WATER QUALITY MONITORING SYSTEM WITH PARAMETER-BASED WATER USAGE SUGGESTION

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
Brac University
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Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my/our own original work while completing degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Approval

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of Fall, 2022 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on December 31st, 2022.

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Ethics Statement

We affirm that this thesis project, "Water Quality Monitoring System With Parameter-Based Water Usage Suggestion," satisfies the requirements for graduation and that there is no evidence of any form of plagiarism in it. Our respected ATC panel teachers and the EEE department assisted us in finishing the project on our own, although some of the data that was included came from outside sources that have been appropriately referenced.

Abstract/ Executive Summary

In recent times water pollution has increased by manifolds due to the rise of industries and people's apathy towards nature. This problem is especially seen in economically disadvantaged countries like Bangladesh. The different regulatory authorities in Bangladesh are struggling to monitor all of the natural water bodies for pollution. Thus, the water bodies are being used by people for farming, household chores, etc regardless of the state of said water bodies.

In this paper, a low-cost remote water quality monitoring system that will suggest water usage based on certain water-health parameters is developed. The data regarding the water body is stored in the cloud. Moreover, the paper also explores the functionality of the system by testing it on two separate lakes. The system relies on a network of sensors and IoT to achieve its desired function.

Keywords: Environment; Water-pollution; Water-health; Sustainability; Sensor-networks; IoT, Cloud.

Dedication

We would like to dedicate this work to our parents and teachers for their countless efforts and encouragement. We would especially like to express our gratitude to our supervisor Tasfin Sir for always helping and guiding us.

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List of Acronyms

HAB	Harmful Algae Bloom
WQI	Water Quality Index
NTU	Nephelometric Turbidity Units
UAV	Unmanned Aerial Vehicle
USV	Unmanned Surface Vehicle
DBSCAN	Density-based spatial clustering of applications with noise
GSM	Global System for Mobile Communication

Chapter 1

Introduction

1.1 Introduction

1.1.1 Problem Statement

Development and Potential Solution Hypothesis:
Bangladesh is proudly crowned as the land of rivers. In fact, having as many as 800 rivers, innumerable canals, and water bodies, Bangladesh has the most complex river system in the world [1].
The rivers have shaped the culture of this region in the past, as has its agricultural prosperity. Rice, along with the abundant fish in the region's rivers, is the region's staple meal. Our waterways play a vital role in communication and transportation. These rivers are busy all year with boats, launches, and steamers. Men and products are transported from one location to the next, as well as from one port to the next [2]. However, in the last few decades, Bangladesh is facing severe water pollution and scarcity. The once glorious water bodies are now choked by pollution caused mainly by human intervention. The situation has deteriorated to the point where nearly 19.4 million people who rely on these rivers for water consumption now drink water that exceeds national health guidelines for arsenic [3]. Furthermore, water contamination by high amounts of manganese, chloride, and iron by industrial waste has grown to the point where river flows are rendering the land unproductive[3]. In fact, the mighty Buriganga river, which flows by Dhaka, is now one of the most polluted rivers in Bangladesh because of the rampant dumping of industrial and human waste. As mentioned in [4], “The water of the Buriganga is now so polluted that all fish have died, and increasing filth and human waste have turned it like a black gel. Even rowing across the river is now difficult for it smells so badly,”.The environmental department of the Bangladesh government has classified Buriganga as ‘Biologically Dead’ because of pollution [4]. Buriganga's suffering typifies the situation of many rivers in Bangladesh, a big flat country crisscrossed by hundreds of rivers that confront an uphill battle to preserve their waters navigable and safe for human and aquatic life. To be fairer, waters are not only tainted by toxic waste; authorities in all municipalities and city corporations across the country have built sewerage lines that discharge waste into rivers, and different service agencies, such as the Water Supply and Sewerage Authority (WASA) in Dhaka, drain a massive amount of waste to surrounding rivers, including the Buriganga [5].

Several measures have been taken so far by the government in the past few years to save our water bodies, for example between 2016 and 2017 seasonal monitoring of the Bhairab River was taken over the summer, winter, and rainy seasons [5]. However, it is quite needless to say that traditional water monitoring practices make it hard for regulatory agencies to monitor so many water bodies at once. In conventional water monitoring procedures, water samples are manually collected and then examined in laboratories. Since it relies on manpower, this method is costly, and it also puts the sample collector's health at risk because he is in contact with potentially contaminated water. It's also a time-consuming procedure, so regulatory agencies can't make quick decisions or take swift actions. Given the deteriorating condition of the rivers, actions need to be taken as promptly as possible.

This section of the report would be incomplete without taking a look at the possible treatment ways of natural water bodies. In the paper titled ‘Remediation of Polluted River Water by Biological, Chemical, Ecological and Engineering Processes ‘[6]the authors have discussed the different causes of water pollution and possible rectification processes that can be taken to overcome this aggravating problem. The different mechanisms of the solution included engineering processes which can be done by improving aeration of water bodies which leads to the higher oxygen concentration levels in the water bodies, diverting the flow of water, construction of different hydraulic structures to facilitate better water quality and filtration systems to remove harmful elements present in the water bodies. Furthermore, H. Anwar & R.Chowdhury (2020)[6] have also suggested different chemical processes based solutions but they pose the risk of pollution themselves. Finally ecological engineering-based methods like the Phytoremediation Process which involves the use of plants capable of refining water, constructing wetlands, using layers of surface bacteria and other microorganisms that aid in the removal of certain harmful chemicals, bacteria capable of breaking down water pollutants, ecological floating beds and introduction of aquatic life which improve water quality. All of the advantages and drawbacks of these different methods have been discussed. In conclusion, it has been suggested that to get maximum results a fusion of these different types of methods must be implemented.

In actuality, water ecosystem restoration is a complex subject that necessitates collaboration at multiple levels in order to create long-term water solutions. In practice, this entails bringing together people from many groups – such as governments, commercial organizations, civil society, academia, and the investment community – in order to foster the mutual trust that leads to meaningful decisions and actions. Sadly we do not have much time left to save our rivers [7]. So, the solution has to be quick and simultaneous. A remote water quality monitoring system can be installed in all bodies of water to monitor a variety of water parameters in order to assess their state and take appropriate action. A remote machine that can report, track, and monitor water bodies with real-time data processing is necessary. As a matter of fact, this problem can be solved a great deal if a device, planted in the river bodies, can measure water quality parameters such as temperature, dissolved oxygen, pH, conductivity, ORP, and turbidity depending on the variability of surface water quality to depict the impact of wastewater on the rivers in a real-time basis and might even suggest a water treatment. This system will be able to monitor many water bodies at the same time and it will also cover large portions of rivers which are otherwise quite impossible

to cover.For example, the sector-5 lake in Uttara, Dhaka, Bangladesh is about 1.14km[8]. Since it is a large waterbody that goes unmaintained in many of its parts, such a remote system can help to monitor its water quality parameters.
Now, it goes without saying that population growth, industrialization, and fast urbanization will continue to accelerate over time. As a result, the demand for this machine will grow in the future, as more waste will be produced as a result of modernization, necessitating more control methods. With more added features and better suggestion capability, this machine will be more needed in the future than it is now.

1.1.2 Background Study

While the importance of monitoring water quality for natural water bodies has been discussed extensively in the 400P report, in this report, particularly this section, the exploration of new concepts needed to verify the multiple design approaches will be made.

To verify the design solutions a thorough understanding of these two new concepts were needed:

- Water Quality Index Model
- Algae-level as a water-quality parameter.

This section will explore the existing literature behind these two concepts.

Water-Quality Index Model:
The Water-Quality Index [WQI] Model is the most popular method of determining water quality.The model uses aggregation techniques to convert many water quality parameter values into a single score or index. In real-life applications, WQI scores are always calculated based on local or international standards

The first WQI model was developed in the 1960s by Horton, and since then many iterations and variations of the formula have come up. While the iterations might be different in many ways the commonalities lie in the general method with which a score is calculated.
The method is :

- Selection of water quality parameters.
- Generation of sub-indices for each parameter.
- Calculation of parameter weighing values.
- Aggregation of sub-indices to calculate WQI value.

There are several WQI models but for the validation of design-1 and 2, the popular Weighted Arithmetic Water Quality Index Method (Brown et al. 1972) was used. Apart from this method is well documented another reason for the choice of this method was that it generates a reliable index with very few parameters. This is important as it is not feasible to integrate many sensors in design-

1 and 2. It is important to realise that whilst the robustness of the WQI models are useful, there is a certain level of uncertainty involved in WQI models as expected from the aggregation of large amounts of water-quality data into a single index [8].

Weighted Arithmetic Water Quality Index Method Formula [9]:

Step-1: Calculate the unit weight (Wn) factors for each parameter by using the formula:

Wn=$\frac{K}{S_n}$

Where,

K=$\frac{1}{\sum_1^n \; S_n}$

$$S_n = \; Standard \; value \; of \; nth \; parameter$$

On summation of all selected parameters unit weight weight factors, Wn=1 (unity)

Step-2: Calculate the Sub-index (Q_n) value by using the formula

$Q_n = \frac{V_n - V_o}{S_n - V_o} * 100$

Where,

V_n= Concentration of the n^{th} parameter

S_n= Standard Desirable value of the n^{th} parameter

V_o= Actual values of the parameters in pure-water (generally V_o=0 for most parameters except for pH for which V_o=7)

Step-3: WQI is calculated as follows:

Overall WQI=$\frac{\sum_1^n \; W_n \quad Q_n}{\sum_1^n \; W_n}$

Table-1 **Local standards for water quality parameters [3].**

Water Quality Parameters	Bangladesh Standards
pH	6.5-8.5
Total Dissolved Solids(TDS)	1000 mg/L
Temperature	20-30 ℃

Turbidity	1-5 NTU

Table-2 **Water Quality Status and Usage Suggestion [4].**

WQI	Water Quality Status	Usage Suggestion
0-25	Excellent	Drinking,Irrigation,Industrial
26-50	Good	Irrigation and Industrial
51-75	Poor	Irrigation
76-100	Very Poor	Irrigation (Some crops)
>100	Unsuitable for any use	Proper Treatment Required before use.

Algae-Level as water-quality parameter:

[5] states that the production of plankton/algae under natural conditions is related to tolerance class because of the abiotic limiting aspects of the environment, such as pollution and soil composition, and the biotic interactions among algae (ecological optimum). The biological niche's anthropogenic and non-anthropogenic environmental factors have an impact on how species appear. The type of algae present and how their abundances change over time have a big impact on the trophic level of lakes. Algal populations are sensitive to changes in their habitat, hence a variety of different species of algae as well as the overall biomass of algae are used as indicators of water quality. Algal populations provide more insight into changes in water quality than measures of nitrogen or chlorophyll-a. The physical, chemical, and biological properties of a body of water collectively make up its water quality[6].

Eutrophication of water bodies, is therefore thought to be a water quality that contributes to the decline of the aquatic environment and has an impact on water use. Due to their frequent outbreaks in areas with high nitrogen concentration, cyanobacteria, also known as blue-green algae, have been identified as a key indicator of eutrophication in freshwater [7]. With this strategy, we hope to evaluate how crucial algal abundance is for affecting water quality in freshwater habitats. To focus emphasis more of the impact of algae as a parameter of water quality, [7] has focused that algae play a big role in biological monitoring programs that evaluate the quality of the water. They qualify for water quality assessments due to their nutrient needs, quick reproduction, and short life span. As a result of changes in water chemistry, such as an increase in water pollution based on domestic/industrial wastes, algae are important indicators of environmental conditions because they react quickly to both the qualitative and quantitative composition of species in a variety of water situations. This affects the composition of genera that are able to tolerate these situations.

Keeping this in mind, a collective method has been proposed to determine and monitor the water quality using algae as a parameter [8]. [8] enlightens upon a process that will take a single image as an input taken from a UAV and then segment that image into its homogenous segments such as the trees, cars, buildings, sky, water body shall be separated. The density-based spatial clustering of applications with noise (DBSCAN) approach is used to segment the data[8].

The clustering method, which groups super pixels, is used to raise the probability that a surface category will be packed or diversified. To reduce the entropy function at the pixel level, this technique incorporates a variety of signals, such as color, texture, and contextual clues. The main idea of the proposed algorithm is to detect the water body initially for which it uses wavelet leader-based texture analysis[8]. The sky area resembles a body of water in that it has a homogenous pattern and similar colors. [8] suggests using a sky region block approach before extracting the water body. The image has already been divided into distinct areas, making it straightforward to block the sky area. The sky area often has a high brightness value. As a result, [8] introduces a straightforward approach for blocking out the sky region using the average brightness (V) of the HSV color space. Finally, the degree of HAB in a pixel is then quantified and assigned a number between 0 and 1. This value is obtained by multiplying the modified vegetation index by the hue-based index, the saturation-based index, and the modified saturation-based index in the extracted water body region [4]. The following formula gives out the probabilistic value for the HAB as given by [8]

$$P_V\,[\mathbf{C}_W;\mathbf{y}] = \frac{G(\mathbf{C}_W;\mathbf{y})}{G(\mathbf{C}_W;\mathbf{y}) + R(\mathbf{C}_W;\mathbf{y})},$$

Based on the amount of harmful algae bloom, the water quality is characterized as following by [8]:

Table-3 **Table showing the condition of pollution in water according to the HAB index [8].**

Harmful pollution Index	**Condition of Water**
<=0.3	Low Organic Pollution
0.4-0.6	Moderate Organic Pollution
0.7-1	High Organic Pollution

1.1.3 Literature Gap

Whilst a lot of high-quality work has been done in the field we want to explore in our project.
It is worth noting that very few such works, of appreciable quality, involve the rivers in Bangladesh. Moreover, putting geographical considerations aside, most of the prior water quality projects involve the monitoring of water quality of household water supplies and not natural water bodies like rivers and ponds. This poses a unique challenge in the context of our project as the monitoring of a natural water body requires the system to be robust and hardy as a lot of variables such as natural elements like wind and water waves are out of the system developers' control. For a household water supply, the system developer does not have to concern himself with such matters.

Another key gap in the literature reviewed was the use of cost-effective sensors. Many of the prior water-quality monitoring projects used expensive sensors such as EXO Sonde. However, such a sensor is not a sensible choice from Bangladesh's perspective as it is still an economically developing country.

However, the key gap identified in the literature was that most of the prior water quality monitoring systems developed only notifies the user if toxic water is detected. There are no facilities in such systems for suggesting a mode of action to give a usage for such water. Since we are developing the water quality monitoring system for public health authorities such a function is essential and would add a lot of value to the project.

1.1.4 Relevance to current and future Industry

Most of water monitoring systems are manual and some that are actually remote are quite expensive.So, our proposed system which is not only inexpensive but also will provide usage based on the WQI value shall be very much relevant in the current market. Also, given the rate at which industrialization is increasing which directly affects our waterbodies the proposed machine can remotely monitor the water in real life and keep track of the pollution produced. This shall also help prevent any corruption in the water management system. This device will become more and more relevant with time with exponential growth in urbanization.

1.2 Objectives, Requirements, Specification, and constant

1.2.1. Objectives

- To allow regulatory bodies and concerned authorities to monitor water-health indicators remotely.
- To enable regulatory bodies and concerned authorities to monitor multiple water bodies

or multiple locations in a single water body at a time.

- To reduce reliance on manual sampling and testing in physical laboratories.
- To provide real-time analysis of the sensor data and recommend appropriate corrective water treatment measures if needed.
- To send a notification to the user if certain levels of toxicity are crossed.
- To increase accountability for water pollution and thus reduce it in the long-term future.

1.2.2 Functional and Nonfunctional Requirements

<u>Functional Requirements:</u>

- **The system shall be used in a water body with much human interaction:**
  Not all water bodies have much interaction with humans. Meaning there are isolated water bodies in this country that are less frequented by humans, such water bodies are not necessarily polluted or encroached by humans nor are they used by humans. Thus it does not make much sense to monitor such water bodies strictly. The system will be used in a water body that is frequently used by humans or near factories and households. Only then can pollutants creep into the water and in turn pose a threat to the general population.
  Sector-5 Uttara Lake is a prime example of a water body with much human interaction. As a lot of people use that water for bathing, cleaning, and general livelihood. It is also near a lot of households that directly dispense their waste into the water.
- **The system shall be able to measure important physical and chemical water quality parameters:**
  There are three types of broad water quality parameters, physical, chemical, and biological [9].
  The system shall be able to measure at least two physical water quality parameters: turbidity, temperature, and total dissolved solids.
  The system shall be able to measure at least one chemical water quality parameter from pH and dissolved oxygen.
  Measuring these parameters will give a genuine representation of water health.
- **The system shall measure water quality parameters from the surface of the water body:**
  Water bodies can be of many depths. The system shall measure water quality parameters from only the surface of the water body, that is it will only take readings from only 2-10cm depth from the surface of the water body.
- **The system shall be remote:**
  The user shall be able to make the system function from afar. This will prevent the user from coming into contact with potentially contaminated water. Moreover, reduces the need for physical water sampling for traditional testing purposes [9-11]
- **The system shall store and transmit data in real-time:**

The system shall be able to store data for later access and transmit the data to users in real-time. This is a key functionality as it will allow regulatory bodies to take timely decisions and actions [12].

- **The system shall analyze water quality parameters and suggest potential solutions to users:**
  The system by means of an algorithm will analyze water quality parameters and if it finds that certain parameters are beyond threshold limits, it will then suggest potential solutions aimed at treating the water and controlling the parameter. For example, if the water pH is too low it will detect this and suggest a means to treat the water.

