# REMOTE MONITORING AND DETECTION OF WATER CONTAMINATION IN EFFLUENT TREATMENT PLANTS

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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

Electrical and Electronic Engineering
Brac University
December 2023

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Electrical and Electronic Engineering
Brac University
December 2023

## 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.

**Student's Full Name & Signature:**

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# Approval

The Final Year Design Project (FYDP) titled "Remote Monitoring and Detection of Water Contamination in Effluent Treatment Plants" submitted by

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of Fall, 2023 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on 14th December 2023.

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# Ethics Statement

This final year design project contains 13% plagiarism, maintaining the similarity index below 35%.

## Abstract/ Executive Summary

Considering the numerous applications of water and its scarcity. Purification and reuse of such a precious natural element is crucial for humankind. Effluent Treatment Plants are already being used for that purpose but the monitoring system for the water quality in such ETP is not keeping up with the times. However, this project suggests a new method of collecting and on-board testing of different parameters for water found in those containers with real-time remote data monitoring. This will all be done using an unmanned aerial vehicle (UAV) which increases the mobility and efficiency of the overall project.



**Keywords:** Unmanned aerial vehicle; Effluent Treatment Plants; remote data monitoring.

## Acknowledgement

We would like to express our service gratitude to our ATC panel members and our friend Sowmitra Kumar Shacha for their time and continuous contributions. The overwhelming support from the Department of EEE, Brac University made it possible to present this in front of such a big audience. With help from Md Mosfiqur Rahman from BWDB Kushtia we were able to secure the permit for testing.

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# Chapter 1: Introduction- [CO1, CO2, CO10]

## 1.1 Introduction

Water is one of the most essential resources required for all organisms to survive. It is impossible for the environment to survive without water. This uncomplicated component known as "water" is essential to everything, beginning with the most fundamental forms of agriculture and progressing all the way up to industries that produce commodities at costs that are unthinkable. In recent years, people have gone to great lengths to cause harm to this naturally occurring component. For instance, looking at nations other than Bangladesh, where water is extremely freely available, it is clear that some of the other countries, such as China, are not particularly lucky in this regard [1]. There is one thing that cannot be afforded under any circumstances, and that is the waste or contamination of water. The use of such polluted water, for instance, might result in serious health complications such as cholera, diarrhea, typhoid fever, and a great deal of other diseases [2].

### 1.1.1 Problem Statement

Before incorporating any sort of water body into someone's daily life a person must first determine whether or not the water in a body of water is suitable for human consumption. If the contamination is not very severe, then the water can be used after undergoing some level of processing. This is the case in some instances. The effluent discharge from industrial facilities is typically directed through effluent treatment plants (ETPs), which are facilities that treat wastewater in order to remove pollutants and toxins before the wastewater is either discharged into the environment or reused in another manner [3]. This is done to ensure that no toxic chemicals are released into the environment; nevertheless, the release of these chemicals is unavoidable in some way or another. Perhaps the workers in the sector failed to notice anything, or perhaps it was a genuine mistake brought on by machinery that was not functioning properly. Regardless of the circumstances, there are bodies of water in the surrounding area that are contaminated, which causes problems for virtually everyone [2].

### 1.1.2 Background Study

Much research has been done on the collection of water using different unmanned vehicles and some on this topic, there are a few ways of collecting the water sample; some went for an approach that used an autonomous surface vehicle (ASV) which monitored the water quality while in motion, achieving the desired outcome [4]. Some even went as far as giving the ASV additional ability for cleaning the water surface [5], mostly solid wastes. Similarly autonomous underwater vehicles (AUV) were also used for pollution monitoring, sonar mapping, etc [6]. Though the underwater medium gives a better understanding of the contamination status at different depths at the same time, it increases complications in measuring surrounding aerial parameters related to or caused by the contaminated water. Another variant of the same concept was presented which was very efficient at monitoring water contamination levels and informing the users about it using IoT technology [7].

However, most of the research revolved around an airborne device that takes a water sample to determine its contamination levels [8]. It is simply because using unmanned aerial vehicles (UAV) grants mobility and the ability to gather more samples in a short period [9]. Measuring and monitoring different contamination parameters like pH, DOC, turbidity, nitrate, and many more [10]. This has evolved to a point where other parameters like surrounding air quality are also measured while providing a point of view from the UAV [11].

On the other hand, branches of the same concept were used in other projects, once it was integrated into agriculture, in this case, the UAV monitored water quality for crops [10]. In other cases, UAVs were also used to monitor and characterize the odor emission caused by water contamination [12]. It is very common for the surrounding air of a contaminated water body to have odor but what the paper focused on is the different causes of this emission and how they contributed to the overall odor of the wastewater treatment plan which is the same for any surrounding containing contaminated water.

### 1.1.3 Literature Gap

The common problem with most of the previous projects is their focus on just collecting the water sample and bringing it back to the user [13]. Most of the research revolves around the collection of water rather than texting it. The ones that do include onboard water testing fail to collect surrounding aerial parameters which are directly related to water contamination. On the other hand, the ones that collect surrounding aerial parameters do not include onboard water testing. Similarly, the ones that excel at monitoring water contamination levels lack mobility.

The effluent treatment plants (ETPs) can update their pollutants and contaminants detection systems with the integration of portable devices capable of onboard testing while also monitoring surrounding aerial parameters, a device that will instantly take a water sample and determine its contamination level. This will speed up the preexisting identification and mitigation process of water-based pollution. Through this integration industries containing ETP will be able to make effective decisions regarding their water quality and what changes should be made, all those decisions will be backed up by reliable and consistent information gathered by the devices.

### 1.1.4 Relevance to current and future Industry

There are a variety of methods that are currently utilized by industries for the purpose of analyzing water parameters; however, the bulk of these methods involve the collection of samples and the subsequent evaluation of those samples using separate kits, which adds additional human work to the process. However, a water sampler that is based on unmanned aerial vehicles (UAVs) minimizes the amount of labor and time required while simultaneously obtaining data in real time, which results in an overall improvement in efficiency. In this day and age of cutting-edge technology, when everything is mechanized, there is a possibility that this tedious process could be improved upon.

## 1.2 Objectives, Requirements, Specification and constant

### 1.2.1. Objectives

- Identify levels of water contamination.
- Monitor changes in water quality and provide real- time data.
- Increase efficiency of water quality monitoring.
- Provide actionable insights.
- Alerting users of potential risks.

### 1.2.2 Functional and Nonfunctional Requirements

Functional Requirements:

- Collecting water samples.
- Curating data for different predetermined parameters (Example: pH, temperature concentrations etc.).
- Sending data to the live server.
- Sending live footage to the ground station.
- Commenting on the data using machine learning.
- Ability to maintain stability with external load.
- At least 30 minutes of battery life for every journey.
- A round range of about 4 km radius.
- Maintaining 30 meters altitude while flying.

Non-functional Requirements:

- Resisting the effects of bad weather.
- Able to overwrite the command of the system.
- Cleaning the sensor probes during readings.
- Waterproofing of the electrical components.
- Backup power source.
- Measure atmospheric data.
- Assuring human/animal safety during the journey.
- Safety of equipment.

### 1.2.3 Specifications

- Size of the UAV (Height: 9”; Length: 8”; Width: 2.5”; Hand: 8”)
- Can store up to 50 ml of sample water.
- Measure temperature, ph, tds, turbidity data of sample water on board.
- Communication with the UAV within a 7–10-kilometer radius.
- Can perform remote sensing for multiple water sources in a short time.

