renewable Powered Portable Weather Update Station** **Publication Year** – 2019 **Citation** – [3]	✓Meteorological Parameters ✓GSM for data transmission ✓Self charging	✓Only measures atmospheric data ✓High Power Consumption ✓Only used for ground operations.	✓ Arduino Mega ✓ LCD, GSM Module ✓ Sensors – Barometer, gas detector, termperature, humidity ✓ Solar Panel
4	**A GSM Based Water Quality Monitoring System using Arduino** **Publication Year** - 02.04.2019 **Citation** – [4]	✓Automated system using IoT for enhanced monitoring ✓Emphasizes on power-efficient system	✓No Self Charging ✓No cloud service for data visualization	✓Sensors – pH, Conductivity, Temperature ✓Arduino Uno Board ✓GSM Module
5	**Arduino Based Solar Powered Battery Charging System For Rural SHS** **Publication Year** –17.11.2016 **Citation** – [5]	✓MPPT ✓Wi-Fi module for remote surveillance	✓It is just a solar powered charging system	✓ Battery ✓ Solar cells ✓ WiFi Module
6	**Iot Based Water Quality Monitoring System** **Publication Year** –April 2016 **Citation** – [6]	✓Zigbee protocol ✓IOT ✓Cloud Computing	✓Zigbee req high strength WiFi network ✓Expensive	✓Raspberry pie ✓Conductivity sensor ✓Dissolved oxygen sensor
7	**Real time, low power, high data rate and cost effective transmission scheme for coastal buoy system** **Publication Year** –Oct 2013 **Citation** – [7]	✓ GPRS ✓GPS ✓FTP	✓Expensive materials and system ✓Large size ✓Heavy weight	✓fiber reinforced plastics filled with polyurethane ✓Sensors – humidity, Anemometer, conductivity and temp.
8	**IoT based smart water quality monitoring system** **Publication Year** -02.07.2021 **Citation** – [8]	✓Wifi Module ✓IOT ✓Sensor Integration	✓Limited operating time ✓Low range operation ✓Use of extra components	✓Sensor – pH, turbidity, termperature, humidity, conductivity, CO2 ✓Arduino ATMEGA ✓ESP 8266, LCD
9	**Smart water quality monitoring system with cost-effective using IoT** **Publication Year** – 26.05.2020 **Citation** – [9]	✓Wifi Module ✓IOT ✓Sensor Integration	✓Limited operating time ✓Low range operation ✓Use of extra components	✓Sensor – pH, turbidity, termperature, humidity, conductivity, CO2, Ultrasonic ✓Arduino ATMEGA ✓Wifi module
10	**IoT Based Underwater Robot for Water Quality Monitoring** **Publication Year** – 2020 **Citation** – [10]	✓ Under water Operations ✓ Recon purpose ✓ Wifi camera	✓Limited operating time ✓Low range operation ✓High power consumption	✓ Arduino UNO ✓ Esp32 CAM ✓ Stepper, gear motor ✓ Water pump ✓ Sensor – pH, turbidity, temperature

Chapter 3

Project Design

This chapter presents the overall design and concept of the sensors and circuits used.

3.1 Introduction

Water quality monitoring plays a crucial role in safeguarding the health of aquatic ecosystems and ensuring the availability of clean water for various human activities. In recent years, there has been a growing emphasis on leveraging technological advancements to develop innovative solutions for real-time monitoring of water quality parameters.

Our mini project focuses on the design and implementation of a water quality monitoring buoy equipped with sensors to measure key parameters including turbidity, pH level, and atmospheric temperature and humidity. The buoy serves as a versatile platform for conducting comprehensive and continuous monitoring of water quality in lakes, rivers, reservoirs, or coastal areas. With the power of sensor technology and wireless connectivity, our project aims to provide timely and accurate data on critical water quality indicators. Whether deployed in freshwater or marine environments, the buoy serves as a cost-effective and scalable solution for enhancing our understanding of aquatic ecosystems and promoting sustainable water management practices.

3.2 Problem Statement

The increasing pollution in marine environments and the need for continuous monitoring of water quality and sea weather conditions present significant challenges. Traditional methods of monitoring are often limited by their stationary nature, high operational costs, and the need for manual data collection. To address these issues, the development of a Water Quality Monitoring Buoy is proposed. This buoy aims to autonomously assess water quality and sea weather conditions using advanced sensors. By providing real-time, continuous data, it will enhance our ability to monitor and respond to environmental changes in marine ecosystems.

3.2.1 Components Used

1. **ESP Wroom 32**

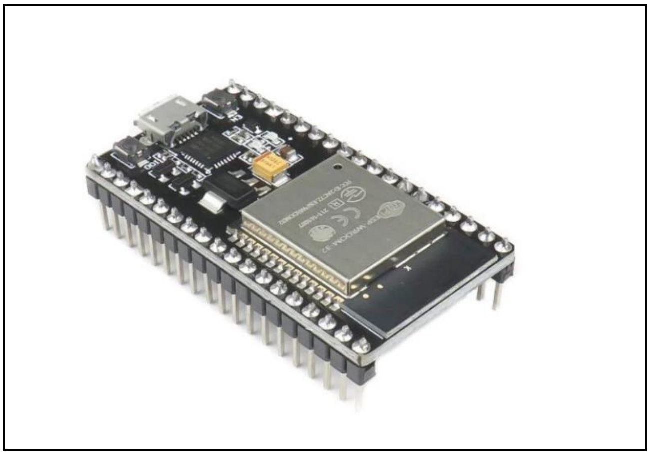

Figure 3.1 - Fig. shows the ESP32 MCU Module

This is ESP WROOM 32 MCU Module. ESP WROOM 32 is a powerful, generic WiFi-BT-BLE MCU module that targets a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as voice encoding, music streaming, and MP3 decoding. At the core of this module is the ESP32 chip, which is designed to be scalable and adaptive.