Non-functional Requirements:

- **The system should be power efficient:**
  Unnecessary power losses should be cut out. For example, the controller should fall asleep when it is not monitored and wake again when it needs to monitor [12].
- **The system should be durable:**
  The system will come into direct contact with the elements so it should be able to handle a certain degree of wear and tear.
- **The system should transmit data relatively quickly:**
  This is necessary for real-time monitoring.
- **The system should have secure data transmission:**
  To ensure that data is not lost due to interference from other signals or malicious hackers, the data transmission link should be secure.
- **The system should collect data and suggest potential solutions with reasonable accuracy:**
  To ensure that water-quality parameters are being recorded with a reasonable degree of accuracy, properly calibrated sensors should be used. The potential water treatment suggested by the system for contaminated water should be relatively accurate too, this can be attained by means of a well-trained algorithm.
- **The system should have an interactive GUI:**
  The GUI of the system should be easy to use and navigate as the user will control the water quality monitoring system from there and also use it to read data and potential solutions.

1.2.2 Specifications

System-Level Specification:

- **Data Acquisition Subsystem:** Involves sensor module gathering data and relaying it to the microcontroller
- **Data Transmission Subsystem:** Involves microcontroller uploading the data to storage via a communication module.

- **Data Management Subsystem:** Involves an application that accesses the data from the cloud storage, processes it, and displays it to the user via a GUI.
- **Data Analysis Subsystem:** Involves implementing an algorithm with which data is analyzed and then a potential course of action is suggested to the user.

System Level Specifications

TABLE 4. Subsystem, Module, Component

System-Level Specification	Module	Component-Level Specification
Data Acquisition Subsystem	• Sensor Module\ • Controller Module • Buoy Platform • USV • UAV	• SKU SEN0161 (pH) • DS18B20(Temperature) • TDS Meter 1.0 (Total Dissolved Solid) • YF-S201 Water Flow Meter Measurement Sensor • Gravity: Analog Turbidity Sensor SKU: SENO-189 • Floating Device • Printed Circuit Board • Power-Bank • Micro USB cable • Arduino Mega 2560 • RC Boat Model • Battery(Turnigy 2200 mAh 4S30C Lipo Pack 11 to 14.1 V) • Two Electronic Speed Controller ESC (Hobby King 30A ESC 30A ESC 3A UBE • Bluetooth (HC-06) • Brushless Motor (PROPDRIVEv2 2826 1000KV Brushless Outrunner Motor) • Buoyancy System (Farm & Ranch 10" Replacement Tire Inner Tube) • 2 Thrusters left & right (1PCS 12-24V 20A 30-200W Underwater Thruster 4 Paddle Propeller Brushless Motor • Battery(Turnigy 2200 mAh 4S30C Lipo Pack 11 to 14.1 V) • SmartBoat3 app • DJI 2212 920kv Brushless

		Motor 1CW & 1CCW ● DJI Phantom 3 9450 Self-tightening Propellers ● 30A RC Brushless Motor Electronic Speed Controller ● KK2.1.5 flight controller ● Frame F450 ● Mini Gear Micro Servo 9g ● GPS Module ● Camera
Data Transmission Subsystem	● Controller Module ● Communication Module	● ESP-32 ● Arduino Mega 2560 ● Maxwell CR2032 3V Lithium Battery ● Power-Bank ● Micro USB cable ● Printed Circuit Board
Data Management Subsystem	● Cloud Service	● ThingSpeak
Data Analysis Subsystem	● Algorithm	● Algorithm

Component-Level Specifications:

TABLE 5. Component, Details, Purpose

Component	Details	Purpose
Arduino Mega 2560	● MicroController: ATMega2560 ● Digital I/O Pins**:** 54 (of which 15 provide PWM output) ● Analog Input ● Weight:37g ● Clock Speed:16 MHz ● Operating Voltage**:** 5V ● Input Voltage:(recommended) 7-12V	Will be used to relay data from sensor to communication module. Will be used for locomotion purposes.

ESP-32	● CPU-:Xtensa dual-core (or single-core) 32-bit LX6 microprocessor, operating at 160 or 240 MHz and performing at up to 600 DMIPS ● Memory: 320 KiB RAM, 448 KiB ROM ● **Wi-Fi:** 802.11 b/g/n ● Bluetooth: v4.2 BR/EDR and BLE (shares the radio with Wi-Fi) ● Security: IEEE 802.11 standard security features all supported, including WPA, WPA2, WPA3 (depending on version)[5] and WLAN Authentication and Privacy Infrastructure (WAPI)	Will be used to transmit data from the sensor to a cloud service via the Internet.
Power-Bank	● 160g ● 5000mAH	Will be used to power the Arduino Mega-2560.
Micro USB cable	● 30 cm cable	Will connect Arduino Mega 2560 to Power-Bank
Maxwell CR2032 3V Lithium Battery	● 3V	Will power ESP-32
ThingSpeak	ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. With the ability to execute MATLAB® code in ThingSpeak you can perform online analysis and processing of the data as it comes in	Will be the cloud service where data will be stored. Can also provide data-analytics features.
SKU SEN0161 (pH)	● Module Power 5.00V ● Circuit Board Size 43mmx32mm ● pH Measuring Range 0-14 ● Measuring Temperature 0-60 ● Accuracy ± 0.1pH 25	Will be used for measuring pH

DS18B20(Temperature)	● Communicates using 1-Wire method ● Operating voltage: 3V to 5V ● Temperature Range: -55°C to +125°C ● Accuracy: ±0.5°C ● Available as To-92, SOP and even as a waterproof sensor	Will be used for measuring temperature
YF-S201 Water Flow Meter Measurement Sensor	● Working Voltage: 5 to 18V DC (min tested working voltage 4.5V) ● Max current draw: 15mA @ 5V ● Working Flow Rate: 1 to 30 Liters/Minute ● Working Temperature range: -25 to +80℃ ● Working Humidity Range: 35%-80% RH ● Accuracy: ±10% ● Maximum water pressure: 2.0 MPa ● Cable length: 15cm ● 1/2" nominal pipe connections, 0.78" outer diameter, 1/2" of thread ● Size: 2.5" x 1.4" x 1.4"	Will be used for measuring water-flow
TDS Meter 1.0 (Total Dissolved Solid)	**Signal Transmitter Board** ● Input Voltage: 3.3~ 5.5V ● Output Voltage: 0 ~2.3V ● Working Current: 3 ~6 mA ● TDS Measurement Range: 0 ~ 1000 ppm ● TDS Measurement Accuracy: ± 10% F.S. (25 ℃) ● Module Size: 42 * 32mm ● Module Interface: PH2.0-3P ● Electrode Interface: XH2.54-2P	Will be used for measuring Total Dissolved Solids (TDS)

	TDS probe: ● Number of Needles: 2 ● ·Total Length: 83 cm ● ·Other: Waterproof Probe	
Gravity: Analog Turbidity Sensor SKU: SENO-189	● Operating Voltage: 5V DC ● Operating Current: 40mA (MAX) ● Analog output: 0-4.5V ● Operating Temperature: 5℃~90 ℃ ● Storage Temperature: -10℃~90℃ ● Weight: 30g ● Adapter Dimensions: 38mm*28mm*10mm/1.5inches *1.1inches*0.4inches	Will be used for measuring Turbidity
Printed Circuit Board		Will be used to house all the electrical components
Floating Device		For a Buoy based system a floating device is required to carry the water-quality monitoring system.
Battery(Turnigy 2200 mAh 4S30C Lipo Pack)	● Operating current 2200mAh ● Provides 11 V to 14.1 V	The Battery provides the power supply required to run the USV device.
Electronic Speed Controller ESC (Hobby King 30A ESC 30A ESC 3A UBE	● Constant Current: 30 A ● Burst Current: 40A ● Battery: 2-4S Lipoly ● BEC: 5V/3A ● Motor Type: Sensorless Brushless	There are two Electronic Speed Controllers which are to control the speed of rotation of the motors.

	• Size: 54x26x11 mm • Weight: 32 g	
Bluetooth Module(HC-06)	• Bluetooth protocol: Bluetooth V2.0 protocol standard • Power Level: Class2(+6dBm) • Band: 2.40GHz—2.48GHz, ISM Band • Receiver sensitivity: -85dBm • USB protocol: USB v1.1/2.0 • Modulation mode: Gauss frequency Shift Keying • Safety feature: Authentication and encryption • Operating voltage range:+3.3V to +6V • Operating temperature range: -20ºC to +55ºC • Operating Current: 40mA	Bluetooth module is used to provide the communication platform to communicate with the device.
GPS(EM506)GG	• High sensitivity (tracking sensitivity: -159dBm) • Extremely fast TTFF (time to first fix) at low signal level • Supports NMEA 0183 data protocol • Built-in SuperCap to reserve system data for rapid satellite acquisition • Built-in patch antenna • LED indicator	The GPS system provides the exact coordinates of the location of the USV boat.
Brushless Motor (PROPDRIVEv2 2826 1000KV Brushless Outrunner Motor)	• Model: PROPDRIVE v2 2826 1000KV • KV: 1000 KV • Max current: 15A • ESC: 20~25A • Cell count: 3s~4s Lipoly • Pole Count: 12 • Max Power: 176W 11.1V (3S) / 235W 15V (4S) • Bolt holes: 16mm & 19mm • Bolt thread: M3 • Connectors: 3.5mm Bullet	The Motors are used to drive the Thrusters of the UV RC boat

	• Weight: 60g • Prop Tests: • 9x4.7 - 11.1V / 113W / 10.2A / 0.632kg thrust • 9x6 - 14.8V / 220W / 14.9A / 0.937kg thrust	
Buoyancy System (Farm & Ranch 10" Replacement Tire Inner Tube)	• Weight: 1 lbs • Dimensions: 13.00 H x 6.30 W x 1.60	The Buoyancy System is used to make the boat float in water.
Thrusters left & right (1PCS 12-24V 20A 30-200W Underwater Thruster 4 Paddle Propeller Brushless Motor)	• Voltage: 12-24 V • Current: 20A • Power: 30-200 W • Motor KV: 1000 KV • Size: Wire length 250mm , Diameter 74mm ,Total length 75mm ,Propeller diameter 60mm	There are 2 thrusters (left and right) used for the motion of the UV RC boat.
Ultrasonic Distance SensorHC-SRO4	• Input Voltage: 5V • Current Draw: 20mA (Max) • Digital Output: 5V • Digital Output: 0V (Low) • Working Temperature: -15°C to 70°C • Sensing Angle: 30° Cone • Angle of Effect: 15° Cone • Ultrasonic Frequency: 40kHz • Range: 2cm - 400cm • Dimensions ○ Length: 43mm ○ Width: 20mm ○ Height (with transmitters): 15mm ○ Center screw hole distance: 40mm x 15mm	Ultrasonic sensor is used to send and receive ultrasonic pulses that relay back information about an object's proximity to avoid collision with other objects.

	○ Screw hole diameter: 1mm (M1) ○ Transmitter diameter: 8mm	
KK2.1.5 flight controller	• Processor- Atmel 644PA • • Sensors- 6050 MCU • Weight-26mg	Will control the movements of our UAV
DJI 2212 920kv Brushless Motor 1CW & 1CCW	• Weight-56g • Dimension- $28 \times 24mm$ • Max Power 370W	Motor to turn the blades of UAV
DJI Phantom 3 9450 Self-tightening Propellers	• Weight-30g • Dimensions - $8.1 \times 17.28 \times 12.72\ in$	Blades of the UAV
30A RC Brushless Motor Electronic Speed Controller	• Weight- 40.8g	Motor speed controller
Frame F450	• Weight - 282 g	The body frame of the UAV
Mini Gear Micro Servo 9g	• Weight-9g • Stall Torque-1.6kg.cm	
Camera	~	Needed for Image Processing

1.2.3 Technical and Non-technical consideration and constraint in design process

Constraints:

- **Lack of Data**
  After detecting toxic water, based on the parameters measured the system will suggest a potential treatment plan. This plan will be suggested by means of an ML algorithm. However, ML algorithms require datasets to be trained and such data sets pertaining to Bangladesh are rare and hard to find.
- **Capacity development**
  People who are not much introduced to technology or living in rural areas might face problems handling and monitoring equipment in case the system has issues.
- **Power consumption**
  As we are using a wireless communication system and also the sensors are used to send data to cloud storage, a huge amount of power is consumed while doing it
- **Sensor constraints**
  Sensors can be expensive so we need to use sensors that are economically viable.
- **Not all water quality parameters can be measured**
  There are multiple parameters that are needed to check and monitor water quality but measuring these many is difficult.
- **Adverse weather conditions**
  Adverse weather conditions can damage the system

1.2.4 Applicable compliance, standards, and codes

Applicable Standards and Codes (CO2)

Water Quality Parameters Bangladesh Standards According to Department of Public Health Engineering:

Table-6 LOCAL STANDARDS FOR WATER QUALITY PARAMETER

Water Quality Parameters	Bangladesh Standards
pH	6.5-8.5
Total Dissolved Solids(TDS)	1000 mg/L

Temperature	20-30 ℃
Turbidity	1-5 NTU

IEEE Standards followed in Devices and Communication Protocols

DEVICE, CODE, DETAILS

Table-7 IEEE Standard Codes

Device/Technology	Standard Code	Standard Details
Bluetooth[13]	IEEE 802.15	This Standard specifies the rules that must be followed to setup Wireless Personal Network (WPAN).
WIFI Module[14]	IEEE 802.11	This standard specifies the Local Network (LAN) technical standards and Media Access Control (MAC) and Physical Layer (PHY) protocols that must be followed for implementing Wireless Local Network (WLAN) computer communication. This standard provides the basis for using devices that use wireless local networks branded as WIFI.
Cloud Server[15]	IEEE 2301 2020	This standard specifies the topology, functional elements and governance elements that need to be ensured to maintain the integrity and security of cloud computing based servers.

Printed Circuit Board	IEEE 370-2020	This standard ensures the quality of measured data for high-frequency electrical components are provided at frequencies up to 50 GHz.
Serial Bus[16]	IEEE 1394-2008	This standard provides specifications for a high-speed serial bus that supports both asynchronous and isochronous communication and integrates well for both 32-bit and 64-bit parallel buses. It is intended to provide a low-cost interconnect between cards on the same backplane, cards on other backplanes, and external peripherals. Interfaces to longer distance transmission media [such as unshielded twisted pair (UTP), optical fiber, and plastic optical fiber (POF)] allow the interconnection to be extended throughout a local network.

1.3 Systematic Overview/summary of the proposed project

Considering the current situation of our waterbodies , we propose such a device that can remotely monitor water health parameters that could be quick, more accurate and also that can collect large number of data over a short period of time. If data can be collected remotely, then it would also reduce risk in the sample collection process and these data can be used to visualize the larger picture and get more valuable information from it such as condition of river bodies in next 5 years, condition of the underwater lives over time and could also extrapolate the source points of pollution as well.

1.4 Conclusion

We have painted a comprehensive condition of our water bodies and provided the vast literature of the water health parameters and also the steps taken in Bangladesh so far to protect and improve the condition of our water bodies. Afterwards, we upheld the the necessity of such a machine that could remotely monitor our water bodies and also decribed the extensive objectives and scopes the device would carry. Besides, we also mentioned the specifications, constraints and functional/non functional requirements of the device and added the IEEE codes for it.
We have finally described the parameters of the water and explained their brief importance in

Chapter 2

Project Design Approach

2.1 Introduction

’’River Pollution will be unbearable by 2050’’a quote by Daily Star newspaper portrays the dire state of water bodies in Bangladesh.Chemical contamination of water bodies makes it unsafe for daily activities such as drinking, cooking, cleaning, swimming, and other activities.Many people rely on the river's water for irrigation and fish farming. Pressures on prevailing water resources have increased along with the advancement of time, the growth of civilizations, and the increased use of water resources, that to the discovery of unusual changes in water health conditions.Today, environmental contamination from drainage and the release of urban and industrial waste has risen, limiting the usage of water that is available. In order to guarantee the availability of good-quality water for its various applications, monitoring water health is essential and crucial.

Due to the importance of river and lake water quality to both human and economic progress, accurate evaluations and calculations of water quality levels are now required.
There are several methods to monitor water quality.

Conductivity, Salinity, and TDS Monitoring

A river's or lake's conductivity is a reliable indicator of its quality. Conductivity impacts the total dissolved solids (TDS) content and salinity of water, which then impacts the water's oxygen levels.

pH and KH Monitoring

To measure pH, tests can be performed using water test kits, which are color-coded and provide a wide range of pH values. These kits function better for figuring out what pH range the water is in.

Chlorophyll Fluorescence Analysis

Algae toximeters are used to determine the ratio of wet-chemical chlorophyll to active chlorophyll in the water sample. This is a useful technique for detecting extreme algal growth and keeping track of water quality.
From the above method, we concluded that measurithe ng number of water health parameters will give the most accurate and efficitive results.

2.2 Identify multiple design approach

-There are two approaches to determining the water quality index and monitoring the health of any water body.