| Subsystem | Components | Specification | Quantity |
|---|---|---|---|
| Electronics Subsystem | Pixhawk 2.4.8 | • Voltage Supplied: 7V.<br>• Core Processor: Cortex M4<br>• Communication interface (UART, 12C, SPI, CAN).<br>• Firmware: Flight Control.<br>• Sensors: Gyro, Magnetometer Barometer & Accelerometer.<br>• Small Chip to record data. | 1 |
| | GPS Module | • Data update rate 10Hz.<br>• Ceramic patch antenna 22x22x3mm<br>• Low noise regulator 3.3V<br>• Rechargeable Backup 3V | 1 |
| | Servo motor | • mg996R 10kg payload | 1 |
| | Brushless DC Motor | • 830kv 12V | 4 |
| | Esp8266 ESP-01 Wi-Fi | • Direct Wi-Fi (P2P, Auto Connection)<br>• Small Memory (1MB for Flash) | 1 |
| | Electronic Speed Controller | • Current Rating - 50 amp | 4 |
| | Microcontroller -Arduino Mega Rev3 | • Operational Voltage - (5-7) V<br>• Recommended Input Voltage - 7-12V.<br>• Voltage (limited) - 6-15V<br>• Input-output pins- 54<br>• Input pins (Analog) - 16<br>• Direct current in pins – 20 mA<br>• Memory for Flash -256 KB (8KB for bootloader)<br>• RAM(S) - 8 KB<br>• ROM(EP) - 4 KB<br>• Speed of Clock -16 MHz | 1 |
| | Power distribution board. | • 200-amp Rating | 1 |

| | | | | |
|---|---|---|---|---|
| Power Management Subsystem | | Lipo battery | • Capacity: 5500mAh<br>• Voltage: 12.8 V (4 S)<br>• Maximum Discharge: 25C (Continuous)<br>• Maximum Discharge: 50C (Burst)<br>• Balance Charging Plug: JSTL-XH<br>• Discharging Plug: XT-60 | 1 |
| Communication Subsystem | | Radio Controller | • Range of Frequency: 2.40-2.48 GHz<br>• Channel Numbers: 08<br>• Power Transmission: 20dBm.<br>• sensitivity of Receiver: -105dBm<br>• Modes: automatic cutting-Edge technology<br>• Encoding Method: FSK<br>• Size of Antenna: 25 mm * 2 (dual antenna)<br>• Operating Voltage :10-12 V<br>• Charging Rate: 1-3C(Input) | 1 |
| | | Circular Polarized Mushroom Antenna | • Frequency: 5225-5950MHz<br>• Gain: 6.0dBi ± 1dBi | 1 pair. |
| | Notification Subsystem | 3DR Telemetry | • Small size<br>• Weight: Under 4-5 Gm.<br>• 920MHz/435 MHz<br>• sensitivity of Receiver to -122 dBm<br>• Power Transmitted up to 500mW.<br>• Serial link of communication is transparent.<br>• Wireless data rates up to 260kbps | 1 pair |
| | | TS351 5.8G AV Transmitter: (For Long Range Vision) | • 4.8 G Technology 5646MHz~5946MHz<br>• Microphone audio device.<br>• 8 Channels<br>• Dual output of AV<br>• Power Input:12V | 1 |

| | | | | |
|---|---|---|---|---|
| | | RC305 5.8G AV Receiver:(For Long Range Vision) | • Frequency Receiving: 5725-5866MHz; 8 channels.<br>• Sensitivity of Receiving: -90dBm<br>• Control of Frequency: built-in System<br>• System of Double lines AV output: analog AV output<br>• Communication port connector: SMA<br>• Power Input: 6.5-15V | 1 |
| Vision Subsystem | | Eachine 1000TVL | • Lens: 2.8mm IR coated<br>• Resolution: Ultra High Definition 1000TVL<br>• Sensor: 1/3 "CCD | 1 |
| Mechanical Subsystem | | Quadcopter Frame | • Material: Glass Fiber + Polyamide Nylon<br>• Frame Weight: 620gm (including landing gear) | |

Table.1. Specification of components from different subsystems.

### 1.2.4 Technical and Non-technical consideration and constraint in design process

- Difficulty flying in heavy winds, when there with a strong wind it will be challenging to control the vehicle.
- Lithium Polymer (LiPo) batteries, are widely available also in Bangladesh, cannot provide voltage for more than 15-35 minutes. However, using a larger power battery will raise the load of the UAV.
- Even though a wireless kill switch has been used for safe operation, an accident can occur if any connection to the ground station is lost.
- We may encounter privacy concerns when flying the UAV in a private area as we are using different camera angles, which could be interrupting in some cases.
- Some people living in rural areas may be frightened to see such an object in the sky in their area, which could lead to chaos.

### 1.2.5 Applicable compliance, standards, and codes

- **IEEE SA - IEEE 1118.1-1990:** The protocol has been designed with control devices, instrumentation, distributed data acquisition systems, and test and measurement in mind. There are specifications for a common architecture, generic bus services, system management, data links, and various physical media.

- **IEEE SA - IEEE 2413-2019:** Describes the Internet of Things (IOT) architectural framework, followed by the international standards ISO/IEC/IEEE 42010:2011. Many IOT domain descriptions, definitions of IOT domain abstractions, and commonalities between different IOT domains are discussed here [14]. This standard discusses the use of IOT in various projects.
- **IEEE SA - IEEE 1937.1-2020:** This standard covers UAV external power interface specifications. The basic interface and performance characteristics of UAV payload devices are given. The UAV payload has three groups of mechanical, electrical, and digital interfaces. A mechanical interface secures UAV cargo. An electrical interface connects electrical terminations electromechanically. Power supply and two-way communication interfaces comprise the electrical interface. Communications protocol is called data interface. UAV payload interface standards and performance parameters guard against temperature extremes, water, humidity, vibration/shock, dust, mold, spray, salt etc.
- **IEEE SA - IEEE 1936.1-2021:** This standard establishes a framework for UAV application support. It contains flight platform, the flight control system, the ground control station, the payload, the control connection and data link, the takeoff and landing system, and so on. It also has specifications for data reference format, data collection and processing, data classification and data recording and analysis.
- **IEEE SA - IEEE 1939.1-2021:** This standard explains effective UAV traffic control for low-altitude airspace organization. From five parts, it explains the structural low altitude based on UAV low-altitude public air routes: remote sensing data, grid technology, route planning, communication and networking, management, and operation.

### 1.3 Systematic Overview/summary of the proposed project

To summarize, water has been tested using a variety of techniques; however, the project that is being proposed is a combination of a few distinct methodologies. The device that will be used for this project will be mobile, will have the ability to conduct tests on board, and will monitor data in real time. The measurements that are to be taken include a variety of parameters, including pH, temperature, turbidity, and total dissolved solids (TDS). As a result, not only does this assist in the healing and regeneration of the environment, but it also assists the user or corporation in successfully purifying and reusing water without any complications, so preventing any accidents that are typically brought on by the utilization of unclean water.

### 1.4 Conclusion

In conclusion, this proposes a solution that reduces the amount of time and work required by humans while also giving data in real time. In essence, this project calls for a more effective and technologically sophisticated strategy to monitor water quality. In spite of the fact that there may be obstacles to overcome, the solution that has been offered has the potential to revolutionize the laborious process of water quality analysis in this modern era of cutting-edge technology.

# Chapter 2: Project Design Approach [CO5, CO6]

## 2.1 Introduction

The process of collecting, storing and testing water has been approached from a variety of different angles throughout this competition. This project makes use of approaches that are either variants or updated versions of one or more approaches that already exist. The primary concept behind this project is that it will collect water with the purpose of testing its parameters on board and providing feedback to the user. This can be accomplished in three distinct ways: the first method makes use of an unmanned aerial vehicle (UAV), which provides mobility. The second method makes use of an autonomous underwater vehicle (AUV), which also provides mobility; however, it is restricted to a particular ETP tank, which requires some form of human intervention to achieve maximum efficiency. Lastly, the third and last approach, which is the fixed box approach, has no mobility, this approach only fulfills the basic requirement of this project.

## 2.2 Identify multiple design approach

### 2.2.1 Design approach 1: Unmanned Aerial Vehicle (UAV) based water sampler.

Unmanned Aerial Vehicles are fixed-wing aircraft that can fly using thrust. The device will be equipped with a pump which picks up water samples and using the sensors inside it will perform an onboard testing providing the detailed result to the user.

**System level block diagram:**

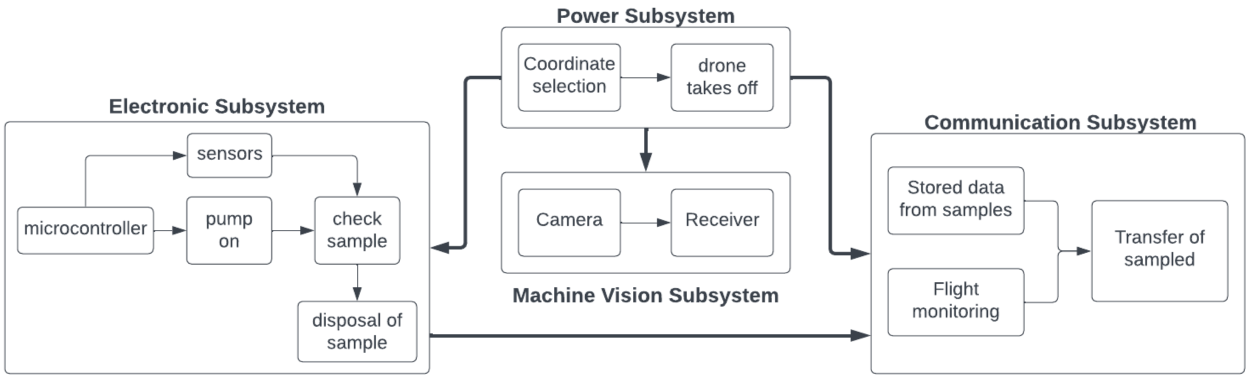


Fig.1. System level block diagram for unmanned aerial vehicle (UAV) based water sampler.