There are 2 CPU cores that can be individually controlled or powered, and the clock frequency is adjustable from 80 MHz to 240 MHz.ESP32 integrates a rich set of peripherals, ranging from capacitive touch sensors, Hall sensors, low-noise sense amplifiers, SD card interface, Ethernet, high-speed SDIO/SPI, UART, and I²C.Using Bluetooth, users can connect to their phone or broadcast low energy beacons for its detection.

The use of Wi-Fi enables a large physical range, as well as a direct connection to the internet via a Wi-Fi router. Perfect for wearable electronic or battery-powered applications, the ESP32 chip uses less than 5µA. In addition, this module can support data rates of up to 150 Mbps and 22 dBm output power at the PA in order to allow for the widest physical range.

Pin diagram -

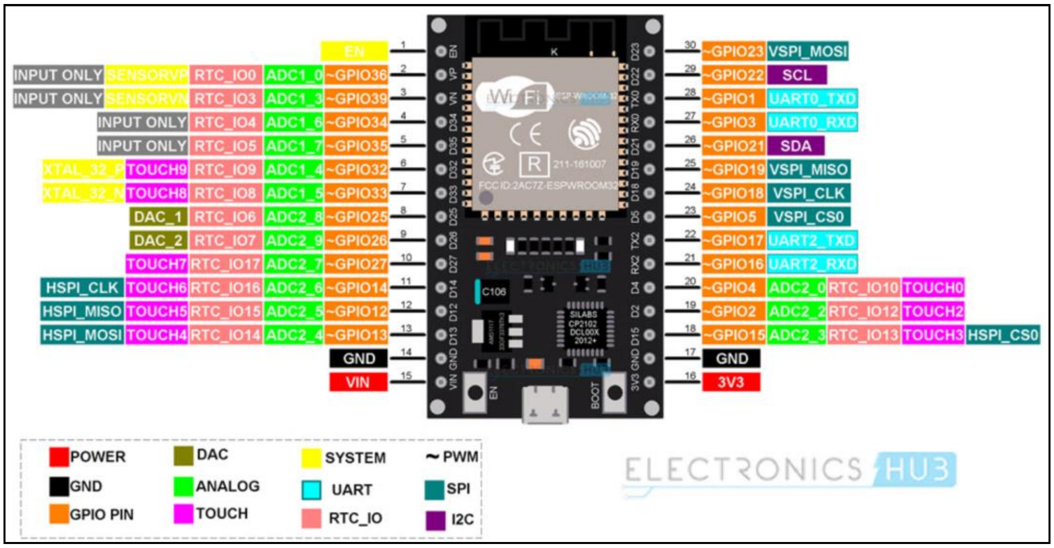

Figure 3.2 - Fig. shows ESP32 MCU Module Pin configuration

Specifications –

- Bandwidth: 72 MHz
- Data Rate: 150 Mbps
- Interface: Ethernet, I2C, I2S, SPI, UART
- Max Frequency: 2.484 GHz
- Max Operating Temperature: 85 °C
- Max Supply Voltage: 3.6 V
- Min Operating Temperature: -40 °C
- Min Supply Voltage: 3 V
- Nominal Supply Current: 500 mA
- Number of ADC Channels: 16
- Number of GPIO: 32

2. Temperature sensor – DHT 11

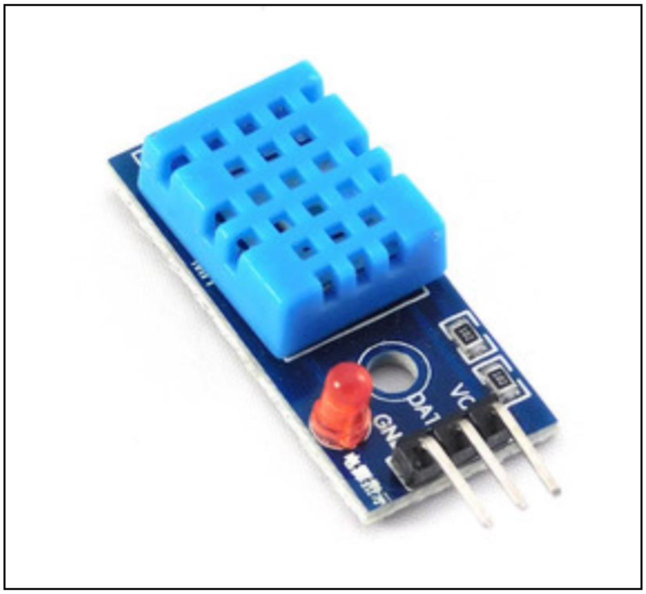

Figure 3.3 - Fig. shows DHT 11 sensor

The DHT-11 Digital Temperature And Humidity Sensor is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed).

Its fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds.

Specifications –

- Temperature range (°C): 0 - 50
- Temperature measurement error: ±2°C
- Humidity measurement range: 20% - 95% RH
- Humidity measurement error: ±5% RH (Relative Humidity)
- Resolution: 16 Bit
- Output form: Digital output

3. Turbidity sensor

Figure 3.4 - Fig. shows Turbidity sensor

A turbidity liquid particle detection sensor is a device that is used to measure the turbidity, or cloudiness, of a liquid. Turbidity is often used as an indication of the presence of suspended particles in the liquid, such as dirt, algae, or bacteria. The sensor works by shining a light through the liquid and measuring the amount of light that is scattered or absorbed by the particle detection. The turbidity sensor has an operating voltage of 5VDC and maimum current of 30mA. It has an operating temperature of -30°C to 80° C and is best compatible with Arduino, Raspberry Pi, AVR, PIC.

It is able to detect particles that are suspended in water and detect quality of water.