Collecting water health parameters to determine the water quality index

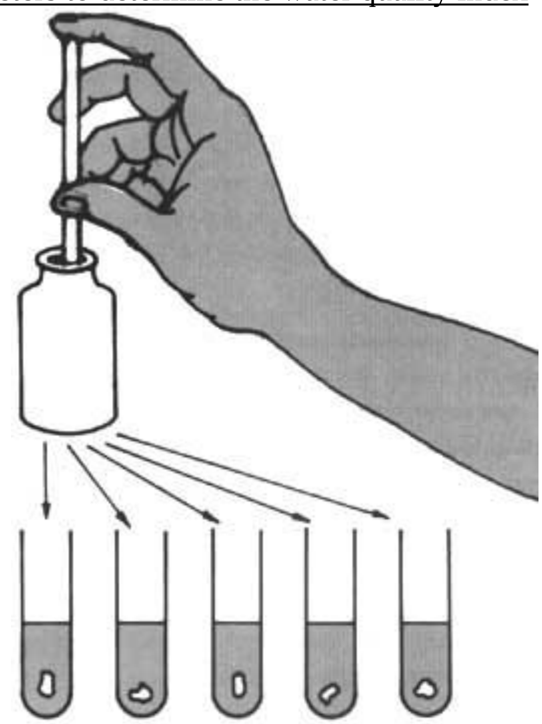


Fig 2.1. Manual sample testing

This process can also be divided into 2 types.
-Physical Testing
Colour, turbidity, total solids, dissolved solids, suspended solids, odor, and taste are collected.color.turbidity and odor/taste of water is physically tested.
Iron and manganese, as well as plant-based compounds like algae and weeds, can also contribute to the color of water. The effectiveness of the water purification system is determined by color tests. Granular matter and dissolved particles cause water to become turbid. Dredging-related soil erosion or the development of microorganisms may be to blame. Filtration costs increase with high turbidity.If pathogens are present, they may be shielded by waste solids and escape the disinfecting effects of chlorine. Odor and taste are related to the presence of living microscopic organisms, decaying organic matter, such as weeds and algae, or industrial effluent made up of ammonia, phenols, halogens, and hydrocarbons.
-Chemical Testing

pH and B.O.D level of any water body is measured using chemical testing
The amount of hydrogen ions is gauged by pH. It serves as a gauge for the water's relative acidity or alkalinity. High alkalinity is indicated by readings of 9.5 and higher,acidity is predicted by values of 3 and lower. Low pH values aid in efficient chlorination but exacerbate corrosion issues. In the marine environment, values below 4 typically do not support live creatures. The pH of drinking water should range from 6.5 to 8.5.B.O.D. : This term refers to how much oxygen microorganisms require to sustain decomposable organic matter in an aerobic environment. Low oxygen levels and organic pollutants are both indicated by high BOD levels.
These 5 samples are collected from the water body through manual sampling and then sent to the laboratories for lab testing.Labs takes a period of time to determine the level of each of these parameters and based on that a WQI value is found[17]

This process of manual testing is lengthy and have a higher percentage of error thus using moder technology data collection is made easier.
The second type of data collection can be done using sensors.Temperature, dissolved oxygen, pH, conductivity, ORP, and turbidity are among the variables that are regularly sampled or checked for water quality.

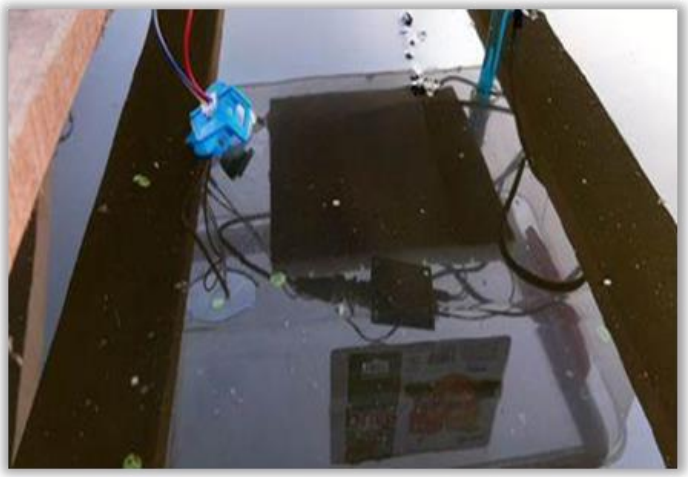


Fig 2.2 Sensors in contact with water.

Sensors shown in the above picture is used to collect data by coming in contact with the water body.requires no human interaction.These sensors collect data, which they then transmit to the control module. The communication module, with which the control module is interfaced, receives the data after relaying it. The data is then instantly uploaded by the communication module to a cloud service for storage. The data can then be accessed from there utilizing the analytics capabilities these cloud providers offer in an orderly manner at a different IP address.
This procedure is quicker and less prone to human mistakes.

Measuring Water Quality Index using Algae level

Fig.2.1. Water contaminated with algae

-Measuring the traditional water health parameter algae can determine the WQI value. Using a drone camera the picture of the water body is taken.The UAV's camera will take images and upload them to the server. To determine how much algae is present in the image's extracted water body, the image must go through the aforementioned image processing libraries.
Then using the level of algae present a value of water er quality index is determined which in turn relays the condition of the water body.

2.3 Describe multiple design approach

Design-1: Buoy-based Model

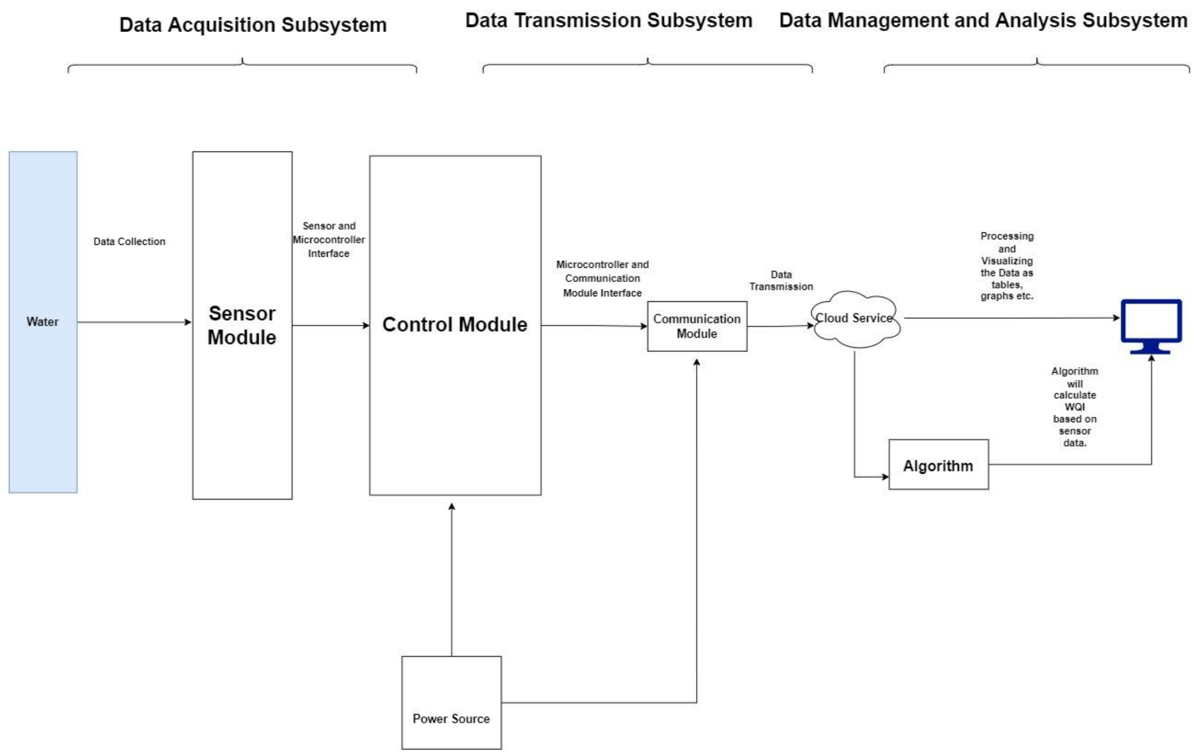


Fig. 2.4 Block Diagram of Buoy-Based Model

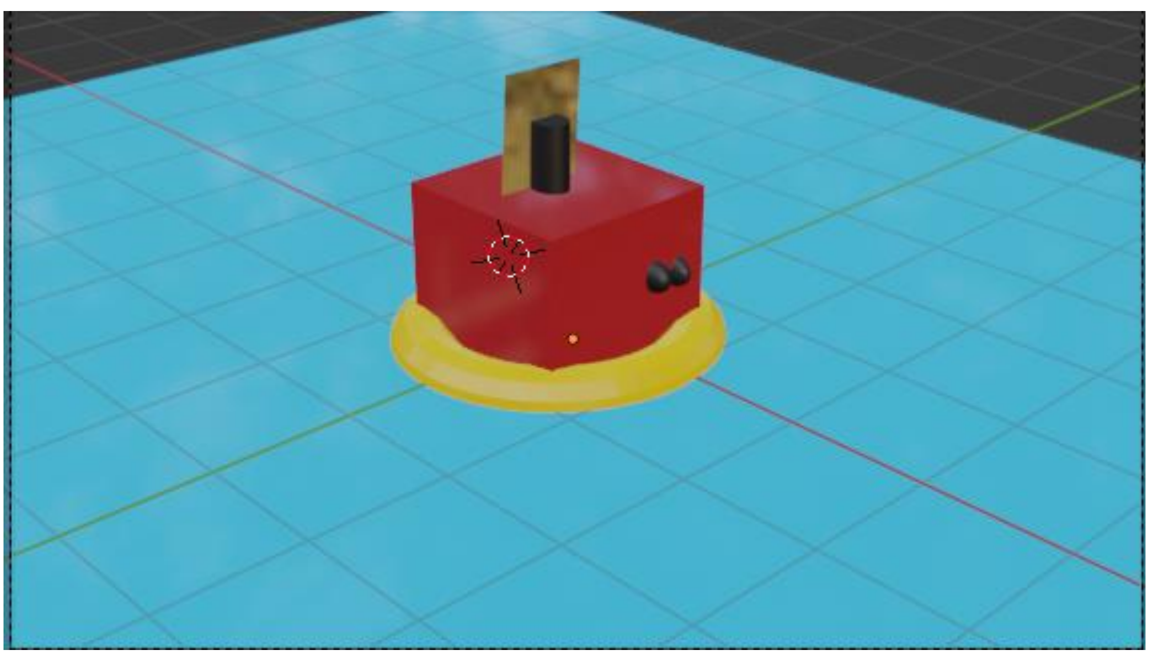


Fig. 2.5. 3-D Model of Design-1

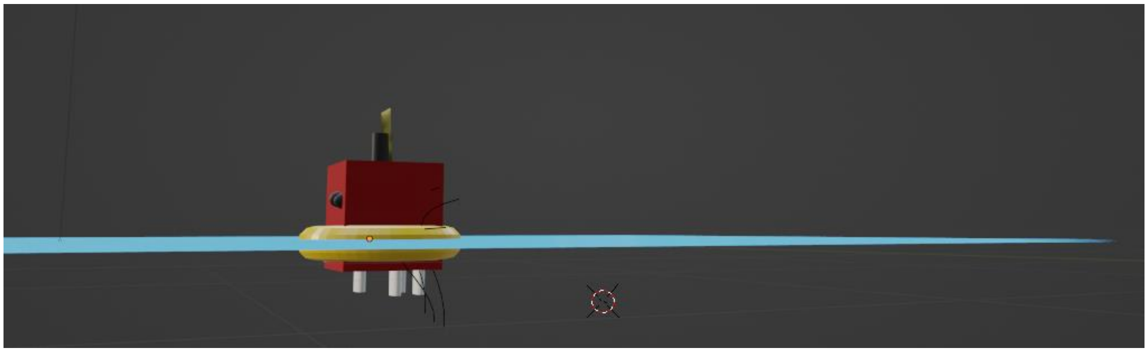


Fig.2.6. Visualization of how the sensors would collect data under the water

In this design, the water quality monitoring system is resting on a stationary buoy. The sensor module picks up important water-health parameters and sends them as data to the control module. The control module then relays the data to a communication module with which it is interfaced.
The communication module then uploads the data in real-time to a cloud service where the data is stored. Using the analytics tools these cloud services provide, the data can be viewed in an organized manner at a separate IP address. Furthermore, based on the data (water-health parameter values), the algorithm will calculate a water-quality index (WQI) value. From the WQI value, we can understand the toxicity level of water and can in turn suggest a potential use of the water.
The 3 main Sub-system of this design:

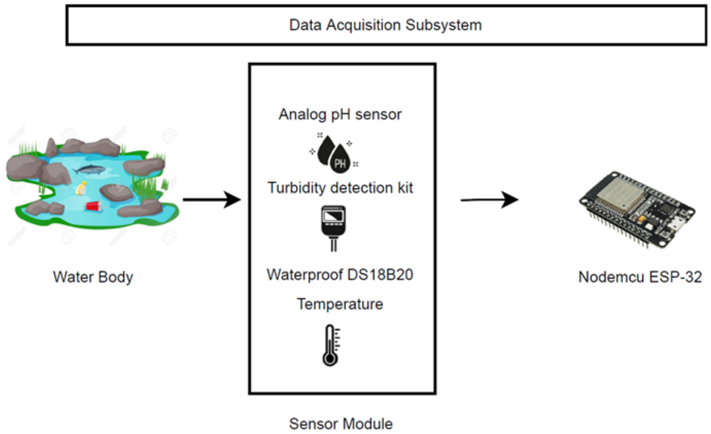


Fig.2.7. Data acquisition subsystem

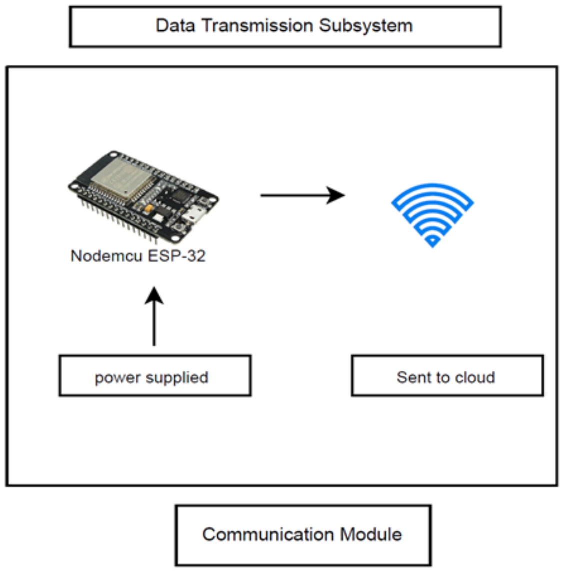


Fig.2.8. Data transmission subsystem

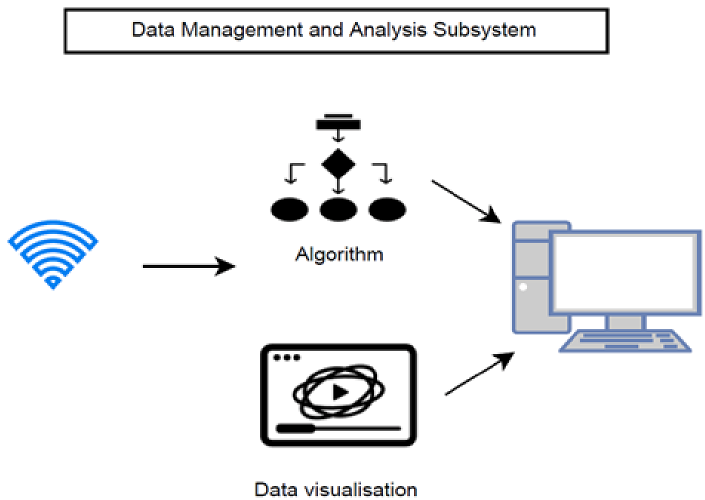


Fig.2.9. Data management and analysis subsystem

Design-2: USV-based Model

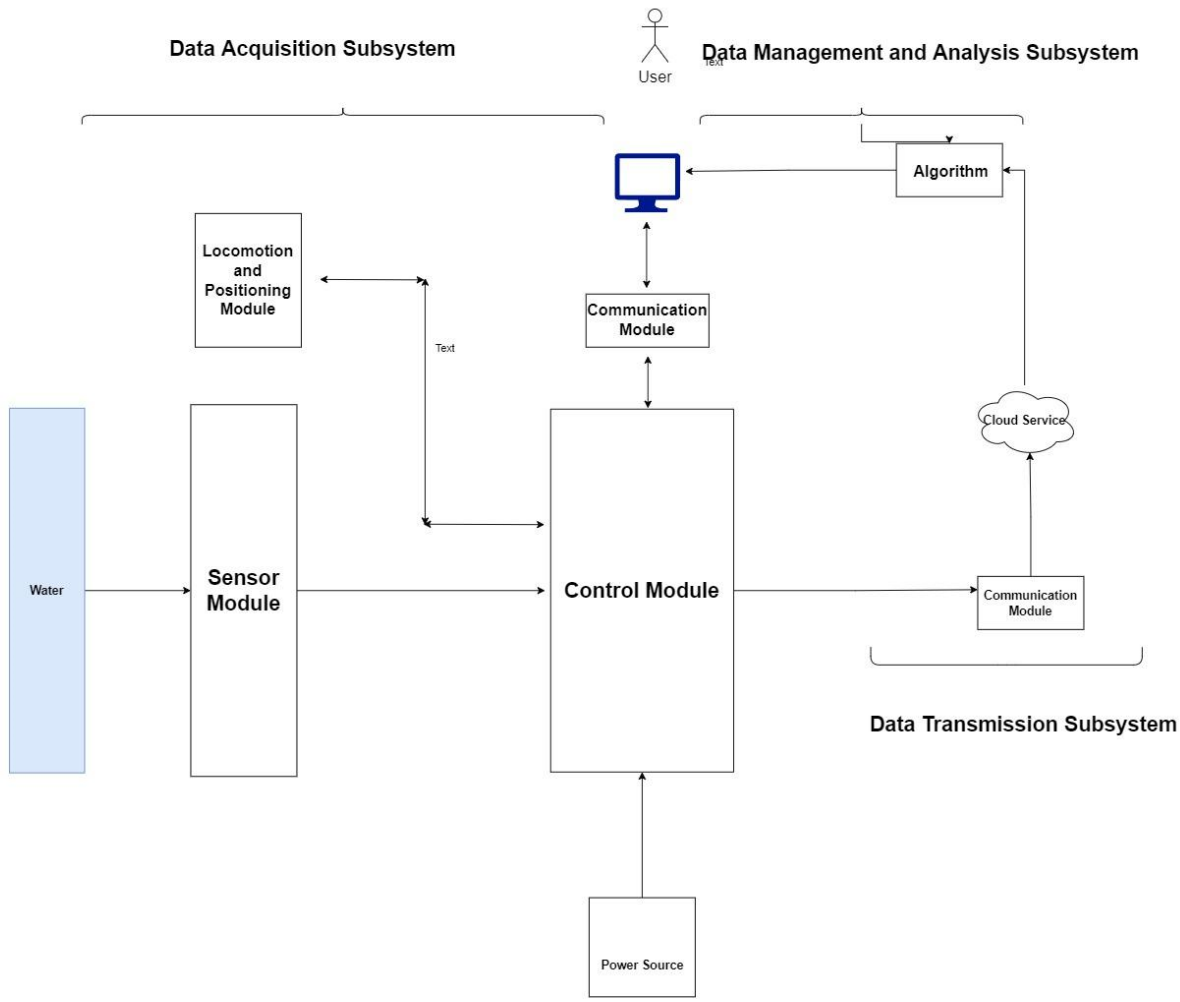


Fig. 2.10. Block Diagram of USV-Based Model

In this design, the water quality monitoring system is coupled with a USV (boat). The user can set the USV on any water body and then control the movements of the USV through a communication module. Thus, the user can collect water-health parameter values in a mobile manner. The USV will further be equipped with a positioning module such as a GPS and an object detection mechanism in order to avoid collisions. After collecting the water-health parameter at a certain location via the sensor module, the data is then sent to the controller module.
The control module then relays the data to a communication module with which it is interfaced.
The communication module then uploads the data in real-time to a cloud service where the data is stored. Using the analytics tools these cloud services provide data that can be viewed in an organized manner at a separate IP address. Furthermore, based on the data (water-health parameter

values), the algorithm will calculate a water-quality index (WQI) value. From the WQI value, we can understand the toxicity level of water and can in turn suggest a potential use of the water.