### 2.2.2 Design approach 2: Autonomous underwater vehicle (AUV) based water sampler.

An underwater vehicle will be put in the water. It will be controlled either autonomously or through remote. The sensors will be fixed inside the chamber of the vehicle. It will be powered through renewable power sources. Thin Film Solar panel will be used to make the outer shape along with the charging circuit. A chamber will be installed with it to put a limited number of chemicals to control various parameters of water. Along with this it will make another way for underwater survey.

**System level block diagram:**

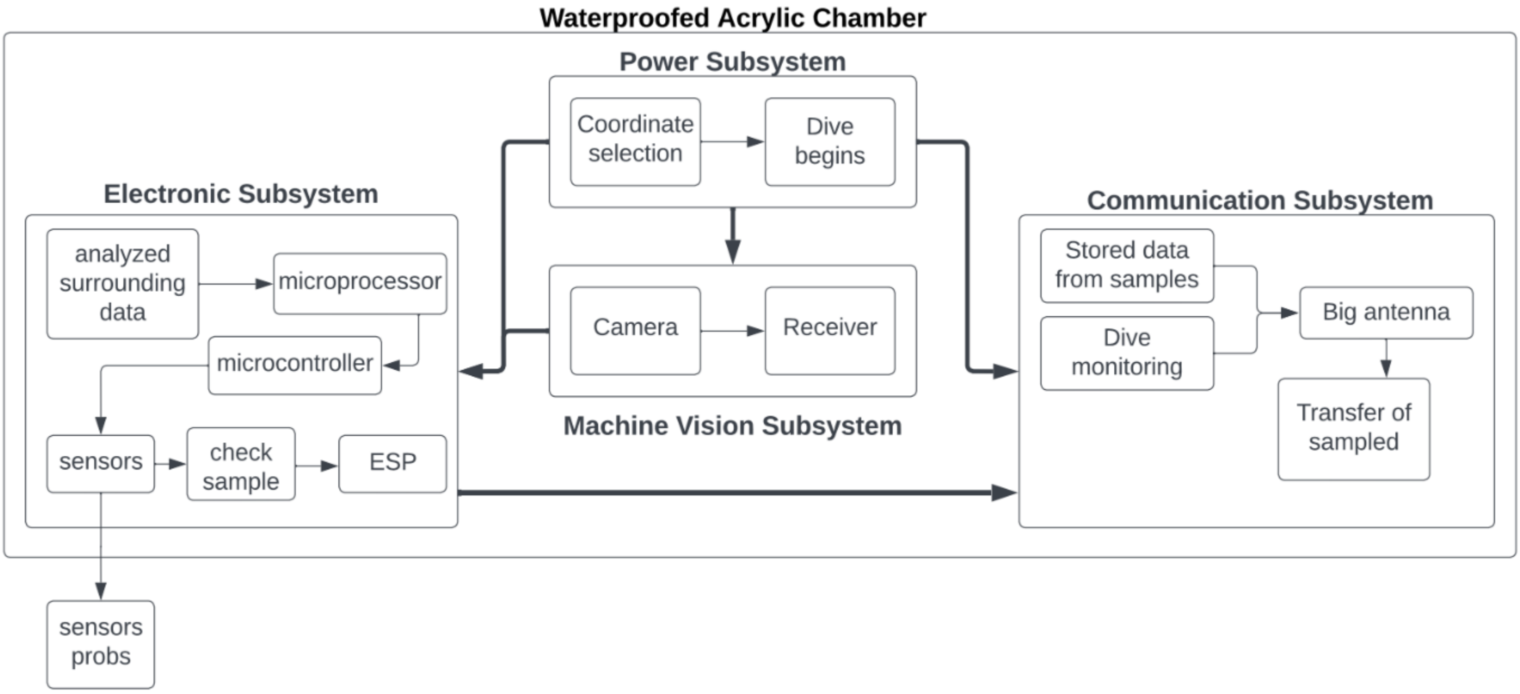


Fig.2. System level block diagram for autonomous underwater vehicle (AUV) based water sampler.

### 2.2.3 Design approach 3: Fixed block water sampler.

A box will be designed which will contain the integrated circuit. This box will be provided with enough power to check the parameters and send the data to the server.

**System level block diagram:**

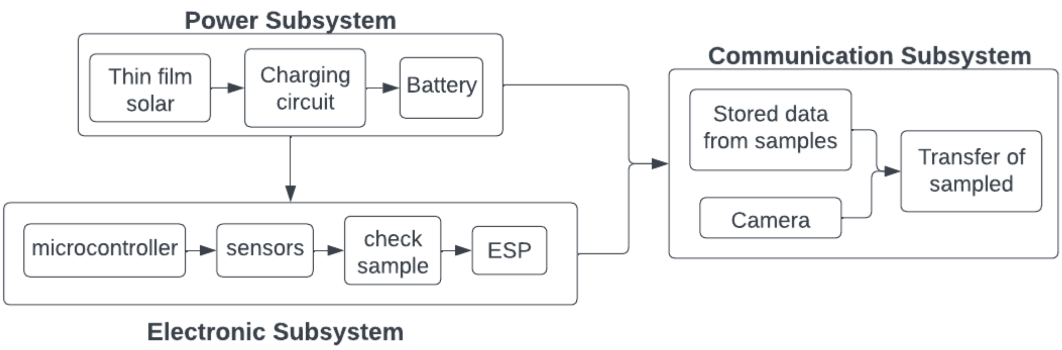


Fig.3. System level block diagram for fixed block water sampler.

### 2.3 Describe multiple design approach

#### 2.3.1 Design approach 1: Unmanned Aerial Vehicle (UAV) based water sampler.

An Unmanned Aerial Vehicle (UAV) will be a fixed-wing aircraft that is capable of flying using wings that generate lift according to the aircraft's front wind speed. The motor located at the front of the UAV will assist it in moving forward. A microcontroller will be used to run a pump that will collect water on board. The water will then be uploaded to the server after the parameters related to the pump have been checked. The water will then be stored by the unmanned aerial vehicle (UAV) for further laboratory examinations, or the servo motor will assist in disposing of the water if it is necessary to check more. A battery, a motor, a motor driver, a propeller, a receiver, a claw, a camera, a microcontroller, and other components are some of the items that can be used in the construction process.