Specifications -

- Working voltage: DC 5V
- Working current: 30mA (MAX)
- Response time: <500 msec
- Insulation Resistance: 100MΩ (Min)
- Operating Temperature (°C): -30 to +80

Standard values according to BIS:

Organoleptic and Physical Parameters
(*Foreword* and *Clause* 4)

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternate Source	Method of Test, Ref to Part of IS 3025	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	Colour, Hazen units, *Max*	5	15	Part 4	Extended to 15 only, if toxic substances are not suspected in absence of alternate sources
ii)	Odour	Agreeable	Agreeable	Part 5	a) Test cold and when heated b) Test at several dilutions
iii)	*p*H value	6.5-8.5	No relaxation	Part 11	—
iv)	Taste	Agreeable	Agreeable	Parts 7 and 8	Test to be conducted only after safety has been established
v)	Turbidity, NTU, *Max*	1	5	Part 10	—
vi)	Total dissolved solids, mg/l, *Max*	500	2 000	Part 16	—

NOTE — It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.

Figure 3.5 - Fig. shows BIS standard values

4. Ph Sensor

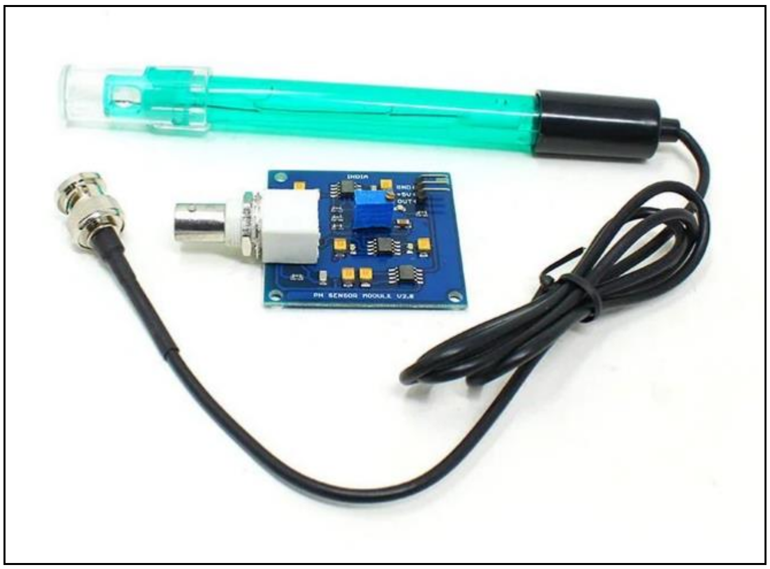

Figure 3.6 - Fig. shows pH sensor along with module

This is Industrial Grade Analog PH Sensor Kit. This probe can be used with this pH sensor module.

The Analog pH Sensor Kit is specially designed for Arduino and Esp controllers and has a built-in simple, convenient, and practical connection and features. It has an LED that works as the Power Indicator, a BNC connector, and a PH2.0 sensor interface. To use it, just connect the pH sensor with the BND connector, and plug the PH2.0 interface into the analog input port of any Arduino Esp controller. If pre-programmed, you will get the pH value easily.

Specifications –

- Input Supply voltage (VDC): 5
- Module Size (mm): 50 x 47 x 16
- Measuring Range: 0 - 14 PH
- Measuring Temperature: 0 - 50 °C
- Accuracy: ± 0.01 PH
- Response Time: ≤ 1min

Calibration:

Input V lvl is from 0 to 5V, so accordingly value for pH(7) = 2.5V

pH(4) = 3V

Voltage = sensor value x (3.3/4095.0)

Slope = Δ pH/Δ voltage

Slope intercept = 7 – (slope x Voltage)

Hence, pH = (Voltage x slope) + Slope intercept … y = mx + c

3.2.2 Software Used/ Libraries Used

1. **Arduino IDE:**

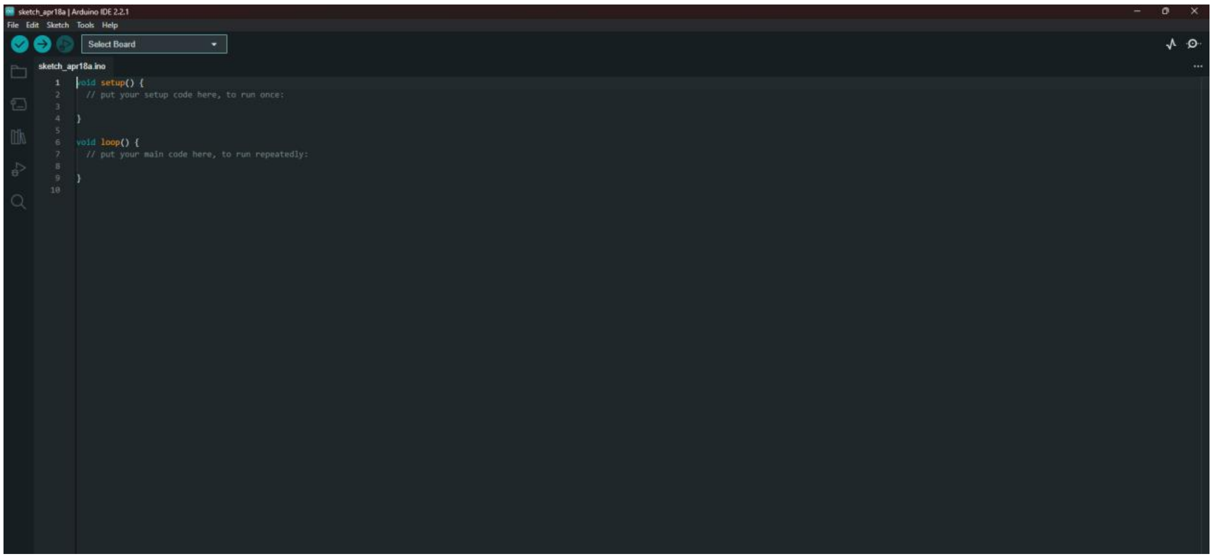

Figure 3.7 - Fig. shows Arduino IDE software

Description: The Arduino IDE provides a user-friendly interface for programming Arduino boards. It is open-source and freely available for multiple operating systems, including Windows, macOS, and Linux. The IDE simplifies the process of writing code for Arduino projects, making it accessible to beginners while still offering advanced features for experienced users.