Design-3 UAV based Image processing Model

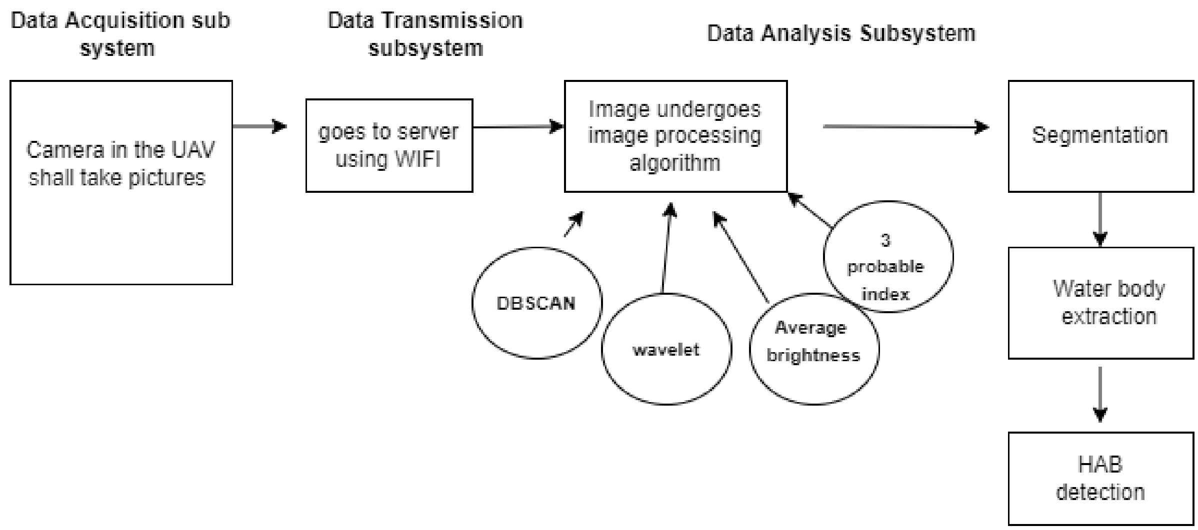


Fig. 2.11. Block Diagram of UAV-Based Model

Algal blooms are collections of algae that are visible on the surface of the water.
Summarisation of the approach:

- Using the density-based spatial clustering (DBSCAN) method, we first partition a picture into homogenous sections (trees, buildings, cars, sky, and water are segregated from one another).
- We extract water bodies from the segmented regions using wavelet leader-based texture analysis because the water bodies can occasionally be confused with the sky.
- Finally, we use the average brightness of segmented portions to remove sky regions from photographs.
- To calculate the amount of green algae present in the extracted water body, we suggest three probabilistic indices based on an RGB-based vegetation index, a hue-based index, and a saturation-based index. These indices are multiplied one more to determine the likelihood that the water body will contain green-blue algae (HAB).Using the aforementioned probability formula, the HAB index between 0-1 will be found and the algae will be marked in a boxed area .

In short **Basic Framework of the process:**

a) Input image
b) Segmentation (sky, buildings, water body)
c) Water body extraction
d) HAB detection

The camera in the UAV shall take pictures and send it to the server. The image shall undergo several aforementioned image processing libraries to detect amount of algae in the extracted water body of the image. Basically, the idea is to input the image, then the image will be segmented to separate and extract the water body in the image. After the water body is extracted, then Harmful Algae Bloom will be detected using a color gradient. That is if the detected area has high amount of algae then the extracted water body will have high green hue, and if not then it will have lighter green hue and if the water body has no algae, then the labelled part will go white.

2.4 Analysis of multiple design approach

A qualitative comparison table for the three design approaches.

TABLE-8 Design Comparison Table

Feature	**Buoy-Based Model**	**USV-Based Model**	**UAV-based Model**
Mobility	Not Mobile	Mobile (yet has certain range depending on communication link with USV and control)	Mobile (yet has certain range depending on communication link with USV and control)
Automatic	Yes (User can set up the system once and leave it)	No (Requires user-input for running USV)	No (Requires user-input for running UAV
Remote	Yes	Yes	Yes
Power Efficiency	Higher	Lower	Lower
Environmental Impact	Lower (Won't disturb Marine-Life as will be located in a single location)	Higher (USV is mobile,so might disturb local marine-life)	Higher (UAV is mobile so might disrupt local bird life)
Working Duration	Higher	Lower	Lower
Communication Link with Cloud Storage	Strong	Strong (has the potential to degrade as USV is a moving element and connection with WIFI may drop)	Strong (has the potential to degrade as UAV is a moving element and connection with WIFI may drop)

Accuracy of Sensor Module	Accurate	Accurate	Moderately lower accuracy as no actual sampling will be done
Risk of Damage	Lower	Higher (even though object detection mechanism is in place with USV still there is a chance of collision with unidentified objects)	Higher
Cost	Lower	Higher	Very High

2.5 Conclusion

-Measuring Water health quality index to determine water health has become an emergency in Bangladesh. The increase in water pollution is gradually decreasing the water reservoirs used for the daily necessities of many people. Human health, agriculture, and marine life are at stake if this issue is not resolved. These Design approaches can play a significant role in improving the water quality measuring process. Monitoring offers the unbiased data required to make wise decisions about the management of water quality now and in the future. Monitoring water quality helps us identify existing, recurring, and developing issues, as well as if drinking water regulations are being met and other beneficial uses of water are being safeguarded.

Chapter 3

Use of Modern Engineering and IT Tool

3.1 Introduction

In this section of the report, the reasoning for selecting modern engineering methods and IT tools to design, develop and validate the solution is provided. The project has three main subsystems: the Data-Acquisition subsystem, the Data-Transmission subsystem, and Data Management and Analysis subsystem. It was vitally important to simulate these subsystems first using appropriate software tools first. Whilst, developing the prototype (hardware implementation) the use of an appropriate coding IDE for the ESP-32 was necessary.

3.2 Select appropriate engineering and IT tools

As stated before the three subsystems were required to be simulated first before moving on to hardware implementation. Thus in this sub-section, first the different IT tools available to simulate the different subsystems will be analyzed and then a final choice will be made. The different IT tools available during hardware development will also be analyzed.

Design 1: Data-Acquisition Subsystem:

This subsystem is essentially the sensor module coupled with the control module. The aim of this subsystem is to take the sensor readings and store them in the microcontroller for later analysis.

Hence the key requirements for the simulation environment for the data acquisition sub-system were as follows:

- Must have readily available libraries/ add-ons for sensors and microcontroller.
- Must have the capacity to interface with any virtual communication emulator/module (Needed for sending sensor data to the cloud)
- Must have vast existing literature. (Manuals, tutorial videos)
- Must have user-friendly interface.

Based on these key requirements and a few others the choice was made:

Proteus-8 Professional:

Proteus is a widely used application favored by developers and engineers to simulate electrical circuits. It is often used when modeling and designing programmable devices such as microprocessors and microcontrollers.

Of all of the simulation environments, Proteus has one of the vastest components and module library. Moreover, in case a component does not already exist in its libraries. That component can readily be found on the internet as Proteus allows users to build their own components/modules.

Moreover, the COMPIM module of Proteus perfectly fits the use case of our designs as we need to establish and test serial communication between Proteus and other simulation tools.

Proteus's one of the most well-documented applications with many manuals, forums, and tutorial videos dedicated to it. The UI is easy to grasp too.

TinkerCAD:

Developed by AutoDesk, TinkerCAD is a free web app used for 3D designs and simulating electronic circuits.

While TinkerCAD is well documented and has a user-friendly UI. The library of the circuit section is limited. Many of the sensors needed to measure water-quality parameters were not available.

Before 2020, TinkerCAD had an ESP-8266 WIFI module in its library. However, they had to retire it due to security issues. Hence, now sending data to TinkerCAD was unnecessarily complicated. No literature was found regarding interfacing TinkerCAD with a virtual COM emulator either.

Multuism:
Multisim is an electronic schematic capture and simulation program [ref]. From our preliminary analysis of this software, it was understood that the tool was mostly used for low-level analog circuitry testing. This is not the desired use case.
Furthermore, the library in Multuism lacked the Arduino Development board and sensors needed to measure water-health parameters.

Final Choice:
Based on the aforementioned reasoning, Proteus 8 Professional was used to simulate the Data-Acquisition subsystem.

Design 1: Data Transmission Subsystem:
In the hardware design the data-transmission subsystem will likely be a communication module that provides internet connectivity such as ESP, GSM, or NB-IoT module. However, Proteus and other simulation environments did not have any built-in communication module which would allow internet connectivity.

Hence the key requirement for the engineering method to be selected was:

- To send data in real-time from Proteus to cloud storage.

The two engineering methods for the simulation of this sub-system.

Simulation Method-1:
In this method, Proteus sent data serially to a python script via Virtual Serial Ports Emulator (VSPE). After the python script received the serial data, it was adequately processed, and then sent to the cloud storage by using the write API key.

Simulation Method-2:
In this method, Proteus was to send data serially to a hardware ESP Module via Virtual Serial Ports Emulators (VSPE). Then the hardware ESP Module was to establish an internet connection and upload the data to the cloud server.

Final Choice:

The problem with Simulation Method-2 was that the Arduino IDE was not showing the "COM-A" of the ESP module.This may have been due to faulty equipment or AT command.
Hence, we chose Simulation Method-1 as it was able to successfully send the sensor data to the cloud storage.

Design 1: Data Management and Analysis Subsystem:
This sub-system could be simulated by any IoT platform. The IoT platform chosen will also be used during hardware implementation.
The key requirement for the IoT platform to be chosen boiled down to

- Show the graphs in real-time.
- Ease of use.
- Existing literature for particular use-case.

ThingSpeak:
ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. {ref}.
In the free version of ThingsSpeak, four channels can be created and a particular channel can have up to eight fields of data. This is more than sufficient for our use case as we require only four fields of data. (pH, Turbidity, Water-Temperature and WQI).
Moreover, in the free version each message can be up to 3000 bytes and 3 million messages are allowed in a year.
Exporting data to a csv file is allowed.
Moreover, ThingSpeak is very beginner friendly and a well documented platform.

Blynk:
Blynk is an IoT platform that is mainly used by iOS or Android devices to control MCUs. However, the web version of this platform exists and can be used to display real-time graphs from sensor readings.
Blynk can largely be used in a similar manner to ThingSpeak. However, the main disadvantage of Blynk is that in the free version of the platform, we can only support only two devices (equivalent to two channels), data is stored for only 1 week, and exporting to a CSV file is not allowed.

Final Choice:
Even though both platforms would have served our use case. We still opted for ThingSpeak as it can support more channels/devices than Blynk. Moreover, data is not deleted after a week, and exporting of CSV file is allowed in the free version of ThingSpeak.

IDE for MCU:

There are many IDEs available for coding the MCU, such as ATMEL Studio, MS Visual Studio, and B4R. However, the most widely used is the Arduino IDE due to the vast add-on libraries it provides and the availability of a serial monitor. Hence, during the hardware implementation, Arduino IDE was used to code the ESP-32.

3.3 Use of modern engineering and IT tools

This sub-section will be divided into the following:

- Use of Proteus to simulate the Data Acquisition subsystem.
- Use of Virtual COM port to simulate the Data Transmission subsystem.
- Use of Thingspeak as the Data Management and Analysis subsystem.
- Use of Arduino IDE during hardware implementation.

Use of Proteus to simulate the Data Acquisition subsystem:

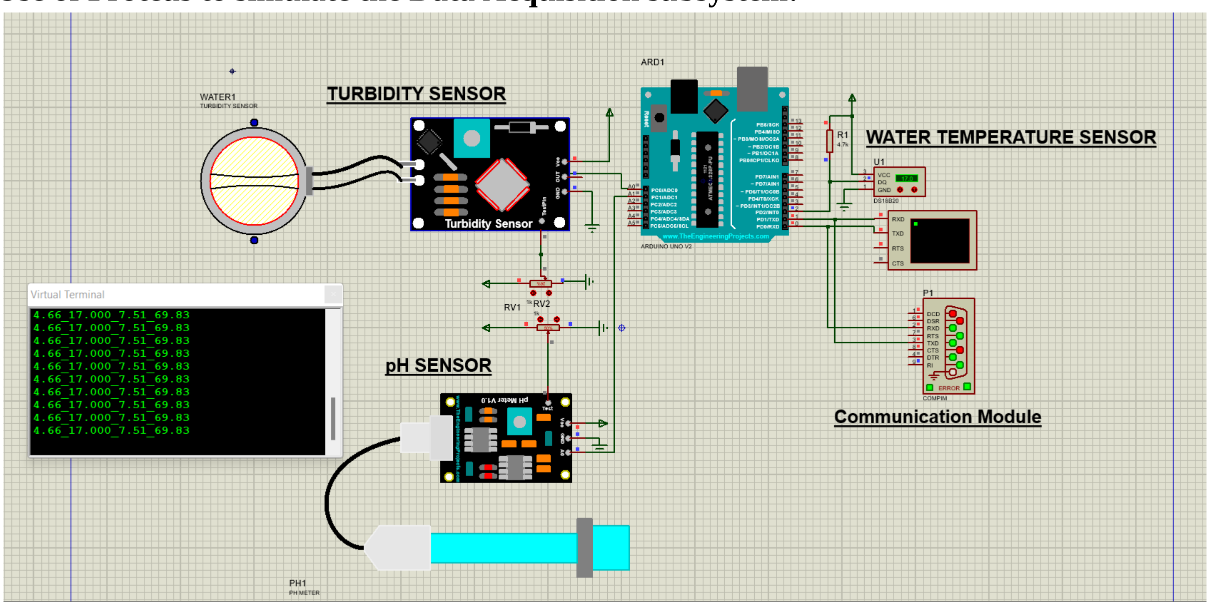


Fig. 3.1. Simulation of Data-acquisition subsystem

The Data-Acquisition Subsystem is able to pick up the sensor readings of Turbidity= 4.66 NTU, pH=7.51, Temperature= 17°C [See Virtual Terminal] . The potentiometer attached to the turbidity sensor and pH sensor acts as a method of varying the values whilst for the temperature sensor it is the two buttons.

Use of Virtual COM emulator to simulate the Data Transmission subsystem:

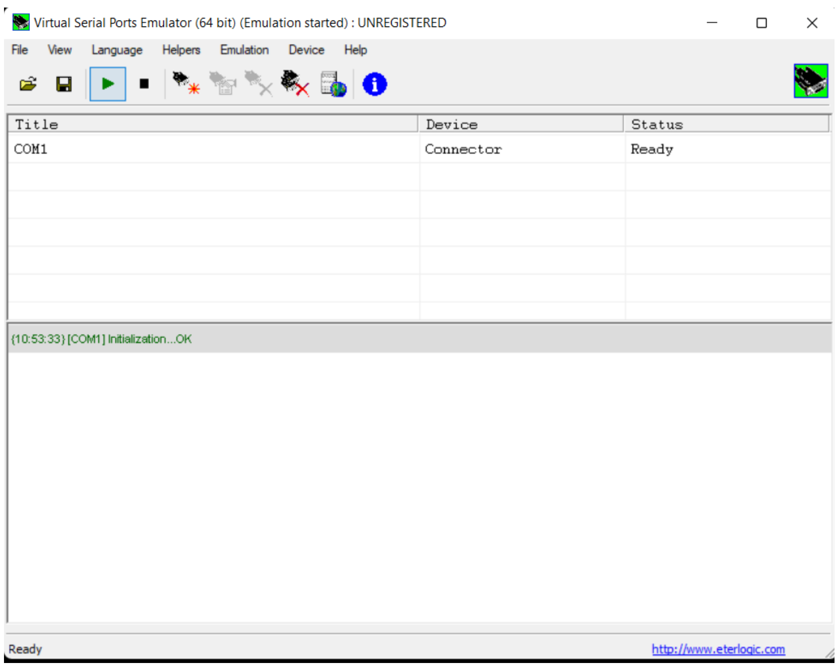


Fig. 3.2. VSPE.