**Component level flowchart:**

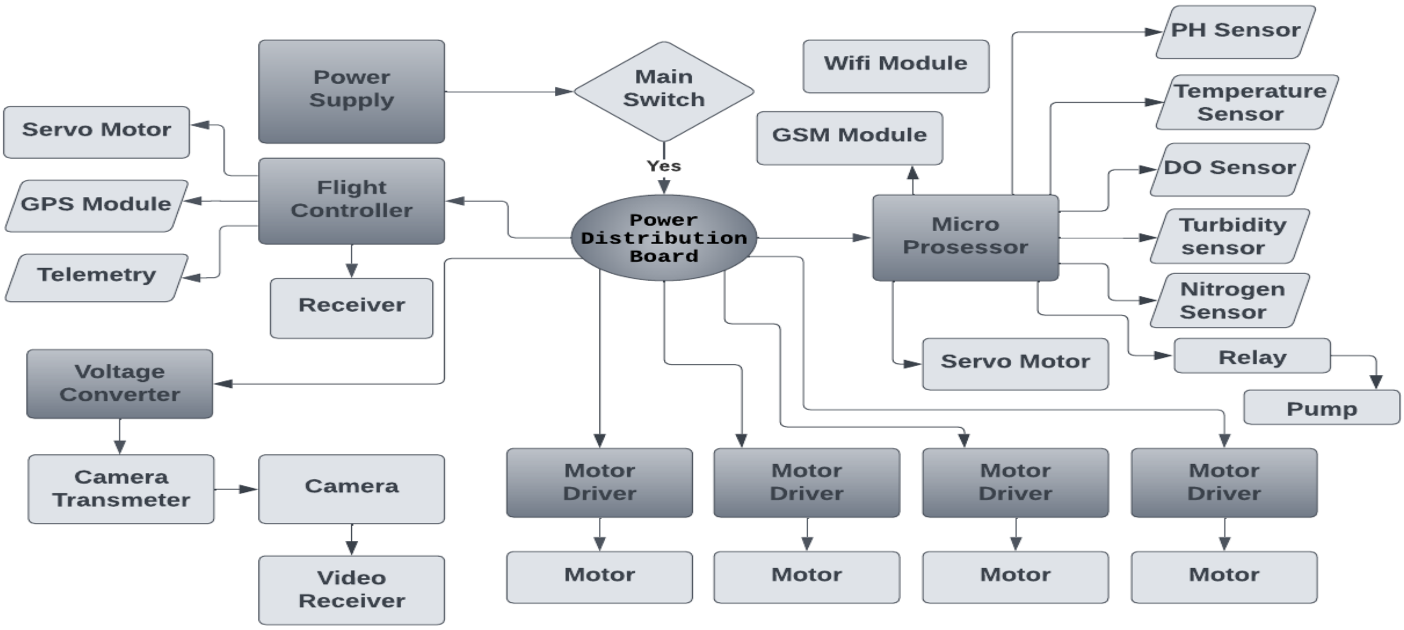


Fig.4. Component level flowchart for unmanned aerial vehicle (UAV) based water sampler.

#### 2.3.2 Design approach 2: Autonomous underwater vehicle (AUV) based water sampler.

The water will be filled by a vehicle that can operate underwater. Depending on the situation, it will either be controlled by itself or by a remote. The sensors are going to be installed all the way inside the chamber of the vehicle. Energy that comes from renewable sources will be used to propel it. Film with a thin layer In addition to the charging circuit, the solar panel will be utilized in the construction of the exterior portion. It will be accompanied by the installation of a chamber that will contain a restricted number of chemicals for the purpose of controlling various water parameters. In addition to this, it will create an additional method for conducting underwater surveys.

**Component level flowchart:**

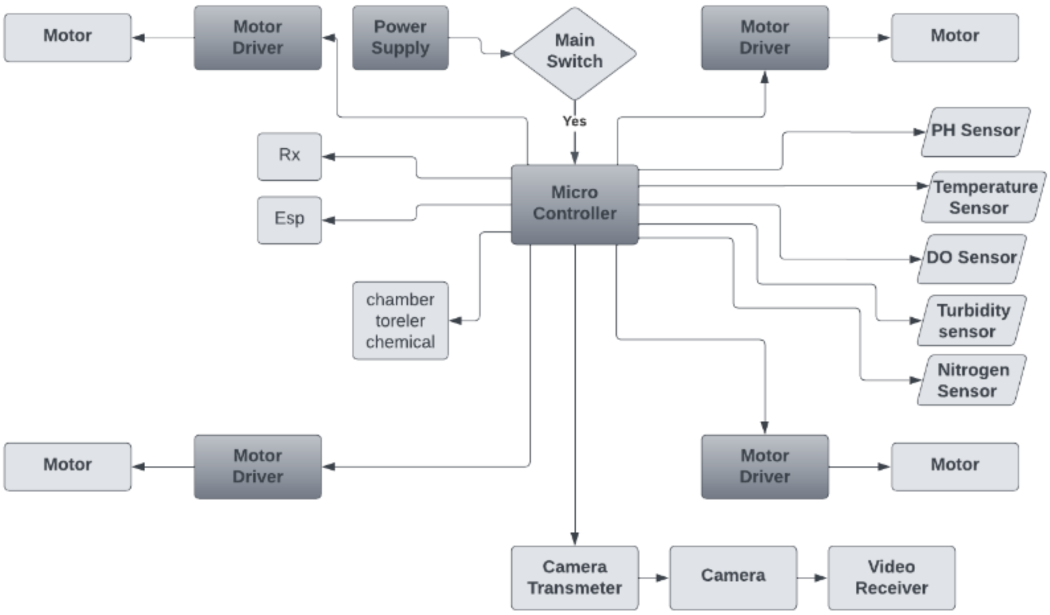


Fig.5. Component level flowchart for autonomous underwater vehicle (AUV) based water sampler.

### 2.3.3 Design approach 3: Fixed block water sampler.

The integrated circuit will be housed inside of a box that will be designed. A sufficient amount of electricity will be supplied to this box so that it can check the settings and communicate in real time to the server providing full access.

**Component level flowchart:**

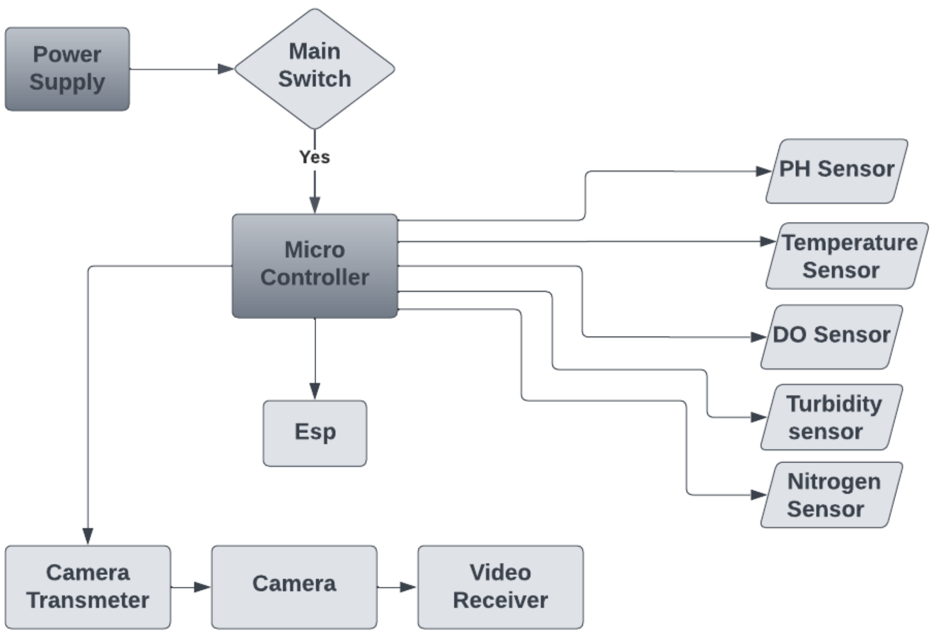


Fig.6. Component level flowchart for fixed block water sampler.

### 2.4 Analysis of multiple design approach

#### Mobility and Navigation

- Design Approach 1: Moderate difficulty - UAVs require precise navigation in three dimensions, obstacle avoidance, and the ability to hover and pick up samples.
- Design Approach 2: High difficulty - AUVs need to navigate underwater environments, avoid obstacles, and swim with precision while maintaining strong communication with the ground station.
- Design Approach 3: Low difficulty - Fixed blocks do not require mobility and navigation.

#### Onboard Testing

- Design Approach 1: Moderate difficulty - Miniaturizing testing equipment and ensuring reliable results in a UAV's limited space can be technically challenging.
- Design Approach 2: Moderate difficulty - Dedicated equipment's are required to carry out onboard testing inside the small space of an AUV.
- Design Approach 3: Low difficulty – Due to the simplicity of the design, installation of both sensors and power sources can be done without any hassle.

#### Energy Source

- Design Approach 1: Moderate difficulty - UAVs need efficient power sources that can simultaneously support flight while continuing sampling and onboard testing.
- Design Approach 2: High difficulty - AUVs require a steady energy source which is capable for underwater operations while continuing sampling and onboard testing.
- Design Approach 3: Low difficulty - Fixed blocks can draw power from the ETP as it is stationary, with the help of wires it can easily take the required amount.

#### Data Transmission

- Design Approach 1: Moderate difficulty – Continuous communication is required for stable transmitting between the UAV and the ground station. It is also required for real-time monitoring of the parameters.
- Design Approach 2: High difficulty – The major problem here is the communication between AUV and the ground station. To solve this an underwater communication links are required, which is very challenging on its own.
- Design Approach 3: Low difficulty – As there is no interference in-between data can be simply transferred from the fixed to the control room.

#### Maintenance and Repairs

- Design Approach 1: Moderate difficulty – As the UAV will be deployed in harsh environments, daily maintenance and repairs are crucial for its survival.