Key Features:

Code Editor: The IDE includes a text editor with syntax highlighting, making it easy to write and edit code in the Arduino programming language (based on C/C++).

Compiler: It features a built-in compiler that translates the Arduino code into machine-readable instructions for the microcontroller.

Library Manager: The IDE comes with a library manager that allows users to easily install and manage libraries of pre-written code, providing access to a wide range of functions and features.

Serial Monitor: A serial monitor tool is integrated into the IDE, allowing users to send and receive data between the Arduino board and the computer via the serial port. This feature is useful for debugging and monitoring the behavior of the code.

Board Manager: Arduino boards come in various configurations and models. The IDE includes a board manager that simplifies the process of selecting the appropriate board and configuring its settings.

Upload Tool: The IDE provides a convenient tool for uploading compiled code to the Arduino board via USB or other supported interfaces.

Examples and Tutorials: It includes a collection of example sketches and tutorials to help users learn how to use Arduino boards and develop their projects.

Community Support: Arduino has a large and active community of users and developers who contribute code, libraries, and support through forums, blogs, and other online resources.

The Arduino IDE is a versatile and powerful tool for developing a wide range of electronics projects, from simple blinking LED experiments to complex robotics and IoT applications. Its simplicity, combined with its extensive features and support, makes it a popular choice among hobbyists, educators, and professionals alike.

2. Thingspeak

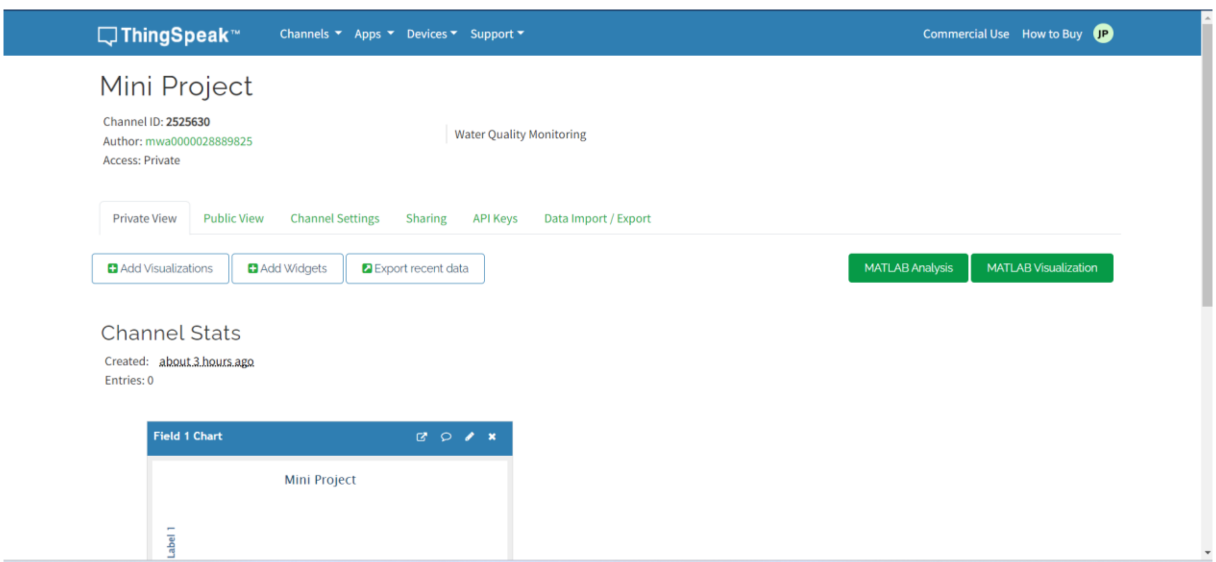

Figure 3.8 - Fig. shows Hompage for Thingspeak

ThingSpeak is an open-source Internet of Things (IoT) platform that allows you to collect, analyze, and visualize data from sensors or other devices. It provides a convenient way to store sensor data in the cloud, create custom dashboards for visualization, and set up alerts based on specific conditions. With ThingSpeak, we can easily integrate different sensors and monitor various parameters in real-time. It also offers integration with MATLAB for advanced data analysis and visualization.

Key features:

Data Logging: ThingSpeak allows you to log data at regular intervals from your sensors, ensuring that you have a comprehensive dataset for analysis and monitoring trends over time.

Integration: It offers seamless integration with a wide range of hardware platforms and programming languages, making it easy to connect your sensors and devices regardless of the technology stack you're using.

Visualization: You can create customizable visualizations such as charts, graphs, and gauges to easily interpret the data collected from your sensors. This is essential for understanding water quality variations and identifying potential issues.

Real-time Monitoring: ThingSpeak provides real-time updates, enabling you to monitor water quality parameters as they change. This feature is crucial for early detection of anomalies or deviations from desired levels.

Remote Access: You can access your data and monitor the system remotely from anywhere with an internet connection, allowing for convenient management and troubleshooting.

Open API: ThingSpeak offers an open API, allowing you to integrate your data with other applications or services for further analysis or automation.

Scalability: Whether you're monitoring a small-scale project or a large-scale deployment, ThingSpeak can scale to meet your needs, accommodating an increasing number of sensors and data points as your project grows.