Here, Proteus sent data serially to a python script via Virtual Serial Ports Emulator (VSPE). After the python script received the serial data, it was adequately processed, and then sent to the cloud storage by using the write API key.

Use of Thingspeak as the Data Management and Analysis subsystem:

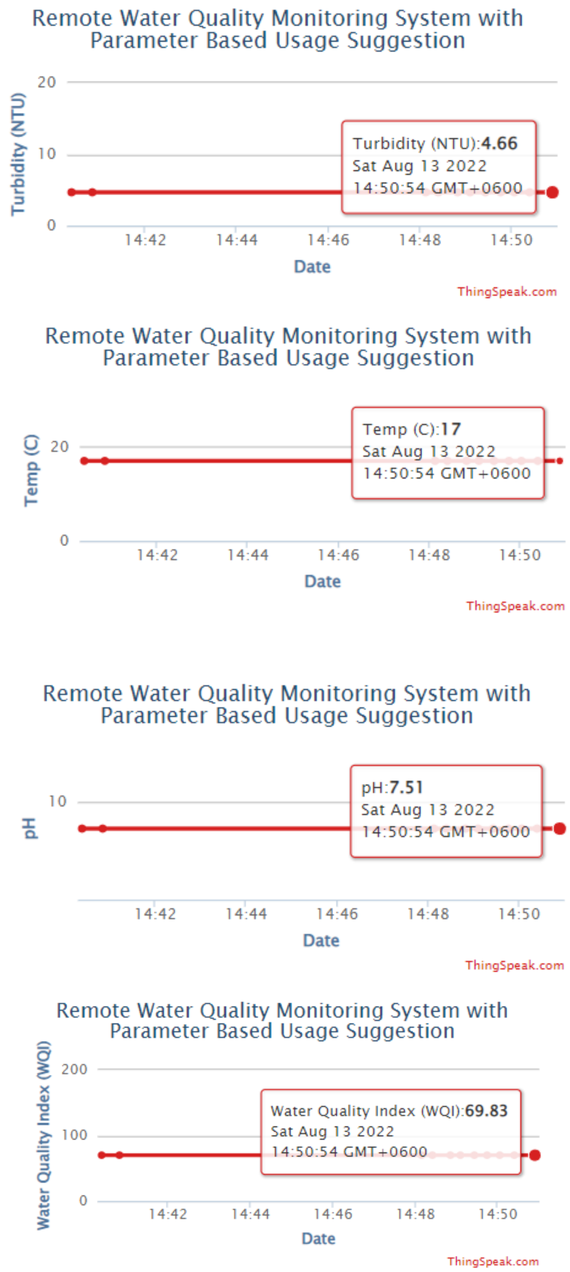


Fig. 3.3. Graphs on ThingSpeak

ThingSpeak was vitally important during both the simulation and hardware development as it is through this platform the real-time sensor and WQI graphs were displayed. The display of the graphs in real-time, even the WQI graph which was calculated by the MCU, is part of the "Data Management" part of this subsystem.

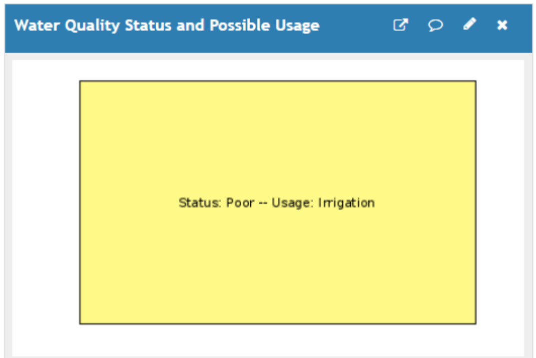


Fig. 3.4. Status and usage

```
% Enter your MATLAB code below

readChannelID =1831845
fieldID1=4;

readAPIKey='MDO3UN2L74Q44NR9';
returnWQI= thingSpeakRead(readChannelID,'Field',fieldID1,'ReadKey',readAPIKey)

[watercond,condIDx]= returnwaterhealth(returnWQI);
plotwaterhealth(watercond,condIDx)

function plotwaterhealth(watercond,condIDx)
vertices=[0 0; 1 0; 1 1; 0 1];
faces=[1 2 3 4]

facecolorpatch1= [0 0.83 0; 0.44 0.95 0.52; 1 0.98 0.53; 0.95 0.98 0.22; 1 0.39 0.39; 1 0 0]
facecolorpatch=facecolorpatch1(condIDx,:);

waterhealthpatch =patch('Faces', faces,'Vertices',vertices,'FaceColor',facecolorpatch)
hold on
text(0.5,0.5,watercond,'FontSize',8,'HorizontalAlignment','center')
hold off

axHandle=waterhealthpatch.Parent;
axHandle.YTickLabel=[];
axHandle.XTickLabel=[];
end

function [watercond,condIDx]=returnwaterhealth(returnWQI)
watercond = {'Status: Excellent -- Usage: Drinking, Irrigation and Industrial'; 'Status: Good
wqilow=[0;26;51;76;101]
wqihigh=[25;50;75;100;1000]

lutwqi= table(watercond,wqilow,wqihigh,'VariableNames',{'Water_Health','WQI_Low','WQI_High'})

condIDx= find(returnWQI >= lutwqi.WQI_Low & returnWQI <= lutwqi.WQI_High)

watercond = string(lutwqi.Water_Health(condIDx));
end
```

Save and Run Save*

From the above two figures, the "Data Analysis" part of the sub-system can be understood. Using MATLAB code on ThingSpeak, the *Water Quality Status and Possible Usage* field will be edited based on the WQI graph.

Use of Arduino IDE during hardware implementation:

Some important and commonly used sequences of codes are highlighted below along with their explanation to better represent the use of Arduino in order to complete our prototype.

```
for(int i=0;i<10;i++)         //Get 10 sample value from the sensor for smooth the value
 {
        buf[i]=analogRead(potPin);
        delay(10);
 }
 for(int i=0;i<9;i++)         //sort the analog from small to large
 {
        for(int j=i+1;j<10;j++)
        {
        if(buf[i]>buf[j])
        {
        temp=buf[i];
        buf[i]=buf[j];
        buf[j]=temp;
        }
        }
 }
 avgValue=0;
 for(int i=2;i<8;i++) //take the average value of 6 center sample
        avgValue+=buf[i];
 float voltage=(float)avgValue*3.3/4095.0/6;//convert to voltage
 delay(3000);
 float turb= 286.67*pow(voltage,2)-1629.4*voltage+2308.065; //calibration
```

The above is the sequence code used to get the turbidity sensor value. The same code logic was used for pH sensor as both are analog sensors. The idea is that the analogRead() function will return any number from 0 bit to 4095 bit depending on the turbidity sensor readings. (ESP-32's ADC Pins are 12 bits). However, the sensor readings vary a lot. To smoothen the data, ten readings will be taken from the turbidity sensor. These readings will be stored in an array. From this array, only the six center readings will be used in the later calculation.

```
float voltage=(float)avgValue*3.3/4095.0/6;
```

In this line of code, the bit number (0 bit to 4095 bit) is converted to an analog voltage.

```
float turb= 286.67*pow(voltage,2)-1629.4*voltage+2308.065;
```

In this line of code, the analog voltage readings of the sensor are converted to turbidity readings in NTU. This is based on calibration.

```
#include<OneWire.h>

#include <DallasTemperature.h>
```

These are the libraries necessary for the temperature sensor DSB1820.

```
sensors.requestTemperatures();
Celsius =sensors.getTempCByIndex(0);
```

This is the piece of code used to take temperature readings.

```
#include<WiFi.h>
#include"ThingSpeak.h"
constchar*ssid="Ez";
constchar*password="lazibsharar";
WiFiClient client;
unsignedlongmyChannelNumber=1916007;
const char * myWriteAPIKey = "OTF2TVVOXSK6HX32";


voidsetup(){
  WiFi.mode(WIFI_STA);
 ThingSpeak.begin(client);
```

```
 Serial.begin(115200);
 delay(1000);
}
```

Importing necessary libraries required to establish WIFI/ mobile hotspot connection with NodeMCU. Also, insert a unique channel number and write API keys to ensure the NodeMCU sends data to the correct thingspeak channel.

```
if(WiFi.status() != WL_CONNECTED){
     Serial.print("Attempting to connect");
     while(WiFi.status() != WL_CONNECTED){
       WiFi.begin(ssid, password);
       delay(5000);
     }
     Serial.println("\nConnected.");
   }
```

The above code will run in void loop(). It ensures that the NodeMCU continually reconnects to the WIFI network if the connection is severed.

```
int x1 = ThingSpeak.writeField(myChannelNumber, 1,Celsius, myWriteAPIKey);
```

Sending temperature data to ThingSpeaks

```
float Qph= abs(((ph-7)/1.5)*100);
float Q_turb= abs((turb/5)*100);
float Q_temp=abs((Celsius/30)*100);
float Wph= (float)60/179;
float Wturb=(float)102/179;
float Wtemp=(float)17/179;
float temp11= Wph*Qph;
float temp21= Wturb*Q_turb;
float temp31=Wtemp*Q_temp;

float temp41= temp11+temp21+temp31;
```

Calculating WQI value using temperature, turbidity and pH data.

3.4 Conclusion

For software application, we used proteus and arduino IDE and thingspeak, and python for our simulation of design-1 and 3.

Chapter 4

Optimization of Multiple Design and Finding the Optimal Solution

4.1 Introduction

To select the optimal solution from the three design approaches the factors taken into consideration are; efficiency in fulfilling the objectives, cost, usability, manufacturability, and maintainability.

Efficiency in fulfilling the objectives:

The objectives were:

- To allow regulatory bodies and concerned authorities to monitor water-health indicators remotely.
- To enable regulatory bodies and concerned authorities to monitor multiple water bodies or multiple locations in a single water body at a time.
- To reduce reliance on manual sampling and testing in physical laboratories.
- To analyze the sensor data in real-time and detect the toxicity level of the water.
- To suggest water usage in accordance with toxicity level.
- To increase accountability for water pollution and thus reduce it in the long-term future.

4.2 Optimization of multiple design approach

Now all three designs if implemented are able to address points 2, 3,4 and 6 to some capacity. However, only design-1 is able to address point 1. This is because design-2 and 3 are USV and UAV-based, hence they require an operator to function. Thus design-2 and 3 are not remote. However, design-1 is remote as the buoy just has to be installed and can be left to operate alone. Moreover, design-3 utilizes algae level, a non-conventional water-health parameter, to deduce the toxicity level of the water. However, algae level as a water-health parameter is still very novel, and cannot be used to suggest water usage. On the other hand, design-1 and design-2 utilize conventional water-health parameters like pH, turbidity, etc to calculate a WQI value. From this WQI value the toxicity level can be deduced and the corresponding water usage.

Table-9 Estimated Cost for the three designs.

Design Approaches	**Cost**
Design-1	5000*
Design-2	21495
Design-3	22430

*Cost of design-1 can be further reduced through optimization.

Design-1 is cheaper than design-2 and 3. The main factor driving the cost of design-2 and 3 is the additional cost required to manufacture USV and UAV. Design-1, on the other hand, utlizes a buoy system which can be quite cheap.

Usability:

The usability of design-1 is superior to the other two designs as the system only needs to be installed once and then left to operate on it's own. However, the other two designs requires an operator, who can run USV and UAV, to function. Furthermore, design-1 can provide 24/7 water-health analysis. Design-2 and 3 are limited in their operation time-span as an operator cannot be expected to run the USV and UAV 24/7.

Manufacturability and Maintainability:
The manufacturing process of Design-1 is less complex and time-consuming than the other two designs simply because design-1 utilizes a buoy system and the other two designs require a USV and UAV. This is an important factor to consider in the selection of the optimal solution as in 400-C, the time to manufacture a prototype is only three months. Moreover, in real-life applications, the design which is less time-consuming in terms of manufacturability has the most potential to be scaled up for mass-use.

Design-1 requires maintenance, in the form of battery, sensor, and communication module checks. This maintenance can be done in 2~3 week intervals. However, design-2 and 3 require maintenance checks before every operation as it is USV and UAV based.

4.3 Identify optimal design approach

Table-10 Quantitative analysis of the three designs based on assigned weight

Factors	**Assigned Weight**	**Design-1**	**Design-2**	**Design-3**
Efficiency in fulfilling the objectives	15	15	12	9
Cost:	10	8	7	6
Usability:	10	10	6	6
Manufacturability and Maintainability:	10	8.5	6	6

Total	45	41.5	31	27

Now based on the aforementioned qualitative and quantitative analysis, design-1 is the optimal solution.

4.4 Performance evaluation of developed solution

After implementing the design-1 and performing tests on it, we faced some issues.

Design -1 required a communication module to transmit the data to the cloud. We initially opted for arduino uno and ESP-01 wifi module. Unfortunately, the transmission was quite unreliable so to switched to ESP-32 Nodemcu completely. This reduced the overall total cost as now we were using only nodemcu which was essentially working both in the data acquisition subsystem and data transmission subsystem. We had essentially planned to use more than three sensors. However, due some of the sensors being unavailable and over-priced, we optimised to use three parameters only -temperature sensor, turbidity sensor and pH sensor which also gave a prominent WQI value according to the Weighted Arithmetic Water Quality Index Method [3]. We also had to make sure that our design -1 prototype was stationary and floating. So, we used four PVC pipes of 3 inches and joined them into a rectangular shape to get more surface water tension which made the body float in a stable fashion.

Lastly, for the data analysis subsystem, we had previously thought of suggesting water treatments according to the WQI value. However, that would have required robust machine learning algorithms. So, we optimised our system to analysis the data and give an usage for the water body according to their WQI value.

4.5 Conclusion

After the optimisation of our prototype by troubleshooting and multiple trial and errors, our prototype was able to remotely acquire data of the water parameters and transmit the data to the thingspeak cloud and after analysis of the results, provide a WQI value and usage for the water body. Basically, our prototype was successful in real time monitoring of water bodies.

Chapter 5

Completion of Final Design and Validation

5.1Introduction

In this section the process of the completion of the final design and the subsequent functional verification, done in two separate water bodies: Mirpur DOH pond and Diyabari Lake, will explored.

5.2Completion of final design

Sensor Calibration:

Three sensors were used in the system, pH, turbidity and temperature. The sensors needed to be calibrated before use.

pH sensor:

The pH sensor used was the *Analog pH Sensor*. To calibrate this pH sensor, the probe was dipped into two buffer solutions of known pH (pH 4.01 and pH 6.86) and the corresponding analog voltage output of the sensor was measured.

The voltage readings were as follows:

Table-11 pH and Voltage Values

pH	Voltage (V)
4.01	1.41
6.86	1.36

From these two readings a regressed linear equation was derived:

$$pH = -57V + 84.38$$

Using this relationship between pH and analog voltage, the calibration was fixed within the code.

*float ph=-(57*volt)+84.38;*

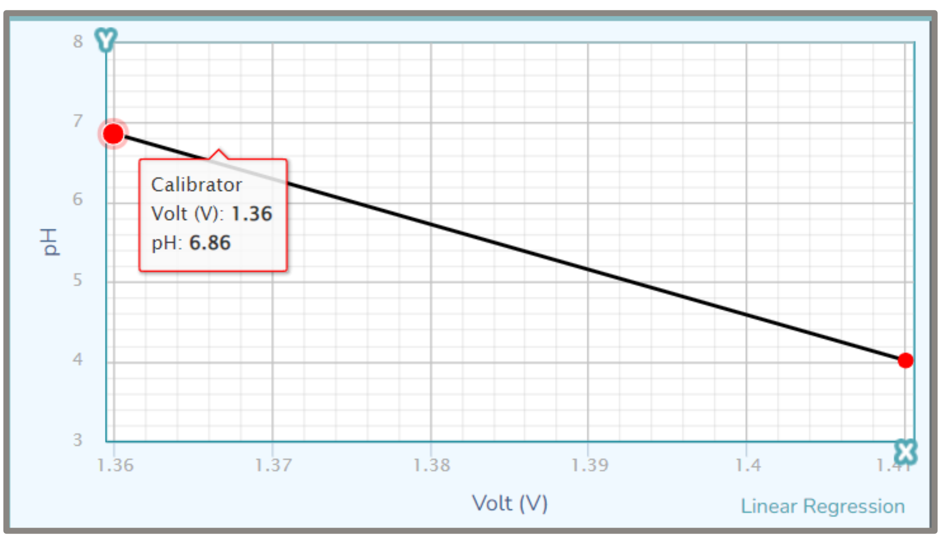
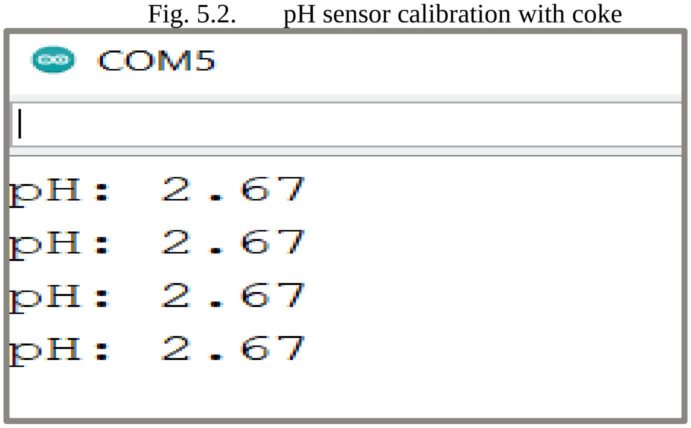


Fig. 5.1. pH vs Voltage calibration curve

Fig. 5.2. pH sensor calibration with coke



The pH sensor calibration was then verified by dipping the probe into a coco-cola. The pH probe gave a reading of pH: 2.67 and the pH of coco-cola is 2.6-2.7 [1].