- Design Approach 2: High difficulty – The AUV will be covered with a layer of epoxy which will come in the way of maintenance and repair, this layer will have to be replaced for every maintenance or repair that is done.
- Design Approach 3: Low difficulty - Fixed blocks can go for long period of time without any maintenance or repairs.

### 2.5 Conclusion

This chapter goes in detail about the specific requirements and conflicts about the three different methods of water testing and sampling. It touches upon different aspects like mobility, energy sources, data transmission, onboard testing, maintenance and repair to analyze the pros and cons among the three design approaches.

While the Fixed block water sampler requires the least amount of maintenance and repair with no external energy source, its lacks in mobility forcing it to be stationary always providing data for a specific location. Though autonomous underwater vehicle-based sampler has a higher mobility range, it struggles with data transmission, maintenance and repair. On the other hand, unmanned aerial vehicle-based water sampler excels in data transmission, mobility and energy source but the maintenance and repair of this method can be quite costly due to its constant exposure to harsh environments.

# Chapter 3: Use of Modern Engineering and IT Tool. [CO9]

## 3.1 Introduction

At various stages of this project like designing, calibration, simulation test runs and many more were possible with the help of various engineering and IT tools. Without them it would have been very difficult to validate the different design approaches. They were also responsible for the visualization of the approaches and how they might function in a real life environment providing insights that would come in handy later during the project.

Devices like UAV's require calibration so that it can understand its whereabouts so does the GPS on the UAV, these calibration processes were facilitated with the assistance of engineering and IT tools. Additionally, a significant aspect of the project involved the collection and transmission of data from different sensors. This complicated task was achieved through the programming of a microcontroller to perform specific functions required for data processing and transfer.

## 3.2 Select appropriate engineering and IT tools

**EasyEDA** is a web-based electronic design automation software tool that is primarily used for designing and prototyping electronic circuits. It's aimed at both beginners and experienced engineers, offering a user-friendly interface combined with powerful design capabilities. The software offers a wide range of built-in libraries for components and symbols. Projects are stored in the cloud, eliminating the need to worry about local backups. Users can access and work on their projects from any device with an internet connection.

Software requirements: Internet connection is required. Browsers that support "EasyEDA" ex, Microsoft Edge, Google Chrome, Mozilla Firefox.

**Blender** is a powerful and versatile open-source 3D computer graphics software used for creating a wide range of visual content, including animations, visual effects, 3D models, games, and more. It's known for its robust feature set and active community, making it a popular choice among artists, designers, animators, and even scientists. Blender is available for Windows, macOS, and Linux, ensuring accessibility for users on different operating systems. Blender has a real-time rendering engine called Eevee, which allows users to see how changes affect the final image or animation in real time, speeding up the creative process.

Software requirements: Windows, macOS, Linux operating system is required. Blender does not have a specific computer requirement as a result it can be used in any capable device. However, high hardware with high specification is advised as it can reduce the rendering time significantly.

**Proteus** is used mainly to simulate almost any electronic circuit in order to test the system. With its wide library of various components like sensors, microcontrollers, semiconductors, transistors and many more, this software has made a name for itself worldwide. Providing users an easy and updated way of testing the capabilities of their circuits before moving on to the hardware phase while pointing out any mistakes or errors made during designing.

Software requirements: Windows 7, 8 or 10 with 32-bit or 64-bit operating system is required. The software itself takes up about 2GB of space. However, downloading extra library items or creating files of multiple projects will take up more space.

**Arduino IDE (Integrated Development Environment)** is a software that is used to program Arduino microcontrollers, it serves as a middleman where users write, compile and debug their code and create a hex file (data stored in a hexadecimal format) with is later uploaded to the said microcontroller. Due to the interface being very simple and easy to navigate with its prewritten example code, anyone with the basic knowledge of coding can use and benefit from this software.

Software requirements: Windows 7, 8 or 10 with 32-bit or 64-bit operating system is required with a minimum RAM of 2GB but then again, more RAM is always appreciated.

**ArduPilot Simulator** is used mainly to simulate unmanned aerial vehicles in different environmental conditions with custom built obstacles providing an easy and safe way to test its capabilities without causing any harm to any physical object. The alternative of this is trial and error method where a prototype must be built and tested generally causing it to destroy and then rebuild it until it is stable enough to carry out its duties. This way not only wastes resources but also wastes a lot of time. However, the software provides a much easier and more effective solution to this problem.

Software requirements: Internet connection is required. MacOS, Linux or Windows operating system is required where the computer device must have a multi-core processer with a dedicated graphics card with a minimum RAM of 4GB but then again, more RAM is always appreciated. The latest version of the Ardupilot software is crucial as it ensures the specific firmware provides maximum possible real-life similarity.

**Qgroundcontrol** is a software that is used to calibrate different sensors and components within unmanned aerial vehicles (UAV). This software is also responsible for the firmware update and the selection of different flight modes made available to the UAV. It can also display the current data regarding the UAV's position, velocity, and battery life. Overall, the software provides a very easy to use interface.

Software requirements: MacOS, Linux or Windows 7, 8 or 10 with 32-bit or 64-bit operating system is required whereas the computer device must have a multi-core processer with a minimum RAM of 4GB but then again, more RAM is always appreciated.

### 3.3 Use of modern engineering and IT tools

**EasyEDA** was used to design the schematic diagram for the design approaches. It really helped to put things into perspective before anything physical was ever envisioned. Moreover, using this software a basic map of the wiring for the design approaches was established which proved to be extremely useful later in the project. Below in figure 7 and 8 the schematic diagram for design approach 1 and 2 respectively can be seen created using EasyEDA.

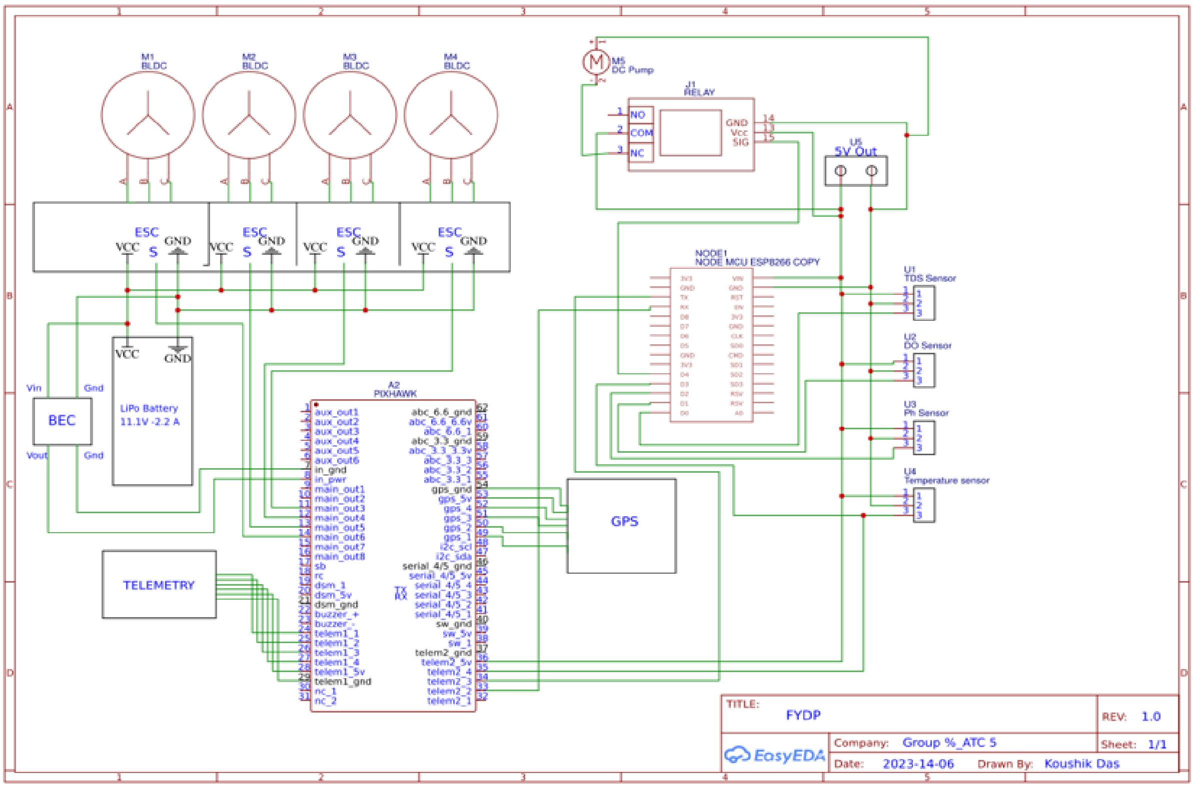

Fig.7. Schematic diagram for design approach 1.