3.3 Block Diagram

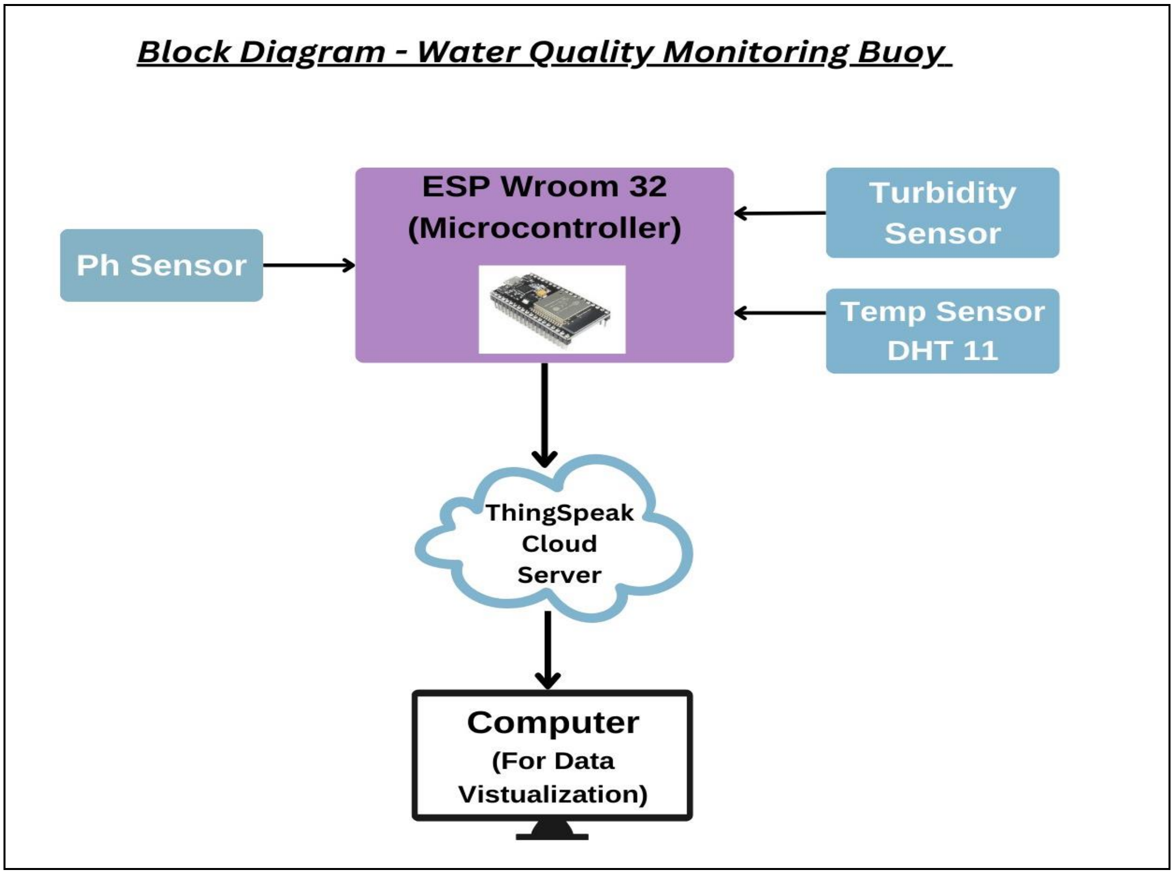

Figure 3.9 - Fig. shows Block diagram of our project

Chapter 4

Implementation

This chapter presents the implemented circuits of temperature and heart-rate sensors.