Turbidity Sensor:

The turbidity sensor used was *Turbidity Sensor Suspended Turbidity Value Detection Module Kit.* The turbidity sensor was calibrated by dipping the probe into drinks with known turbidity (NTU) readings and then measuring the corresponding analog voltages.

The following readings were taken:

Table-12 Turbidity Values

	Turbidity (NTU)	Voltage (V)
Tap-Water	0.8 [2]	3.01
Coco-cola	2.2 [2]	2.66
Milk	107.2 [2]	2.21

From these three readings a regressed quadratic equation was derived:

$$turbidity = 2308.065 - 1629.4V + 286.67\,V^2$$

Using this relationship between turbidity and analog voltage, the calibration was fixed within the code.

*float turb= 286.67*pow(voltage,2)-1629.4*voltage+2308.065;*

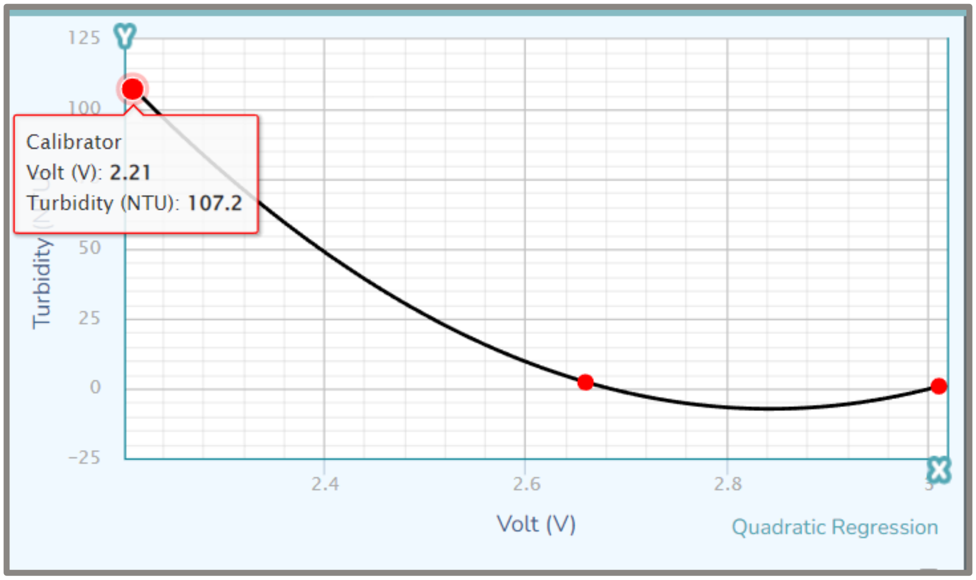
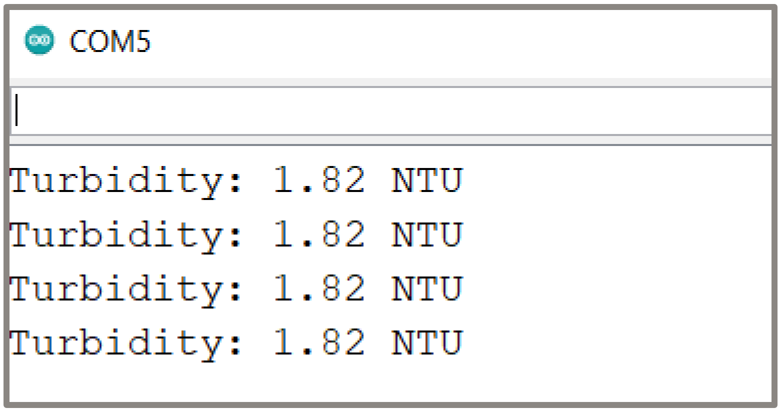


Fig. 5.3. Turbidity vs Voltage calibration curve

Fig. 5.4. Temperature sensor calibration with 7up



The turbidity sensor calibration was then verified by dipping the probe into 7-up. The probe gave a reading of 1.82 and the pH of coco-cola is 1.80 NTU [18].

Temperature Sensor:

The DSB1820 water-proof sensor did not require calibration. It's functional verification was done by comparing it with a house-hold thermometer.

Entire Proto-type:

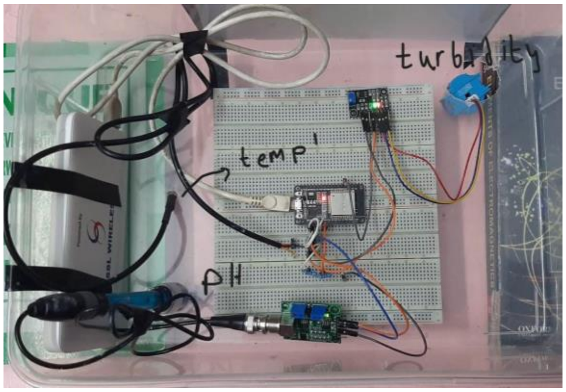


Fig. 5.5. Primary circuit

Fig. 5.6. Prototype floating in water

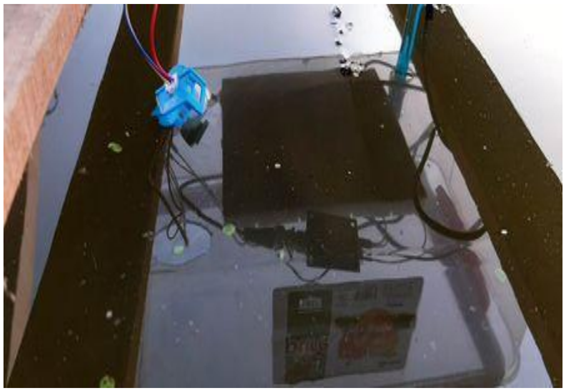


Fig. 5.7. Sensors floating in water

The primary circuit was built on a breadboard. This primary circuit was then attached to a circuit house which in turn was attached to a buoy. Drills were holed into the circuit house to ensure the sensors made contact with the water whilst the primary circuit did not get wet.

5.3 Evaluate the solution to meet desired need

The functional verification of this project was done in two locations:

- Mirpur DOHS Pond
  Date: 13/12/22022
  Time: 13:45 - 14:08

- Diyabari Lake
  Date: 13/12/2022

Time: 14:40 - 14:51

Fig. 5.8. Mirpur DOHS Pond

Fig. 5.9. Diyabari Lake

Mirpur DOHS Pond:

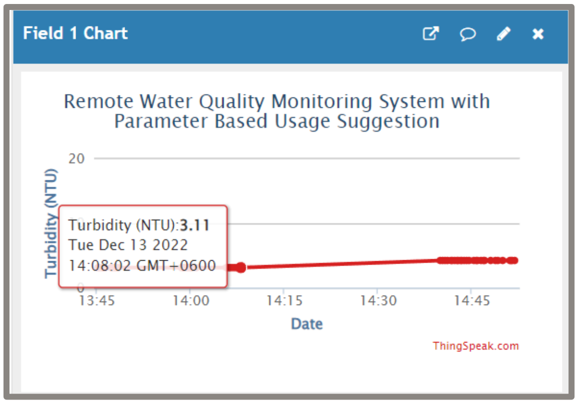


Fig. 5.10. Turbidity: 3.11 NTU

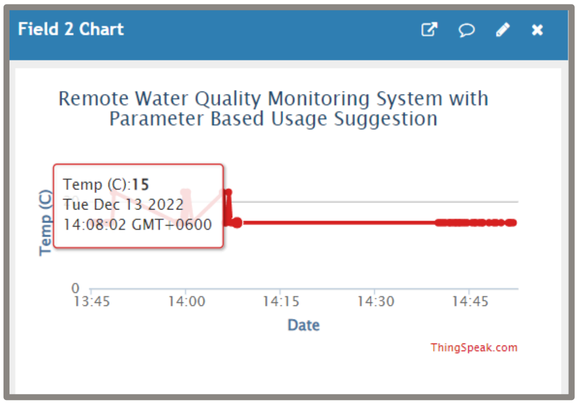


Fig. 5.11. Temperature: 15°C

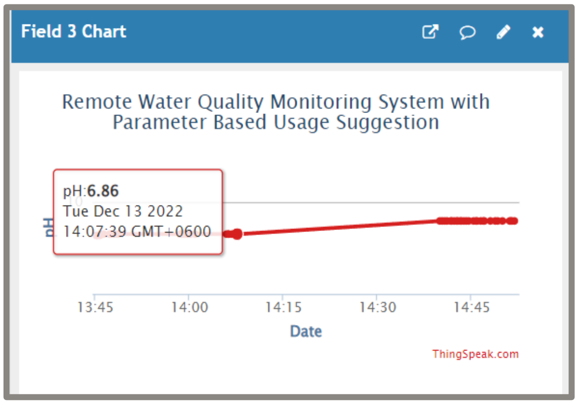


Fig. 5.12. pH: 6.86

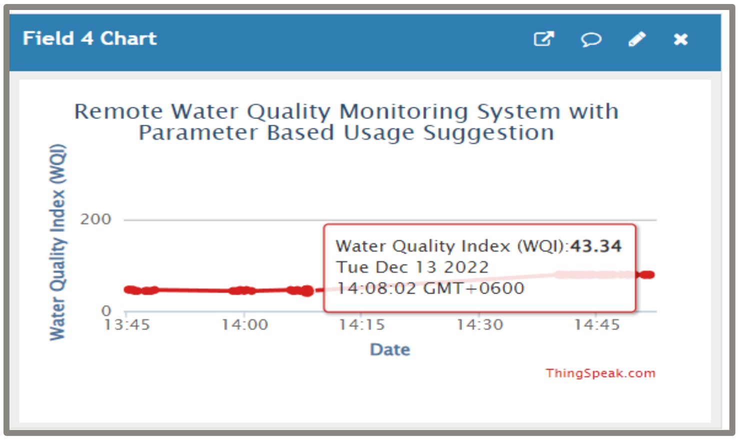


Fig. 5.13. WQI: 43.34

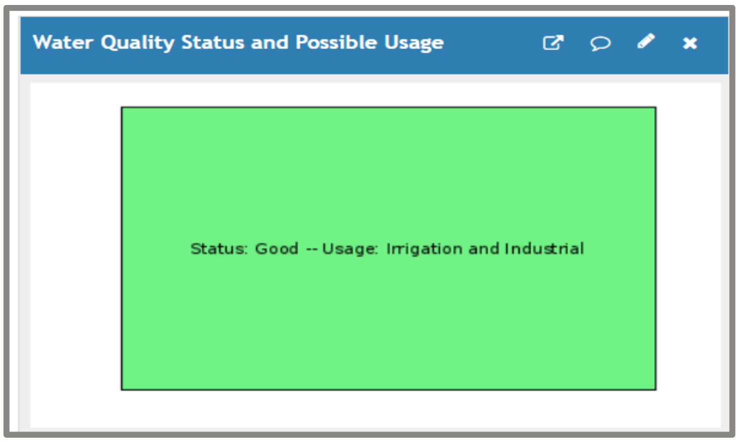


Fig. 5.14. Status and usage based on WQI value.

Based on the parameters: Turbidity: 3.11 NTU, Temperature: 15°C, pH: 6.86 the WQI value of Mirpur DOHS pond is 43.34. This means that the pond's water quality status is good and can be used for irrigation and industrial purposes.

Diyabari Lake:

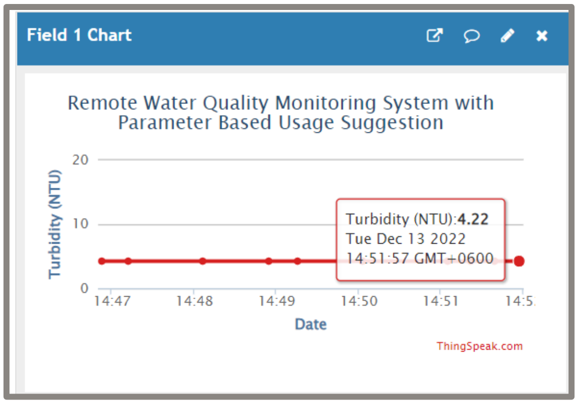


Fig. 5.15. Turbidity: 4.22 NTU

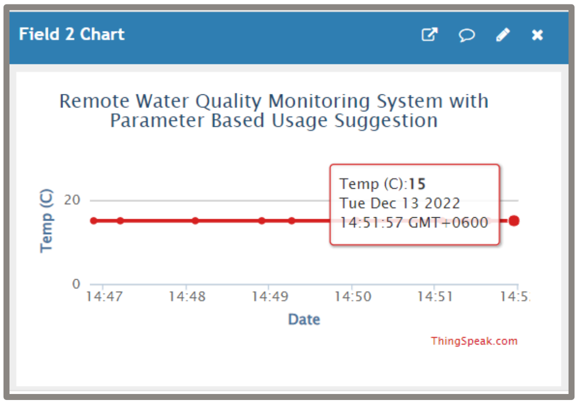


Fig. 5.16. Temperature: 15℃

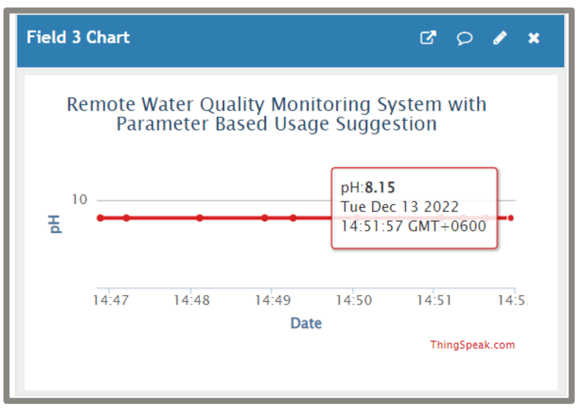


Fig. 5.17. pH: 8.15

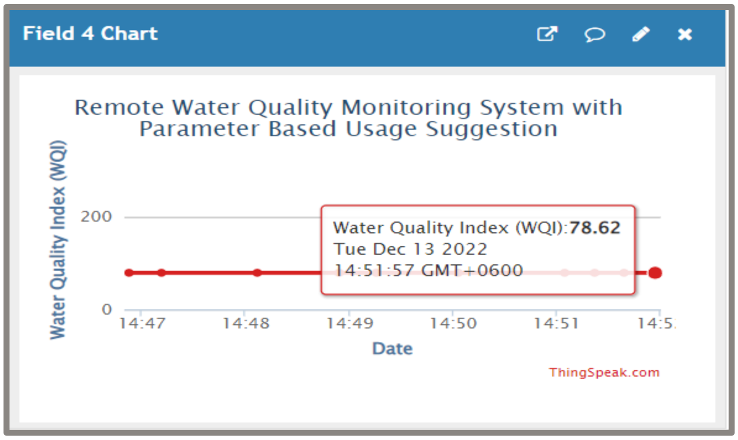


Fig. 5.18. WQI: 78.62

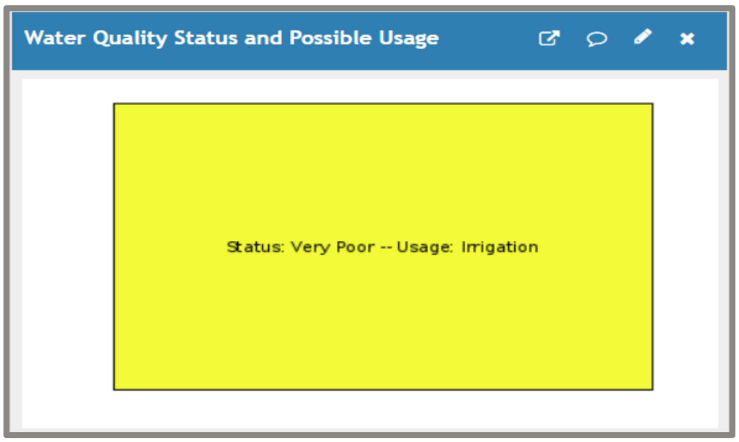


Fig. 5.19. Status and usage based on WQI value.

Based on the parameters: Turbidity: 4.22 NTU, Temperature: 15℃, pH: 6.86 the WQI value of Diyabari lake is 78.62. This means that the pond's water quality status is poor and can be used for irrigation purposes of some crops.

5.4Conclusion

We tested our prototype on two water bodies, diabari lake and Mirpur DOHS lake. In this water bodies, our data was quite similar to the standard codes of clear and dirty water.

Chapter 6

Impact Analysis and Project Sustainability

6.1Introduction

The health parameters of waterbody monitoring offer the unbiased data required to make wise decisions about water quality management now and in the long run.

We will be able to find new, ongoing, and changing problems, figure out if drinking water needs are being met, and protect other good uses using our prototype design. Monitoring data also helps lawmakers and water body management bodies like Kalyan Shamities figure out if water regulations are working, if water quality is improving, and if new policies need to be made to protect public health and the environment. Our monitoring system will not only be able to access and evaluate water quality parameters in real time, but it will also allow us to gather and store a vast amount of data over time.

6.2Assess the impact of solution

The health parameters of waterbody monitoring offer the unbiased data required to make wise decisions about water quality management now and in the long run.

We will be able to find new, ongoing, and changing problems, figure out if drinking water needs are being met, and protect other good uses using our prototype design. Monitoring data also helps lawmakers and water body management bodies like Kalyan Shamities figure out if water regulations are working, if water quality is improving, and if new policies need to be made to protect public health and the environment. Our monitoring system will not only be able to access and evaluate water quality parameters in real time, but it will also allow us to gather and store a vast amount of data over time.

Societal:

Bacteria that cause diarrhea, cholera, dysentery, typhoid, hepatitis A, and polio can be found in contaminated water. The UN estimates that each year, 297,000 children under the age of five pass away from illnesses brought on by poor hygiene, sanitary conditions, or contaminated water. Thus water monitoring system has a huge impact on societies living in rural areas whose lives mainly depend on nearby water bodies.