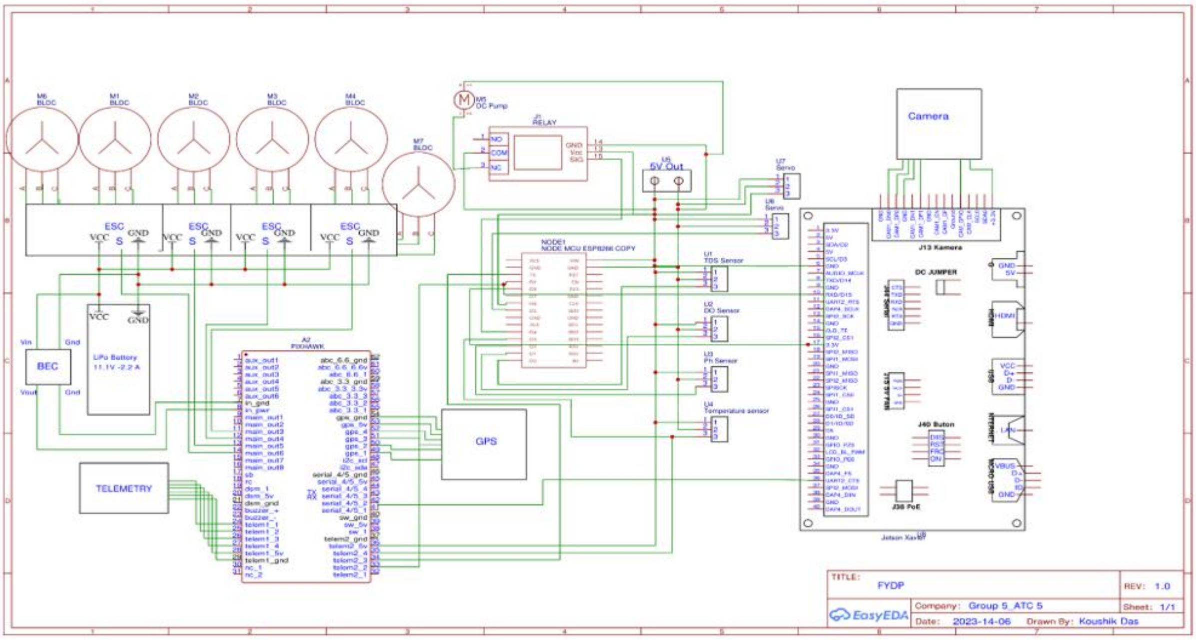

Fig.8. Schematic diagram for design approach 2.

Figure 7 contains the complete circuit design, where a Pixhawk is used to control the 4 propellers which are powered by the lipo battery, telemetry is used to establish communication with the ground station and GPS is used to track the location of the UAV. ESP8266 is connected in series with the rest of the circuit where it is used to control the DC pump for water extraction, afterwards the collected water sample is tested using the different sensors, this data is then stored and transferred to ground station.

Figure 8 contains the complete circuit design, where a Pixhawk is used to control the 6 propellers which are powered by the lipo battery, GPS is used to track the location of the rover. ESP8266 is connected in series with the rest of the circuit where it is used to control the servo motors for chemical release. It also controls the DC pump for water extraction, afterwards the collected water sample is tested using the different sensors, this data is then stored and transferred to ground station. Due to complications in communication the Jetson Xavier microprocessor is connected to the rest of the circuit which will make onboard decisions for the rover.

**PCB Design** was also done using easyEDA. Firstly, the components were placed then their necessary connections were made with proper annotations while maintaining the planned layout. Finally, the auto-route option was used to complete the design of the PCB as shown in figure 9.

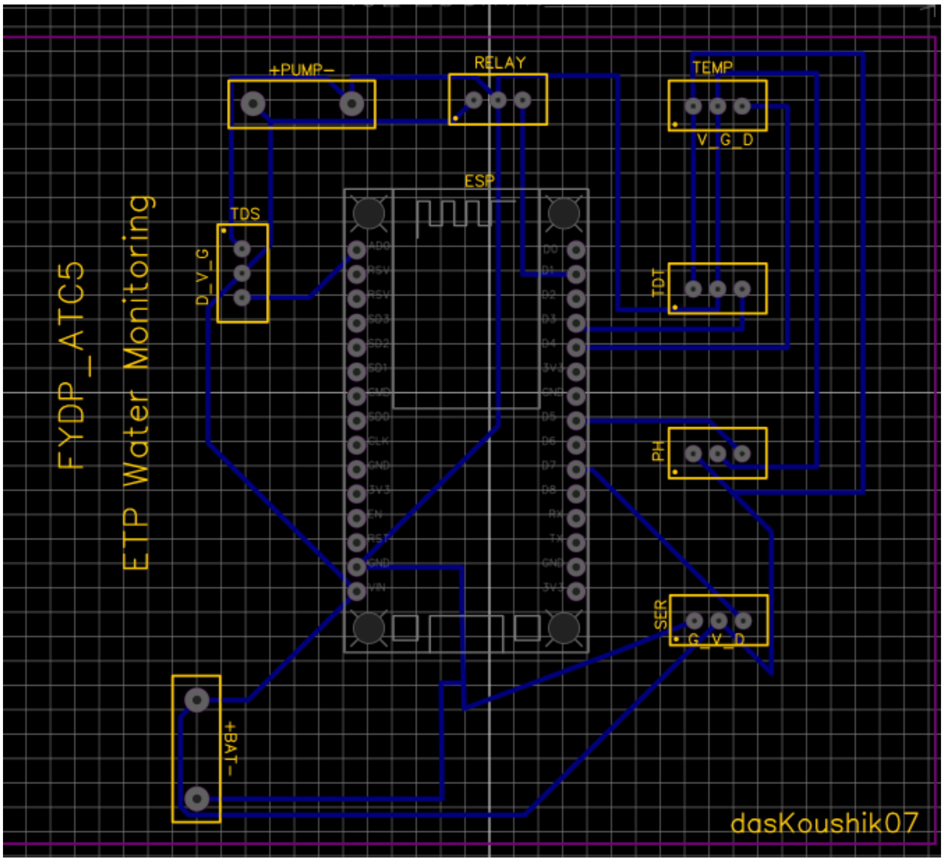


Fig.9. PCB design for this project.

**Blender** was used to visualize the multiple design approaches, a 3D look for how things might turn out after the project is completed. Below in figure 10, 11 and 12 the 3D simulation of design approach 1, 2 and 3 respectively can be seen created using blender.

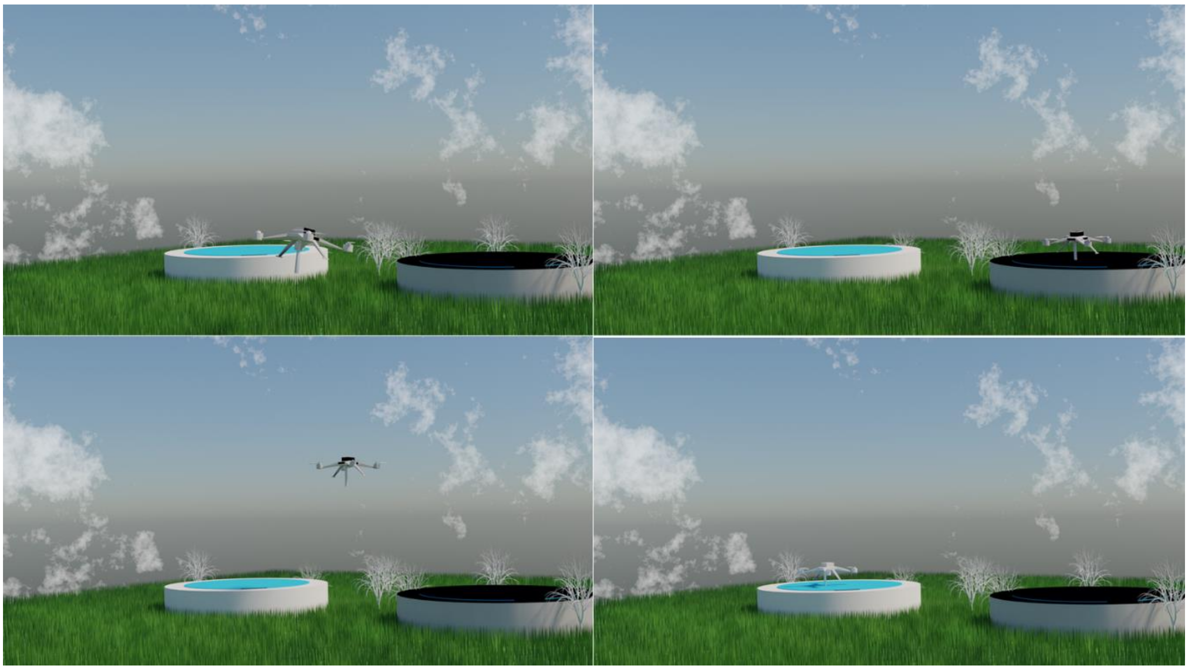

Fig.10. 3D simulation of design approach 1.