4.1 Implemented Circuit

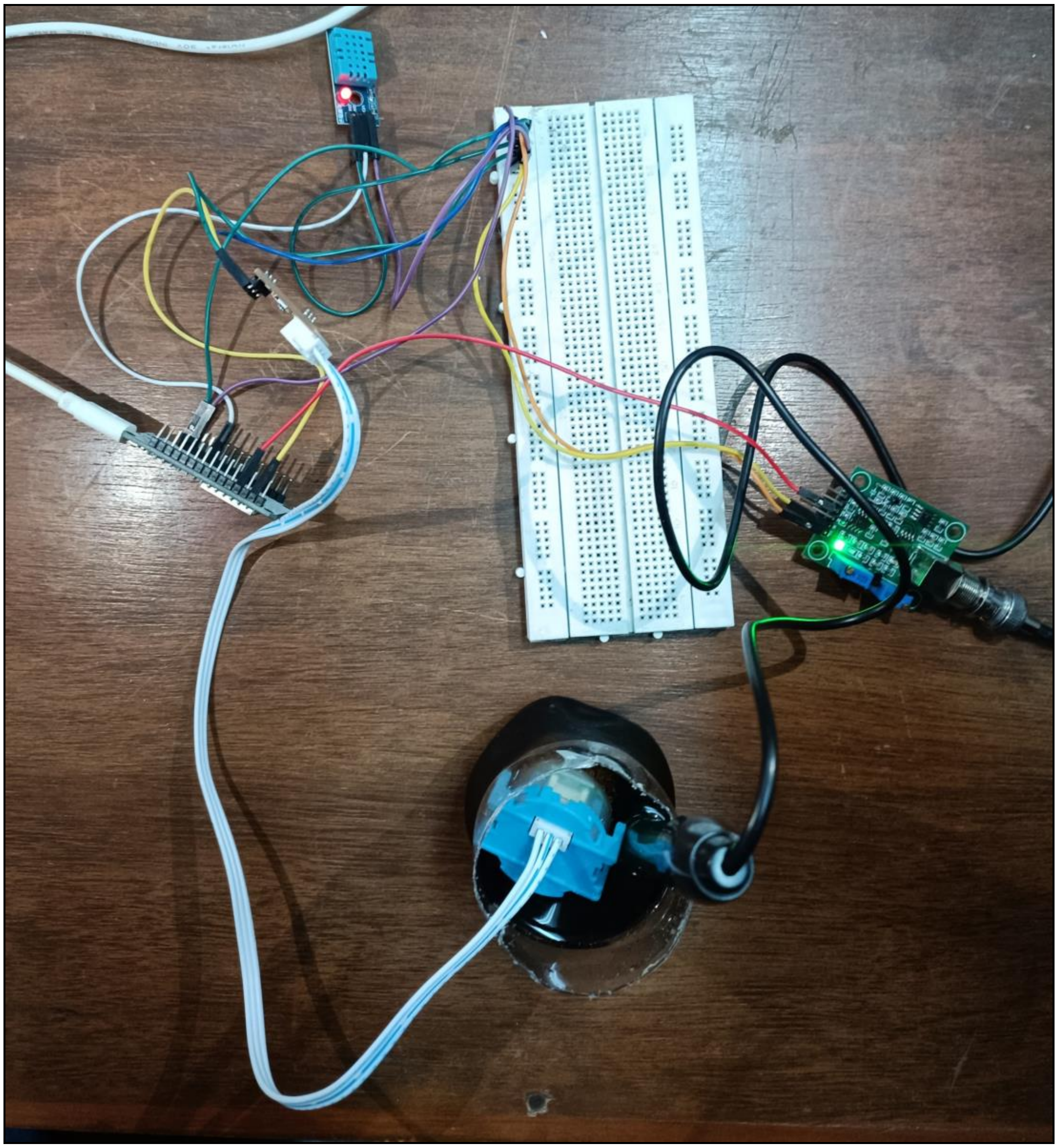

Figure 4.1 - Fig. shows

4.2 Algorithm of the Code

Setup –

- Initialize serial communication.
- Connect to WiFi.
- Initialize sensors.

Main Loop:

- Check WiFi connection.
- If connected:
  - ➢ Read from DHT sensor (temperature and humidity).
  - ➢ Read pH value.
  - ➢ Read turbidity value.
  - ➢ Send data to a server using HTTP POST.
- If not connected, indicate a WiFi disconnection.

Reading pH:

- Read analog value from pH sensor.
- Convert to voltage.
- Calculate pH using calibration data.

Reading Turbidity:

- Read analog value from turbidity sensor.
- Convert to voltage.
- Map analog value to NTU (Nephelometric Turbidity Units).

4.3 Data on ThingSpeak

Clear Water:

Figure 4.2 - Fig. shows 4 Charts representing –

Field 1 – Temperature
Field 2 – Humidity
Field 3 – Turbidity
Field 4 – pH value

Lake Water:

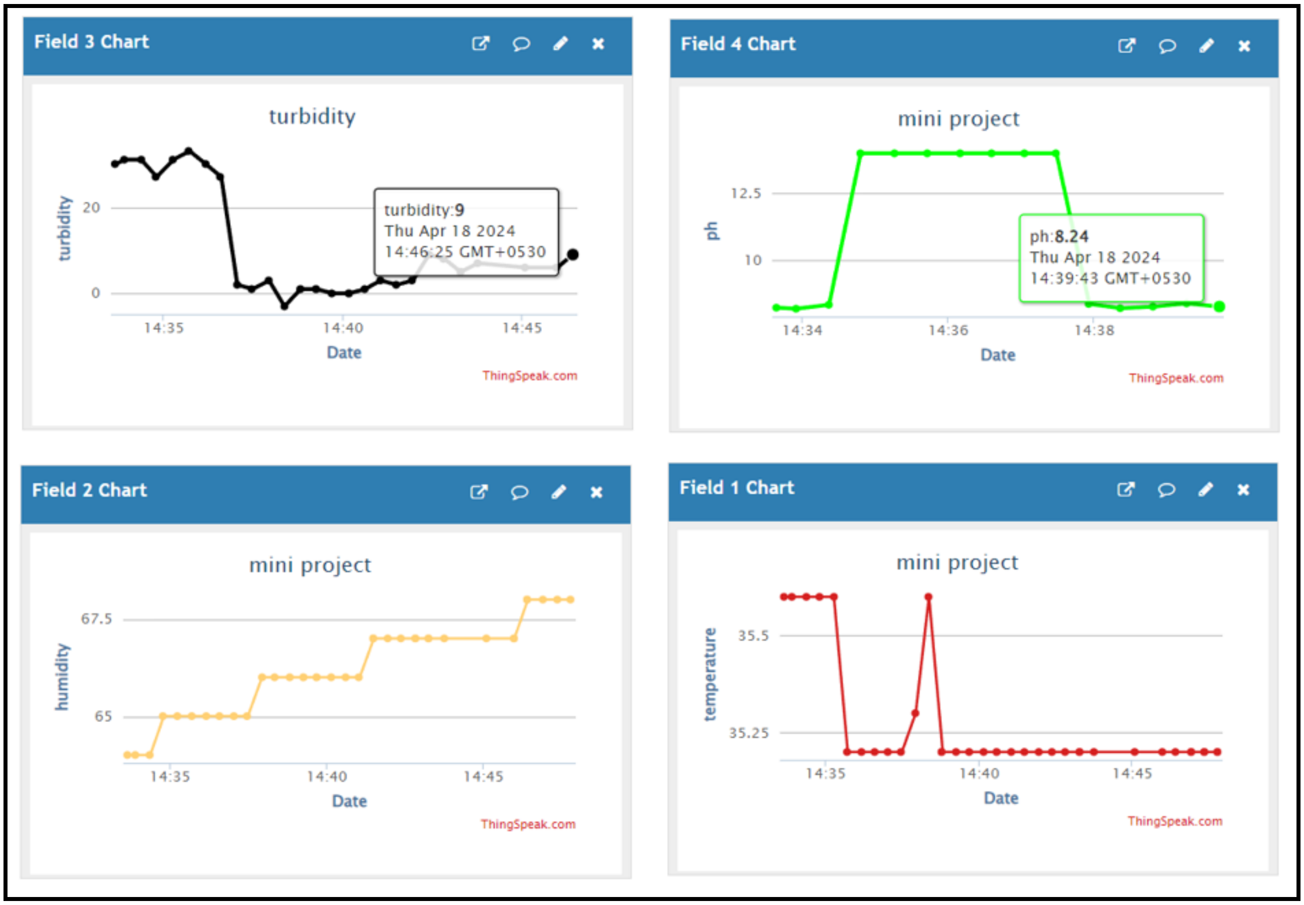

Figure 4.3 - Fig. shows 4 Charts representing –

Field 1 – Temperature
Field 2 – Humidity
Field 3 – Turbidity
Field 4 – pH value

Polluted Water:

Figure 4.4 - Fig. shows 4 Charts representing –

Field 1 – Temp
Field 2 – Humidity
Field 3 – Turbidity
Field 4 – pH value

Carbonated water (SODA) –

Figure 4.5 - Fig. shows 4 Charts representing –

Field 1 – Temp
Field 2 – Humidity
Field 3 – Turbidity
Field 4 – pH value

4.4 Analysis

Sample	pH level	Turbidity (ntu)	Temperature(°C)	Humidity
Clear Water	7.01	0	35	66%
Lake Water	8.24	9	35	68%
Polluted Water	8.43	159	35	68%
Carbonated water	2.92	1	35	69%

pH Level:

The pH scale measures how acidic or alkaline a substance is. Most freshwater organisms thrive in a pH range of 6.5 to 8.5. From the table above we can see that clear water has a pH of 7.01, which is close to neutral and generally suitable for most aquatic life. Lake water and polluted water have higher pH levels (8.24 and 8.43 respectively), indicating more alkaline conditions which might be tolerable for some species, but can negatively affect sensitive species and lead to issues such as ammonia toxicity. Ammonia is a common waste product in aquatic environments. However, at high pH levels, the less toxic ammonium form (NH_4^+) converts to the highly toxic free ammonia (NH_3). This can be particularly harmful to fish and invertebrates with sensitive gills.

At extreme pH levels (both acidic and basic), aquatic organisms struggle to maintain the proper balance of ions across their gills. This can lead to difficulty breathing, reduced oxygen intake, and ultimately suffocation. Also many enzymes essential for various bodily functions in aquatic life rely on specific pH ranges for optimal activity. Significant deviations from these ranges can disrupt metabolism, growth, and reproduction, with some exceptions

Turbidity (ntu):

Turbidity measures the clarity of water. Higher turbidity (as seen in polluted water with a reading of 159 NTU) can reduce the amount of light penetrating the water, affecting photosynthesis in aquatic plants. This disrupts photosynthesis for aquatic plants, which form the base of the food chain in many aquatic ecosystems. Reduced plant growth can lead to a decline in food sources for herbivores and ultimately impact the entire food web.

Turbid water can alter the behavior of some aquatic life by reducing visibility. This can make it more difficult for fish to find food and mates, and may increase predation risk. It can also clog fish gills, and other filter feeders, hindering their ability to breathe and obtain oxygen reduce growth rates, and lead to disease.

Lake water has moderate turbidity, which could be a sign of suspended particulates that might be organic or inorganic in nature. The impact of turbidity depends on the specific type of particles suspended in the water. Organic matter, such as decaying leaves, may have less detrimental effects than inorganic pollutants like heavy metals. The "polluted water" sample with 159 NTU turbidity likely has a significant negative impact on the ecosystem.

Temperature:

All samples are at 35°C, which is warm for most aquatic environments. Elevated temperatures can decrease oxygen levels in the water, increase the toxicity of certain compounds, and accelerate the metabolism of aquatic organisms, which requires them to consume more oxygen and food. Water temperature influences the metabolic rate of aquatic organisms. Warmer water generally leads to increased activity and oxygen consumption. However, if oxygen levels cannot keep up with the demand, fish and other organisms may experience stress or suffocation.

Colder water can hold more dissolved oxygen than warmer water. If the water temperature rises significantly, the amount of dissolved oxygen may become insufficient to support aquatic life. Different aquatic species have preferred temperature ranges. Significant and rapid temperature changes can disrupt the balance of an ecosystem by favoring certain species over others.

The impact of temperature depends on the specific water body and the organisms present. Freshwater fish generally have a narrower temperature tolerance than marine fish. The reading of

35°C, while within the range for some freshwater fish, is on the higher end and could be stressful for some species.

Humidity:

Varies slightly from 66% to 69%. While humidity does not directly affect the water quality, it can influence the rate of evaporation and thus the concentration of substances in the water.

Based on these readings, while the temperature and humidity are constant across samples and provide limited insights, the pH and turbidity show significant variation that can have direct impacts on aquatic wildlife and marine ecology. The clear water provides the most benign conditions for aquatic life, while the polluted water represents environments that could be harmful to many aquatic species. The lake water, while not as extreme as the polluted water, shows signs that it could be experiencing environmental stress that may affect some aquatic organisms.

Chapter 5

Conclusion and Future Work

This chapter presents the conclusion and also discusses the future scope of our project

5.1 Conclusion

Our Water Quality Monitoring Buoy project has provided valuable insights into the health of aquatic ecosystems through the analysis of key parameters such as pH level, turbidity, temperature, and humidity. By utilizing components like the ESP32, turbidity sensor, pH sensor, and DHT11, along with the Arduino IDE software for programming, we were able to develop a robust monitoring system capable of real-time data collection.

Through the data collected and visualized using ThingSpeak, we have observed significant variations in water quality across different samples. Clear water exhibited conditions conducive to supporting diverse aquatic life, with a near-neutral pH and low turbidity. However, lake water and polluted water samples showed signs of environmental stress, with elevated pH levels and increased turbidity, indicating potential impacts on aquatic organisms and ecosystem health.

Our findings underscore the importance of continuous monitoring and management of water quality to safeguard aquatic ecosystems and public health. By leveraging IoT technologies and cloud-based platforms like ThingSpeak, we can enhance the efficiency and effectiveness of water quality monitoring efforts, enabling timely interventions and informed decision-making.

Moving forward, our project lays the groundwork for further research and the development of proactive strategies to mitigate water quality issues and promote sustainable management practices. With ongoing monitoring and collaboration, we can strive towards maintaining and restoring the health and resilience of our water resources for future generations.

5.2 Future Scope

1. While the project currently measures parameters like pH levels, turbidity, temperature, and humidity, integrating additional sensors could provide a more comprehensive understanding of water quality. For example, sensors for dissolved oxygen, conductivity, chlorophyll levels, or specific pollutants like heavy metals could be incorporated to broaden the scope of monitoring.