Also, the large number of chemicals used in daily consumable water has increased to an alarming rate which makes water monitoring systems a rising concern.The optimal Buoy-based remote water monitoring device that could be installed in any remote water body will be able to monitor water quality both now and in the future with the assurance of giving continuous updates of the monitored water body’s quality status..The system will stop people from polluting water bodies if they spot a monitoring gadget as they would be alarmed.The sanity of aquatic bodies will be improved.

Health:

Water quality monitoring is essential to determine the health of waters, from ports to fishing, marine protected areas to rivers and inland waterways. Contaminated water that as oxygen dissolved in the water ideally above 6.5-8mg/L has poor quality and these types of pollution has become a concern. Protection from the detrimental effects of water quality and water health is necessary for residents of coastal towns where these factors are abundantly visible.

Saltwater intrusion, excessive water extraction for irrigation, and environmental contamination from industrial effluents all have an impact on Bangladesh's water quality. The number of cases of dysentery, diarrhea, and other waterborne diseases will decrease if water bodies are monitored in real time using our device. Healthy brain and body function, growth, and development are supported by clean air and water.

Safety

Water monitoring system has the most impact on human life and marine life. In order to assess if succeeding in cleaning up the rivers, the quality of the water must be monitored. It indicates the condition and make-up of streams, rivers, and lakes both in the present and over the course of days, weeks, and years. Due to the numerous chemicals used in industry and daily life that can end up in waterways, monitoring water quality in the 21st century is becoming more and more difficult. Thus these harmful actions might lead to water scarcity and numerous unsafe water bodies. All the living lives on earth is dependent on clean water,if this isn't available in future then hundred of different water-borne diseases will agitate the current state of life.

Economical

Water and extreme poverty are inextricably linked. Providing access to consistent sources of clean water is crucial to poverty reduction. Safe drinking water and sanitation increase the percentage of a community's population that is able to attend school and remain gainfully employed. Water-related diseases are a constant threat to health, keeping people out of the workforce and in poverty. So with a monitoring system like ours, we can reduce such issues of poverty.

6.3Evaluate the sustainability.

SWOT Analysis:

TABLE 13. SWOT ANALYSIS

	Strengths	**Weaknesses**
Internal	• Developed by cutting edge technology • Continuous real-time monitoring with limited human interaction needed. • High durability • Can be used by both industrial and government water regulatory bodies.	• Initial startup cost is a little expensive. • It is not always possible to extrapolate this method to all sorts of water health monitoring applications since other water indicator parameters might be involved which are not measured in our system.
	Opportunity	**Threats**

External	• In the future we can further develop the system so that water health is monitored in different stations and nodes where all the separate monitoring systems can be integrated together for a central monitoring system for a more robust and extensive water health monitoring. • The system prototype can be further developed for government water regulatory bodies like the NWC (National Water Council) and WARPO (Water Resources Planning Organization)	Maybe hard to implement in remote areas with poor internet connectivity. Inclement weather conditions might interfere with the functionality of the monitoring system. The System could be at risk from cyber-attacks.

6.4Conclusion

We performed thorough analysis of sustainability of our working prototype and concluded that this device would have very positive impacts on the society and environment in the long run.

Chapter 7

Engineering Project Management

7.1Introduction

Project planning is the process of completing a project by following the right stages at the right time. It is the most crucial criterion for achieving the objective and obtaining the desired results. The keystone of the project life cycle, project planning outlines your destination and method of transportation for all parties involved

We have also created a project plan for our endeavor, which included timelines and member responsibilities, and we gave it our all to complete each assignment and even for our future works, we plan on doing so.

Using many Gantt charts,Log-book, and time lines we divided our work over a year-long (three-semester) time frame.

7.2Define, plan and manage engineering project

Project Plan			
EEE400P			
Task	Start Date	End Date	Duration (Days)
Research	10/02/2022	17/02/2022	7 Days
Topic selection	17/02/22	25/02/22	8 days
Problem identification	26/02/22	28/02/22	2 days
Topic Review and Finalization	1/03/222	7/03/22	7 days
Concept Note Preparation	7/03/22	25/03/22	18 days
Project Proposal Report	26/03/22	23/04/22	27 days
EEE400D			
Simulation Using Software (proteus , thinkspeak)	2/05/22	22/5/22	21 days
Simulation using python and image processing	23/5/22	20/6/22	27 days
Processing of data	20/6/22	08/7/22	18 days
Documentation	15/7/22	15/8/22	30 days
Project Design Report final adjustments	15/8/22	30/8/22	15 days
EEE400C			
Data collection	20/10/22	30/10/22	10 days
Matching the simulation with Outcome	5/11/22	30/11/22	25 days
Project Final Report Presentation	1/12/22	20/12/22	20 days

7.3Evaluate project progress.

BREAKDOWN OF THE WORKFLOW WITH ASSIGNED GROUP MEMBER

EEE400P														
Task name	Responsibility	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Topic Selection	All													
Background Research	Mashiat													
Literature Review and Gap	Mashiat, Aanika, Lazib,Soubir													
Specification, requirements, constraints	Lazib, Aanika													
Progress presentation preparation	All													
Concept Note	All													
Multiple Design Approach	Lazib Mashiat													
Equipment Selection	Lazib Soubir,Mashiat													
Budget Planning	Lazib													
Impact Analysis	Lazib													
Sustainability	Soubir													

Applicable Standard Codes	Soubir													
Risk Management	Aanika, Mashiat													
Preparing for Presentation part 1	Mashiat, Aanika													
Preparing presentation part 2	Lazib, Soubir													
Project proposal Report	All													

EEE400D														
Task name	Responsibility	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Simulation of the Multiple Design Approaches I	Lazib													
Simulation of the Multiple Design Approaches II	Mashiat, Aanika													
Optimal Solution Analysis	Lazib, Aanika													
Machine Learning Algorithm Development	Mashiat Lazib													
Documentation	Lazib, Aanika, Mashiat													
Preparing Draft Report	Lazib, Aanika, Mashiat													
Preparing for Design Presentation	Mashiat													
Project Design Report	Aanika, Lazib													

EEE400C														
Task name	Responsibility	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Ml training	Mashiat													
Testing and Evaluation	Lazib, Aanika													
Adjustment	Soubir													
Data Collection and sampling	Lazib													
Data Analysis	Lazib													
Result Analysis	Mashiat, Aanika													
Documentation	Mashiat, Aanika													
Preparing Draft Report	Lazib, Aanika, Mashiat													
Preparing for Project Presentation	Lazib, Aanika, Mashiat													
Project Final Report	Lazib, Aanika, Mashiat													

7.4Conclusion

The project timeline is formed, the project deliverables and requirements are defined, and the project plans are documented during the planning phase. We have entailed in developing a set of

plans to lead our team through the project's implementation and closure phases. We were able to manage time, cost, quality, modifications, risk, and associated problems thanks to the plans made during this phase. They will also assist help us in maintaining future projects so that the project is completed on time, on plan, and within budget.
Throughout the whole year ,we have divided our project work among all the members and fitted it into a timeline. For 400P and 400D we were able to maintain the adequate time line correctly.Since we were able to finish the prototype in 400C a few days ahead of schedule, we made the decision to change the design and include more accurate sensors. Thus, the assigned timelines assist all of the participants in monitoring our work and completing the project without difficulty or haphazard issues.

Chapter 8

Economical Analysis

8.1Introduction

The proposed remote water quality monitoring system's main stakeholders are regulatory bodies of any water body: lakes, ponds, canals, rivers, etc. The system has to be economically feasible for purchase and operation by these regulatory bodies.

8.2Economic analysis

The current water-quality monitoring methods employed by the regulatory bodies relies on manpower for sampling and testing. This method is not cost-effective as employees need to be hired. Thus the remote water quality monitoring system will reduce costs for regulatory bodies if employed.

8.3Cost benefit analysis

Table-14 Cost Benefit Analysis

Cost Type	**Item**	**Specification**	**Unit Price (BDT) [1]**	**Units**	**Cost (BDT)**	**Cost (USD)**
Cost To Assemble One Unit	pH Sensor	Analog pH sensor	3400	1	3400	32.88
	Turbidity Sensor	Turbidity Value Detection Module Kit	1400	1	1400	13.54
	Temperature Sensor	DSB1820	600	1	270	2.61
	Power Bank	Joyroom JR-T012 10000mAh Dual USB Power Bank Joyroom JR-T012 10000mAh Dual USB Power Bank	1100	1	1100	10.64

	Control Unit	ESP-32	720	1	740	7.16
	Other Electronics	Wires, Veroboard	200	-	200	1.93
	Buoy	Pipes,Build Materials	775	-	775	7.49
Total Cost of One Unit					**7885**	**76.24**

Cost Type	Item	Specification	Unit Price (BDT)	Units	Cost(BDT)	Cost (USD)
Service and Maintainence Cost To Run Unit Per Month	Power Bank	Charging Power Bank	25		25	0.24
	Data Service	Internet Connectivity*	150		150	1.45
	Repairs	Sensor replacement, wires rerouting cost on average	150		150	1.45
	Cloud	ThingSpeak commercial license**	2000		800	19.33
Total Cost for Service and Maintainence For One Unit					**1125**	**10.88**

* The data requirement for this project is low as only numerical data is being sent.
** Standard ThingSpeak license (commercial), 1 channel, every 5 min data update. Calculated using ThingSpeak pricing calculator. [19]

Cost Analysis:
https://docs.google.com/spreadsheets/d/1k0onf3h5f4Gy4wZkWOwNIqJIp0Q4JYxB0kq1ey6XuA4/edit?usp=sharing

8.4 Evaluate economic and financial aspects

Under the assumption that the system had been developed by a B2G service. The revenue stream comes from two ways:

- Selling Product (system)
- Selling Service

Selling Product:
The cost to assemble one unit of the system as seen previously is 7885 BDT. By applying a 15% profit margin for the B2G service, the product can be sold for 9067.75 BDT.

Selling Service:
The cost to operate one unit of the system for one month is 1125 BDT. By applying a 15% profit margin for the B2G service, the service can be sold for a monthly subscription of 1293.75 BDT.

8.5 Conclusion

The system developed is an IoT-based one, Hence, for the true potential of the system to be realized, in terms of cost, Bangladesh must become an IoT-enabled society. Despite Bangladesh's weak data connectivity, high data prices, and expensive imported IoT-enabled control modules, the total cost of the system to run it for a month is 9010 BDT.[20]
This is quite reasonable under the circumstances, and if Bangladesh is in the future becomes IoT enabled then economies of scale will apply and the cost will reduce further.

Chapter 9

Ethics and Professional Responsibilities

9.1Introduction

To establish any project ethical responsibility should be top tier to take into consideration.A set of rules that guide our study designs and procedures are known as ethical considerations. Voluntary involvement, mutual consent, anonymity, secrecy, risk of damage, and results communication are some of these guiding concepts.
We need to take into account safeguarding research participants' rights, improving the validity of research, and keep our academic or scientific credibility authentic.

9.2Identify ethical issues and professional responsibility

While carrying out the implementation processes BANGLADESH WATER ACT LAW[21] should be taken into consideration for assuring the ethical views of the country.

Bangladesh Water Act 2013 (BWA) is stated below.

- **'Bangladesh Water Act 2013 (BWA)** is a framework Law to integrate and coordinate the water resources management in the country. The Water Act will establish a new, integrated approach to the protection, improvement, and sustainable use of countries' rivers, lakes, estuaries, coastal waters, and groundwater.'
- Permission from the local authority in Uttara (sector-5,7,13) called 'KOLLYAN SHOMITY' for the monitoring system and sample collection in water bodies is needed.

- Permission from people who are using the water body for daily necessities and living near it should be taken.

Consideration regarding if the system will produce an alarming amount of pollution in the surrounding area or not. For example-noise or air pollution,
The system might create disturbance to the people living near the water bodies or to aquatic life.

9.3Apply ethical issues and professional responsibility.

Buoy-Based Model

- For the buoy-based model to be continuously floating in the water body, permission is needed from local authorities. Because the stationed unknown item would be there for a long time, it should not bother or invade the privacy of anyone who lives nearby.
- People nearby should be aware of the system before implementing it because it might concern or scare them. Consent from the people living nearby and informing them beforehand might make it easier for them.
- level of noise pollution of any sort should be taken into consideration as it will be moving on the surface and the level of noise should be suppressed to a level that doesn't cause any disturbance to the people living nearby.
- Also, air pollution needs to be controlled to a minimum range. If, any toxic gas is being released should be taken into consideration.
- Cautions regarding aquatic life in the water should be taken into consideration in the system when it is on the surface.
- A floating device in any area needs extra permission from local authorities and people living nearby for privacy purposes. We need to make people aware beforehand.
- This model should be handled and moved in a precocious manner so that no one gets hurt or scared.
- Cleaner power sources should be used so that zero air pollution takes place and non-renewable energy sources should be replaced by renewable ones such as solar panels.
- The system should be attached to a bright sign so that swimmers or any other object floating should be made cautious of its presence.
- It is important to make the buoy visible to boats so that neither the buoy nor their possessions are harmed.
- Marine life in the water should be carefully considered to ensure that their existence is not destroyed or disturbed in any manner..

9.4 Conclusion

Any project's most important component is delegating tasks to team members and cooperating with them to produce good outcomes. However, we had to remember to adhere to ethical principles while working. There were no unethical actions, such as fabricating data and failing to properly cite the study that we used. This was done with great care to ensure the genuineness of our work.

Chapter 10

Conclusion and Future Work

10.1 Project summary/Conclusion

We started the project in an attempt to help prevent the deterioating condition of our waterbodies.
We initially had three approaches for this purpose- buoy, USV and UAV. After careful consideration and analysing all the limitations and requirements, we opted for a buoy based IOT monitoring design.After days of work, we finally built a prototype that can access three water parameters (temperature, turbidity and pH) after coming in contact with the water. The working prototype is able to real time monitor the water bodies and assess the water health parameters and give a WQI value. Based on the WQI value, it shall return a usage for the water based on that region.

10.2 Future work

We plan to collect the data for a long period of time to prepare datasets for maching learning algorithms to be run on. In that way, data visualization will be better and we can also infer valuable information such as the condition of pollution in the long run, detecting major pollution points in the water, detect floods in the future. We also intend of replacing the batteries with solar panels to make the device greener and environmental friendly. Finally, more sensors can be added to the device such as camera, TDS sensor to make WQI values more prominent and also we can create image datasets for future research.

Chapter 11

Identification of Complex Engineering Problems and Activities

11.1: Identify the attribute of complex engineering problem (EP)

Attributes of Complex Engineering Problems (EP)

	Attributes	Put tick (√) as appropriate
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	√
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	√
P6	Extent of stakeholder involvement and needs	
P7	Interdependence	

Note: Project must have P1, and some or all from P2-P7

11.2: Provide reasoning how the project address selected attribute (EP)

We had to understand the basics of IOT, calibrate the sensors and write codes to make the device work properly so that required more detailed knowledge of electronics and analysis although we were quite familiar with breadboard circuit construction.Initually, we had used arduino uno and esp-01 for data transmission. This had some conflicting implications as sensors were more accurately calibrated with arduino but transmission was very poor using esp-01. So, we replaced both arduino uno and esp-01 with esp-32 nodemcu which later on solved the problem. So, our data acquisition subsystem and data transmission susbsytem were working fine. We have kept standard codes for the application and references for our analysis of results.

11.3 Identify the attribute of complex engineering activities (EA)

Attributes of Complex Engineering Activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	
A4	Consequences for society and the environment	√
A5	Familiarity	√

Note: Project must have some or all of the characteristics from attributes A1 to A5

11.4 Provide reasoning how the project address selected attribute (EA)

All the sensors used in the project are quite available in the market and the device is quite easy to use as well.The device will not only help monitor our water bodies and provide usage for them , it will also be quite a method to alert and teach the society about certain boundaries to help maintain the sanity of waterbodies.

References

[1] Md. Galad Uddin,S.Nash and A.I.Olbert, “A review of water quality index models and their use for assessing surface water quality,” *Ecological Indicators*, vol.122, 2021, doi: https://doi.org/10.1016/j.ecolind.2020.107218.

[2] Dr.Eugene, “Calculation of Water Quality Index,” *YouTube*, Date video uploaded: 16/7/2022, Available: Calculation of Water Quality Index. [Accessed: 27/7/2022]

[3] Bangladesh Department of Public Health Engineering, http://www.dphe.gov.bd/, (accessed March.1, 2022.)

[4] Md. A. Hossain,M.G. Morshed and F.Rafiq, “ Assessment of Water Quality Scenario of Karnaphuli River in Terms of Water Quality Index, South-Eastern Bangladesh,” *JAWRA Journal of the American Water Resources Association*, vol.7, 2019, doi: 10.12691/ajwr-7-3-3

[5] Deb, S., & Kalamdhad, A. S. (2016). Use of Algae as a Bio-indicator to Determine Water Quality (A Case Study). *South Asian Journal of Experimental Biology*, *5*(6), 235–243. https://doi.org/10.38150/sajeb.5(6).p235-243

[6] S. Barinova and K. Mamanazarova, “Diatom Algae-Indicators of Water Quality in the Lower Zarafshan River, Uzbekistan,” *Water*, vol. 13, no. 3, p. 358, Jan. 2021, doi: 10.3390/w13030358.

[7] D.Gökçe,*Intechopen.com*,2016

[8] C. W. Park, J. J. Jeon, Y. H. Moon and I. K. Eom, "Single Image Based Algal Bloom Detection Using Water Body Extraction and Probabilistic Algae Indices," in *IEEE Access*, vol. 7, pp. 84468-84478, 2019, doi: 10.1109/ACCESS.2019.2924660.

[9] N. Hassan, *Water Quality - Science, Assessments and Policy*. IntechOpen, 2020. doi: 10.5772/intechopen.77531.