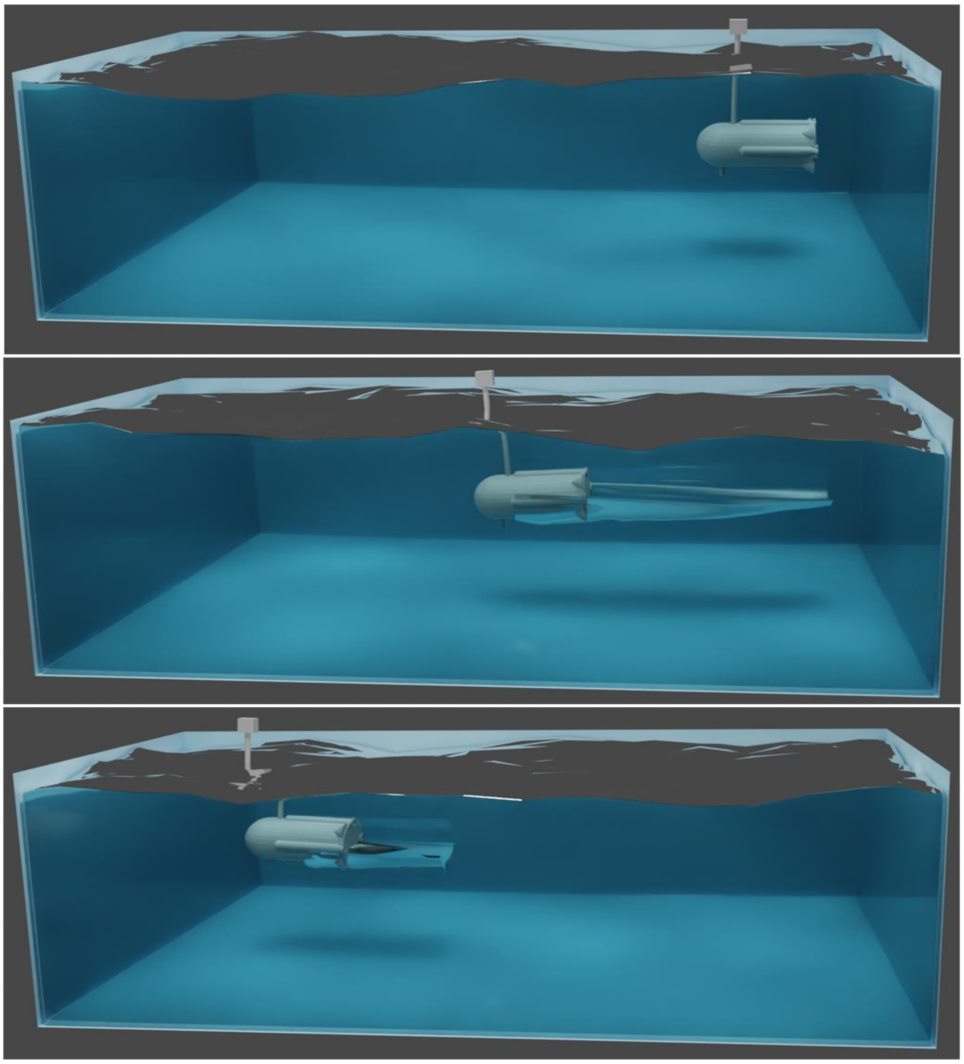

Fig.11. 3D simulation of design approach 2.

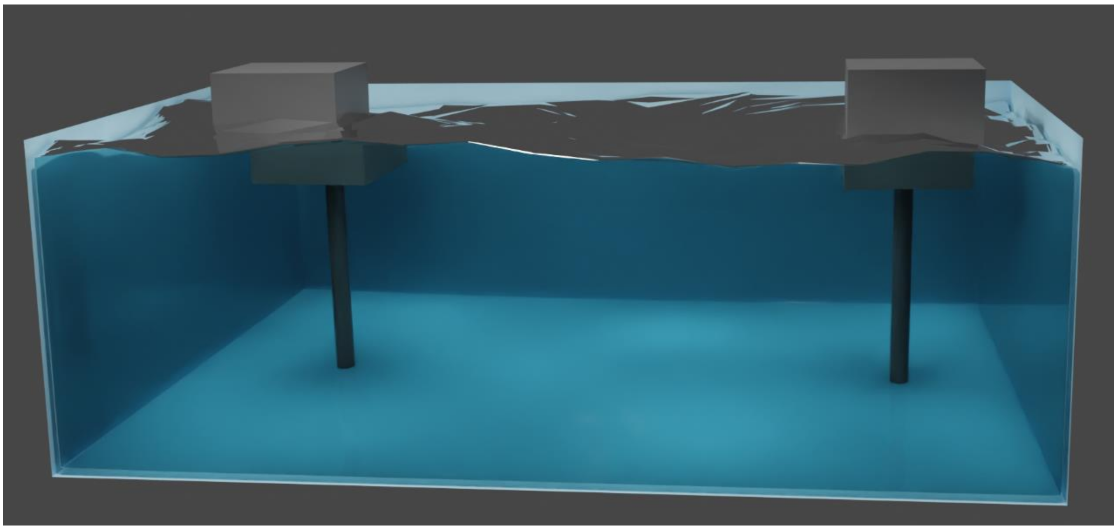

Fig.12. 3D simulation of design approach 3.

Figure 10 captures the entire process where the UAV is flying toward one of the ETP containers then it drops down sinking the pipe collecting water from it. Afterwards the UAV flies up while performing onboard testing, the data is then transmitted back while the UAV moves on to repeat the process for different ETP containers.

Figure 11 shows a virtual representation of how the autonomous underwater vehicle (AUV) will travel around inside the allocated ETP container in order to collect samples, test the water inside the container, and release any essential chemicals if they are required.

Figure 12 shows a prototype of the fixed block water sampler which is a digital representation of the device. A minimum of two of these fixed blocks will be required for an ETP container. These blocks will be positioned at both ends of the container, and they will be responsible for continuously taking readings of the water parameters and transferring them back to the operator.

**Proteus** was used to simulate the circuit that was envisioned in easyEDA and through this simulation the possible output of the water testing unit can be seen.

**Arduino IDE (Integrated Development Environment)** was used to program the microcontroller which was responsible for collecting all the sensor values and displaying the data to the user or operator through the website blynk.cloud as shown in figure 13.

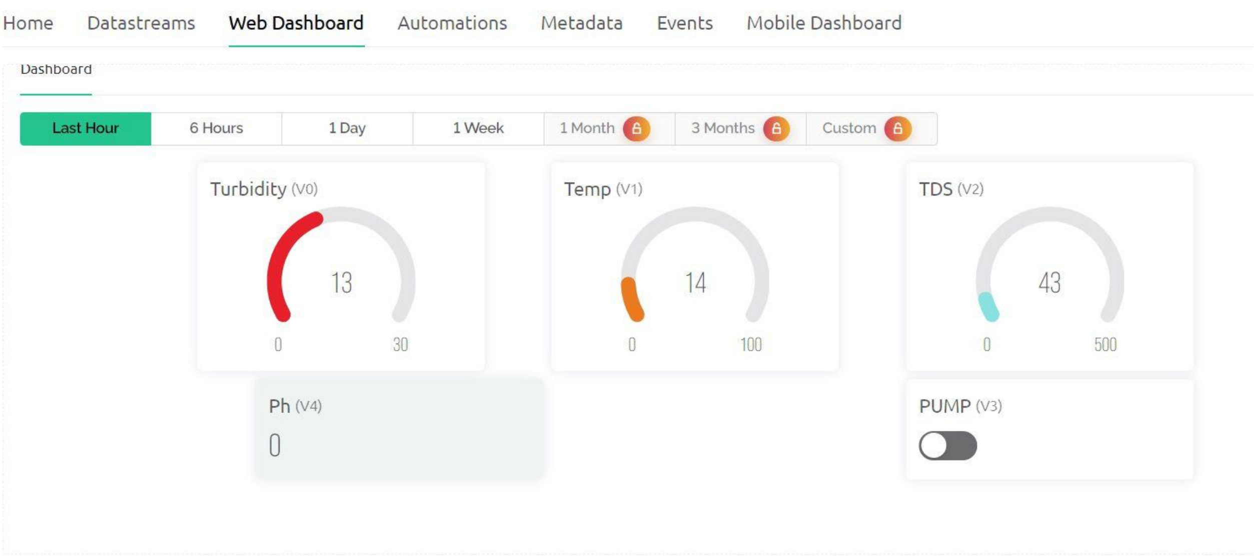


Fig.13. User interface using blynk.cloud.