2. Integrating autonomous navigation capabilities into the buoy could enable it to navigate and position itself optimally for data collection in different marine environments.

3. Implementing outreach programs and educational initiatives to engage local communities and raise awareness about water quality issues can encourage active participation in conservation efforts.

4. Establishing collaborative networks of monitoring buoys which will help enhance coverage area and data accuracy by pooling resources and sharing data. This could involve partnerships with governmental agencies, research institutions on global scales

5. Developing a dedicated mobile application alongside the web interface to improve accessibility and usability for the general public.

6. Incorporating solar panels, which will the buoy become more energy independent, reducing reliance on external power sources and extending its operational capabilities. This ensures continuous monitoring even in remote locations where traditional power sources may be limited or unavailable. This will also minimize the risk of power outages or disruptions to data collecting operations

7. Excess energy generated during daylight hours using solar can be stored for use during periods of low sunlight or inclement weather

8. Solar-powered buoys contribute to reducing carbon emissions and environmental impact compared to conventional fossil fuel-powered alternatives.

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Acknowledgement

We would like to express our sincere gratitude to our principal Dr. S. K. Ukarande, our HOD, Dr. Bharathi Singh and our guides, Dr. Rupali Patil and Dr. Sandeep Sainkar for their expertise, guidance, and kind co-operation for the successful completion of project on “Water Quality Monitoring Buoy”. We are also grateful to our classmates and team members, for their insightful feedbacks and suggestions which were significantly beneficial. We also thank all our respective concerned teachers & lab faculty of our department for their assistance throughout the project. This project would not have been possible without the contributions and support of these individuals, and we are immensely thankful for their involvement.

Appendix A

Code used in Arduino IDE

```
 # include <WiFi.h>

//#include "ThingSpeak.h"

# include <HTTPClient.h>

# include "DHT.h"



#define DHTPIN 4

#define DHTTYPE DHT11

const int pHpin = 34;  // ADC pin the sensor is connected to
const int turbidityPin = 36;

// Calibration points (update with your measured values)
const float voltageAtpH7 = 2.5;  // The voltage measured in pH 7 solution
const float voltageAtpH4 = 3.0;  // The voltage measured in pH 4 solution

DHT dht(DHTPIN, DHTTYPE);



const char* ssid = "Atharva";

const char* password = "12345678";

// Domain Name with full URL Path for HTTP POST Request

const char* serverName = "http://api.thingspeak.com/update";

// write API Key provided by thingspeak

String apiKey = "NMD3AHAE6ZC8GPQO";



void setup()
{

    Serial.begin(115200);

    WiFi.begin(ssid, password);

    dht.begin();
```

```
    Serial.println("Connecting");

    while (WiFi.status() != WL_CONNECTED)
    {

        delay(500);

        Serial.print(".");

    }

    Serial.println("");

    Serial.print("Connected to WiFi network with IP Address: ");

    Serial.println(WiFi.localIP());

}

void loop()
{

    if (WiFi.status() == WL_CONNECTED)
    {

        WiFiClient client;

        HTTPClient http;

        delay(10000); // wait for 10 seconds

        float h = dht.readHumidity();

        float t = dht.readTemperature();



        if (isnan(t))
        {

            Serial.println(F("Failed to read from DHT sensor!"));

            return;

        }

        float pHvalue = readPH();
        float ntuval = turbidity();
        Serial.println(ntuval);



        // Your Domain name with URL path or IP address with path

        http.begin(client, serverName);
```

```
        // Specify content-type header

        http.addHeader("Content-Type", "application/x-www-form-urlencoded");

        // Data to send with HTTP POST

        String httpRequestData = "api_key=" + apiKey + "&field1=" + String(t) + 
"&field4=" + String(pHvalue) + "&field3=" + String(ntuval) + "&field2=" + String(h);

        // Send HTTP POST request

        int httpResponseCode = http.POST(httpRequestData);



        /*

        // If you need an HTTP request with a content type: application/json, use the 
following:

        http.addHeader("Content-Type", "application/json");

        // JSON data to send with HTTP POST

        String httpRequestData = "{\"api_key\":\"" + apiKey + "\",\"field1\":\"" + 
String(random(40)) + "\"}";

        // Send HTTP POST request

        int httpResponseCode = http.POST(httpRequestData);*/



        Serial.print("HTTP Response code: ");

        Serial.println(httpResponseCode);



        http.end();

    }

    else
    {

        Serial.println("WiFi Disconnected");

    }

}

float readPH()
{
    int sensorValue = analogRead(pHpin);  // Read the sensor's output
    float voltage = sensorValue * (3.3 / 4095.0);  // Convert to voltage

    // Calculate the slope (m) and intercept (b) for the line y = mx + b
    float slope = (7.0 - 4.0) / (voltageAtpH7 - voltageAtpH4);
```

```
    float intercept = 7.0 - (slope * voltageAtpH7);

    // Convert the voltage to pH value using the calibration data
    float pH = (voltage * slope) + intercept;

    // Ensure pH value stays within the expected range
    pH = constrain(pH, 0, 14);




    delay(1000);  // Wait a second between readings
    return pH;




}

float turbidity()
{
    float ntu;


    int analogvalue = analogRead(turbidityPin);
    Serial.println(analogvalue);
    float voltage = analogvalue * (5.0 / 4095.0);
    //   float  ntu = -1120.4*sq(voltage)+5742.3*voltage-4352.9;
    ntu = map(analogvalue, 753, 2010, 100, 0);

    //  voltage = voltage/800;
    //    voltage = round_to_dp(voltage,2);
    //
    //    if(voltage < 2.5){
    //      ntu = 3000.00;
    //    }else{
    //      ntu = -1120.4*sq(voltage)+5742.3*voltage-4353.8;
    //    }

    delay(1000);
    return ntu;







}

float round_to_dp(float in_value, int decimal_place)
{
    float multiplier = powf(10.0f, decimal_place);
    in_value = roundf(in_value * multiplier) / multiplier;
    return in_value;
}
```