[10] M. Kumar Jha, R. Kumari Sah, M. S. Rashmitha, R. Sinha, B. Sujatha and K. V. Suma, "Smart Water Monitoring System for Real-Time Water Quality and Usage Monitoring," *2018 International Conference on Inventive Research in Computing Applications (ICIRCA)*, 2018, pp. 617-621, doi: 10.1109/ICIRCA.2018.8597179.

[11] N. Vijayakumar and R. Ramya, "The real time monitoring of water quality in IoT environment," 2015 *International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015]*, 2015, pp. 1-4, doi: 10.1109/ICCPCT.2015.7159459.

[12] S. Geetha and S. Gouthami, “Internet of things enabled real time water quality monitoring system,” *Smart Water*, vol. 2, no. 1, Dec. 2016, doi: 10.1186/s40713-017-0005-y.

[13]AssignmentPoint“RiskMatrix”,https://www.assignmentpoint.com/business/management/risk-matrix.html. (accessed April 23, 2022)

[14][1]“Bluetooth (SO-06-004),” *Enterprise Policies, Standards, and Guidelines*. https://gta-psg.georgia.gov/psg/bluetooth-so-06-004 (accessed Dec. 24, 2022).

[15][1]M. Shoemake, “Texas Instruments White Paper Wi-Fi (IEEE 802.11b) and Bluetooth Coexistence Issues and Solutions for the 2.4 GHz ISM Band,” 2001. Accessed: Dec. 24, 2022. [Online]. Available: https://www.ti.com/lit/wp/sply010/sply010.pdf?ts=1671903556309&ref_url=https%253A%252F%252Fwww.google.com%252F

[16][1]“ST 352:2013 - SMPTE Standard - Payload Identification Codes for Serial Digital Interfaces,” *ST 352:2013*, pp. 1–28, Feb. 2013, doi: 10.5594/SMPTE.ST352.2013.

[17][1]O. Wang, “IEEE Addresses Standards for the Cloud,” *IEEE Standards Association*, Apr. 18, 2011. https://standards.ieee.org/beyond-standards/ieee-addresses-standards-for-the-cloud/ (accessed Dec. 24, 2022).
[18]“The Different Methods of Monitoring Water Quality,” *AZoCleantech.com*, Mar. 10, 2022. https://www.azocleantech.com/article.aspx?ArticleID=1475
[19]https://edu.rsc.org/soundbite/coca-cola/2021233.article#:~:text=How%20acidic%20is%20Coke%3F,little%20contribution%20to%20the%20acidity.
[20]http://stemsdl22.eduhk.hk/wp-content/uploads/2022/03/TurbidityTestOfDrinksManuel.pdf
[21] https://thingspeak.com/prices/thingspeak_standard

Appendix

Log-Book:For 400P

Date/Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
28/2/2022 https://meet.google.com/jfm-vacw-wsm	All members	>Discussion about project ideas and problem statements.		
2/3/2022	All Members	>Discussion about project ideas and problem statements.		
3/3/2022 **5:00PM** **https://meet.google.com/arx-jcui-fcu**	Lazib Soubir Aanika Rafi Sir	>1st meeting with Tentative Project Ideas and Problem Statements		>Comments about the project ideas. >Sir helped us narrow down the 14 project ideas to three
4/3/2022 https://meet.google.com/tud-rjbd-bmw	All members	>Topic Finalization >Work Division	**Mashiat-** >Problem-Statement >Background research >Scope **Lazib-** >Design >Specs, >Requirements **Aanika-**	

			> Constraints **Soubir-** >Standards and Codes, >Conclusion Everyone- >Slide Preparation	
9/3/2022 7:00PM https://meet.google.com/qbx-qfef-ysi	Aanika Mashiat Lazib Mohaimen Sir	>Discussion about Presentation, Requirements, Specifications, and Design Approach		>Mohaimen Sir gave helpful feedback about presentation
24/3/2022 Offline Meeting	All Members Rafi Sir and Tasfin Sir	>Concept Note Discussion	**Lazib** - >Requirements, >System-Level Specs >Component Level Specs, > Design-1 and Design-2 **Soubir**- >Standards and Codes >Component Level Specs for USV/ RC Boat **Aanika and Mashiat** >Problem Statement >Objective, >Design-3, Specs >Constraints	> Fix Title > Reference > Keep Cost in mind >Advice about Specs >Advice Standards and Codes

26/3/2022 Offline	All members Rafi Sir	>Draft-Concept Note Checking	**Lazib** >Requirements Version-1 **Aanika and Mashiat** >Requirements Version-2 **Mashiat** > Problem Statement >Conclusion >Methodology >Project plan >more on design 3 **Soubir** >Standard and Codes **Everyone** > Revision	
26/3/2022 Offline	All members Mohaimen Sir	>Requirements + Specification		> Suggested one way of writing Requirements and Specifications
26/3/2022 Offline	Lazib Rakib Sir	>Discussion about potential Cloud Service to be used		>ThingSpeak seems to be a good choice for our project
27/3/2022 Offline	Lazib Tasfin Sir	>Concept Note Updates		
4/4/2022 Offline	Lazib Mashiat Aanika Rafi Sir Tasfin Sir	>Final Draft of Concept Note Checking	**Lazib and Aanika** > Requirements Modification >Add one point to constraint **Mashiat** > Problem Statement Modification	>Choose a tentative location and adjust problem statement and requirements accordingly
4/4/2022 Offline	Lazib Mashiat	>Asked about helped resources from which Data set regarding water treatment can be procured from		https://archive.ics.uci.edu/ml/index.php

	Aanika Tanzim Reza Sir (CSE Faculty)			https://www.kaggle.com/datasets https://datasetsearch.research.google.com/ (3 sites from which Data Set can be researched from)
4/4/2022 Offliine	All memebrs	>Work Division of Proposal Report	**Mashiat** >Project Plan >Methodology **Lazib** >Budget >Impact **Soubir** >Sustainability >Codes **Aanika** >Ethical >Risk >Safety	
7/4/2022 (Offline)	Tasfin Sir, Aanika, Mashiat			>Advice on Ethical consideration,risk and safety > Advice on Methodology and project plan
11/4/2022 (Offline)	Tasfin Sir Aanika			>comments on Ethical consideration,risk and safety
15/4/2022 (Online)	Lazib Soubir	>Impact and Sustainibility Discussion		
22/4/2022 (Online) meet.google.com/ugt-yspd-sxr	Mashiat Aanika Lazib	>Discussion about ATC Mock Presentation > Methodology and Impact Discussion > Ethics Discussion	**Aanika** >technical papers >Risk Matrix Color Code **Mashiat**	

			>technical paper >methoodolgy edit >UAV component selection **Lazib** >help mashiat with knn algo >technical papers > log book **Soubir** > technical papers	
23/4/2022 (Offline)	Tasfin Sir Lazib	> Checking Impact Matrix >Checking Comparison table for Design Approaches > Update on Proposal Report		> Checked impact matrix > Suggested not to propose best design
23/4/2022 (Online) cqr-uxfj-ysb	Tasfin Sir Mashiat	> ESP-32,GPRS,GSM issue		>comments on methodology and project plan and third design.
23/4/2022 (Online) cqr-uxfj-ysb	Tasfin Sir Aanika Lazib Mashiat			>comments on Full proposal report
24/4/2022 (Online) https://meet.google.com/ryq-uhmf-fot	Mashiat Lazib	>Flowchart Discussion > Back Groun Reearch and Lit Gap		
24/4/2022	All members	>Finishing Touches Before ATC Mock Presentation	Everyone > Slide Preparation > Report formatting	
24/4/2022 (Online) https://meet.google.com/rbf-kvcn-fwi	Rafi Sir Tasfin Sir All members	>ATC Mock Presentation		> Provide apt references > Make Slide shorter.
27/4/2022	All members	>Finishing Touches		

		>Practice Viva		
27/04/2022	Mashiat, Lazib, Aanika	> Final edits and submission		

Log-Book:For 400D

Date/Time /Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
20/6/22 1PM-2PM Offline	All of us Tasfin Sir	- Discussion about ML part of the project	-Lazib, soubir will look for data sets - Lazib, soubir will look for wqi issues	
27/6/22 1PM-2PM Offline	All of us Tasfin Sir	- Discussion about progress presentation COs	- Lazib main ckt of Design 1 and 2 - Aanika UAV - Mashiat-3D models -Aanika Mashiat Slides -Soubir WQI values	
28/6/22	-Aanika - Mashiat - Lazib	- Worked on slides for progress presentation		
29/6/22	-Aanika - Mashiat - Lazib	- Worked on slides for progress presentation		
2/7/22 SFTF Closing Ceremony	-Lazib - Rakib Sir	- Informed sir about SFTF-22		-Told to communicate with ATC
4/7/22 1PM-2PM Offline	- Lazib - Tasfin Sir	- Informed sir about SFTF-22 -Serial communication ways	- Investigate Virtual comm emulator, esp-01, python serial communication	- Told we will be given extension on deadline for 400D submission

4/7/22 1PM-2PM Offline	-Lazib - Mashiat - Aanika - Tasfin Sir	- Updated Sir on progress presentation -USV and UAV issue - Reached decision on wqi issue	- Lazib will work on simulation of Design-1 and 2 - Mashiat will work on Design-3 - Aanika will work on 3D models	- for now work on usv and uav
17/7/22 1PM-2PM Offline	-Lazib -Aanika -Mashiat	- Gave Update on Data Sets vs WQI values High quality data set not found so WQI values to be used . - showed wqi paper		
18/7/22 12PM-12:30PM Offline	-Lazib - Tasfin Sir	- Gave Update on Data Sets vs WQI values High quality data set not found so WQI values to be used . - showed wqi paper		Title needs to be fixed
18/7/22 1PM-2PM Offline	-Lazib - Aanika -Mashiat -Tasfin Sir	-Requested Briefing on 400D COs - Specific issue with CO5 and CO6 organization	-Aanika will copy pertinent material from 400P to 400D and 3D model - Lazib and Mashiat will continue working on Simulation	
18/7/22 https://meet.google.com/wgk-ssde-cvk Online	-Lazib - Aanika -Mashiat -Tasfin Sir	- Received Briefing on 400D COs		
1/8/22	-Lazib -Tasfin Sir	-Showed sir the simulation of sensors and control module	- Will investigate serial communication procedures	
1/8/22	-Aanika - Mashiat	-Showed sir the image processing -Discussed about conference		

	- Tasfin Sir			
3/8/22	-Lazib - Tasfin Sir	-Showed sir the successful serial communication between proteus and thingspeak - 400D Functional verification and Modern IT tools , misc' report writing progress shown		- Told to wrap up simulation and work on presentation and a 1st draft of 400D report
4/8/22	Aanika, Mashiat	About 3D and 3rd approach		
5/8/22 https://meet.google.com/wny-vpwy-bvz	-Lazib -Aanika -Mahiat	- Discussion about USV/UAV issue - workflow		
12/8/22	Aanika, Mashiat	Discussion about BG research and selection of IT tools		
19/8/22	Aanika, Mashiat	Project Plan		
25/8/22	Aanika, Mashiat	3rd design functional verification		
28/8/22	Aanika, Mashiat	Slides, Report		
30/8/22	-Lazib -Aanika -Mahiat	- Slides and Presentation Preperation	Slide Prep- Aanika Slide Content- Lazib, Aanika, Mashiat	
9/9/2022	-Lazib -Aanika -Mahiat	- 400D remaining report division	**Lazib:** BG Research,Constraints, Block Diagram-1 and 2, Modern IT tools, Functional Verification, Selection of Optimal Approach, Budget, Engineering Attributes,Logbook, Referencing,Formatting	Submit ASAP

			Mashiat: BG research, Block Diagram-3, Modern IT tools, Functional Verification, Referencing, Projec t Plan **Aanika:** Specs, Requirements, Block Diagram-1, Budget, Impacts, Ethics, Risk, Summary	

Log-Book:For 400C

Date	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
25/10/12 Offline	Lazib, Aanika, Mashiat	Market research about sensors and other equipments	Mashiat will purchase the sensors	
30/ 10/22 offline	Lazib, Aanika, Mashiat	Assemble the circuit on the breadboard	all	
12/11/22 offline	Lazib, Aanika, Mashiat	Trial and error with circuit connection	all	
15/11/22 offline	Lazib, Aanika, Mashiat	Assembling the code	Lazib	
20/11/22 offline	Lazib, Aanika, Mashiat	Functioning the circuit by connecting to thingspeak Day-01	Lazib, Aanika	

25/11/22 offline	Lazib, Aanika, Mashiat	Functioning the circuit by connecting to thingspeak Day-02	Mashiat, Aanika	
27/11/2022 offline	Lazib,Aanika, Mashiat	Replacing arduino uno and esp-01 with nodemcu	Mashiat, Aanika	
30/11/2022 offline	Lazib, Mashiat, Aanika	Functioning the circuit by connecting to thingspeak	All	
5/12/2022 offline	Lazib,Aanika, Mashiat	Purchasing the buoy body	Mashiat	
7/12/2022 offline	Lazib,Aanika, Mashiat	Assembling the buoy body	Aanika, Mashiat	
8/12/2022 offline	Lazib,Aanika, Mashiat	Waterbody real testing And taking videos	lazib	
13/12/2022 offline	Lazib,Aanika, Mashiat	Preparing slides for the presentation	All	
16/12/2022 offline	Lazib,Aanika, Mashiat	Report Writing	All	
20/12/2022 offline	Lazib,Aanika, Mashiat	Report Writing	All	

Related code/theory

```
// WIFI
#include <WiFi.h>
#include "ThingSpeak.h"
const char* ssid = "Ez";   // your network SSID (name)
```

```
const char* password = "lazibsharar";   // your network password
WiFiClient  client;
unsigned long myChannelNumber = 1916007;
const char * myWriteAPIKey = "OTF2TVVOXSK6HX32";

// Timer variables
unsigned long lastTime = 0;
unsigned long timerDelay = 5000;

//POTPIN TURBIDITY
//POTPIN1 PH

//TURBIDITY
const int potPin=34;
int buf[10],temp;
unsigned long int avgValue;

//PH
const int potPin1=35;


//Temperature
#include <OneWire.h>
#include <DallasTemperature.h>
#define ONE_WIRE_BUS 32
OneWire oneWire(ONE_WIRE_BUS) ;
DallasTemperature sensors(&oneWire);
float Celsius =0;

void setup() {
  // put your setup code here, to run once:

  WiFi.mode(WIFI_STA);
  ThingSpeak.begin(client);
  Serial.begin(115200);
  pinMode(potPin,INPUT);
  pinMode(potPin1,INPUT);
  delay(1000);

}

void loop() {
  // put your main code here, to run repeatedly:

 if ((millis() - lastTime) > timerDelay) {
```

```
 //turbidity
for(int i=0;i<10;i++)       //Get 10 sample value from the sensor for smooth the value
  {
    buf[i]=analogRead(potPin);
    delay(10);
  }
  for(int i=0;i<9;i++)        //sort the analog from small to large
  {
    for(int j=i+1;j<10;j++)
    {
      if(buf[i]>buf[j])
      {
        temp=buf[i];
        buf[i]=buf[j];
        buf[j]=temp;
      }
    }
  }
  avgValue=0;
  for(int i=2;i<8;i++)                      //take the average value of 6 center sample
    avgValue+=buf[i];
  float voltage=(float)avgValue*3.3/4095.0/6;
  delay(3000);
  float turb= 286.67*pow(voltage,2)-1629.4*voltage+2308.065;
  Serial.println (turb);
  delay(2000);


 // ph
  float voltage1=analogRead(potPin1);
  float volt= voltage1*(3.3/4095.0);
  Serial.println ("Sensor Output (V):");
  Serial.println(volt);
  float ph=-(57*volt)+84.38;
  Serial.println (abs(ph));
  delay(3000);


 // temp
  sensors.requestTemperatures();
  Celsius =sensors.getTempCByIndex(0);
  Serial.print(Celsius);
  Serial.print(" C ");

  //WQI
  float Qph= abs(((ph-7)/1.5)*100);
```

```
float Q_turb= abs((turb/5)*100);
float Q_temp=abs((Celsius/30)*100);
float Wph= (float)60/179;
float Wturb=(float)102/179;
float Wtemp=(float)17/179;
float temp11= Wph*Qph;
float temp21= Wturb*Q_turb;
float temp31=Wtemp*Q_temp;

float temp41= temp11+temp21+temp31;


 // Connect or reconnect to WiFi
    if(WiFi.status() != WL_CONNECTED){
      Serial.print("Attempting to connect");
      while(WiFi.status() != WL_CONNECTED){
        WiFi.begin(ssid, password);
        delay(5000);
      }
      Serial.println("\nConnected.");
    }
    int x1 = ThingSpeak.writeField(myChannelNumber, 1,Celsius, myWriteAPIKey);
    delay(10);
    int x2 = ThingSpeak.writeField(myChannelNumber, 2,turb, myWriteAPIKey);
    delay(10);
    int x3 = ThingSpeak.writeField(myChannelNumber, 3,ph, myWriteAPIKey);
    delay(10);
     int x4 = ThingSpeak.writeField(myChannelNumber, 4,temp41, myWriteAPIKey);
    delay(10);

    if(x1 == 200 && x2 == 200 && x3==200 && x4==200){
      Serial.println("Channel update successful.");
      lastTime = millis();
    }
    else{
      if(x1!=200){
      Serial.println("Problem updating channel x1. HTTP error code "+String(x1));
      }
      if(x2!=200){
      Serial.println("Problem updating channel x2. HTTP error code "+String(x2));
      }
      if(x3!=200){
      Serial.println("Problem updating channel x3. HTTP error code "+String(x3));
      }
      if(x4!=200){
      Serial.println("Problem updating channel x3. HTTP error code "+String(x4));
```

```
        }
      }

    }
}
```