**ArduPilot Simulator** was used to simulate the flight of the UAV from design approach 1. Which can be seen in figure 14. Along with the manual control of the quadcopter, simulation of how the quadcopter is going to behave while continuing autonomous flight in real life weather conditions. For the remote communication of the quadcopter the 3DR Telemetry is used here which can cover approximately 3 KM range. So, here the coordinate points are going to be pre seated by the user. After arming the quadcopter properly, it will start its autonomous flight. However, the altitude is also pre seated by the user depending on the location. A pathway is designed, and the quadcopter will start following that direction. After that, by reaching the destination the quadcopter will notify the ground station and remain stabilized at a pre-selected altitude for the next step.


Fig.14. ArduPilot flight simulation for design approach 1.

**Qgroundcontrol** was mostly utilized for the purpose of setting up the firmware as shown in figure 15 and doing the overall calibration of the UAV. Among the various characteristics that were calibrated the major ones were the compass, the gyroscope, the accelerometer, and the radio.

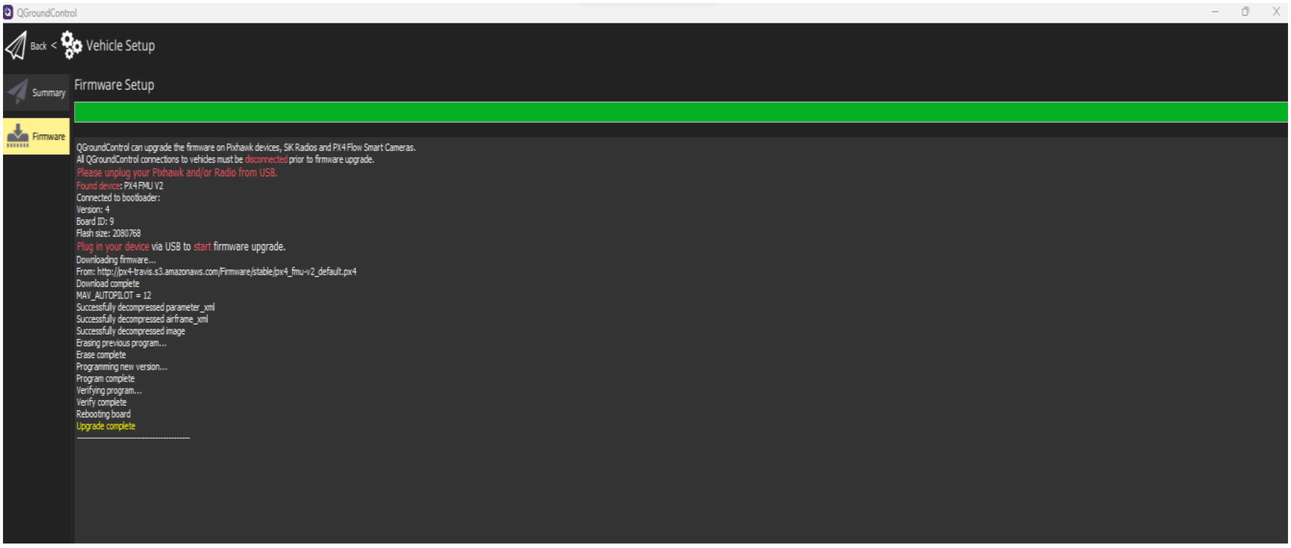


Fig.15. Firmware update using Qgroundcontrol.

### 3.4 Conclusion

In conclusion, this project would not be able to stand on its own if it did not make use of modern engineering and IT tools. These instruments were necessary at each and every stage of the process, beginning with the planning, designing, envisioning, and materializing stages. It would not have been possible to finish this project without the assistance of these tools. They were essential for processes like interpreting the sensor data, transferring that data back to the user or operator. These very tools were also responsible for the entire setup phase of the UAV.

# Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution. [CO7]

## 4.1 Introduction

There are a few different ways that the concept that has been offered by this project can be brought to reality, and each of these ways serves the same goal, which is to evaluate the parameters of the water that is found in effluent treatment plants. The use of a fixed block water sampler, an AUV-based water sampler, and a UAV-based water sampler are the three methods that are utilized to accomplish this. There are benefits as well as drawbacks associated with each of them. Despite that, they are quite different approaches, and as a result, there are very few aspects that can be compared between them. resulting in other aspects of comparison, such as the complexity of communication, the quantity of human labor that is displaced, or the amount of maintenance that is performed on the device.

## 4.2 Optimization of multiple design approach

**Proteus** was used to simulate all the three design approaches proving and verifying that the designs are valid and working. Below in figure 16, 17 and 18 the proteus simulation of design approach 1, 2 and 3 respectively can be seen created using proteus.

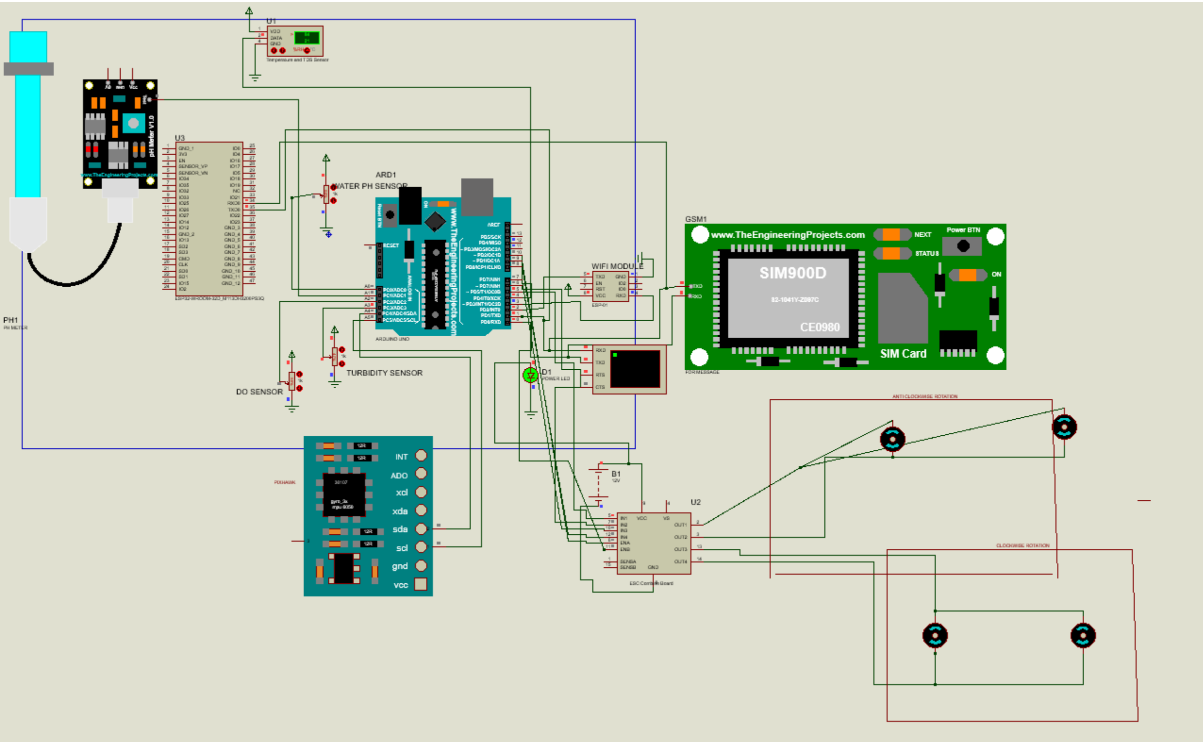


Fig.16. Proteus simulation for design approach 1.

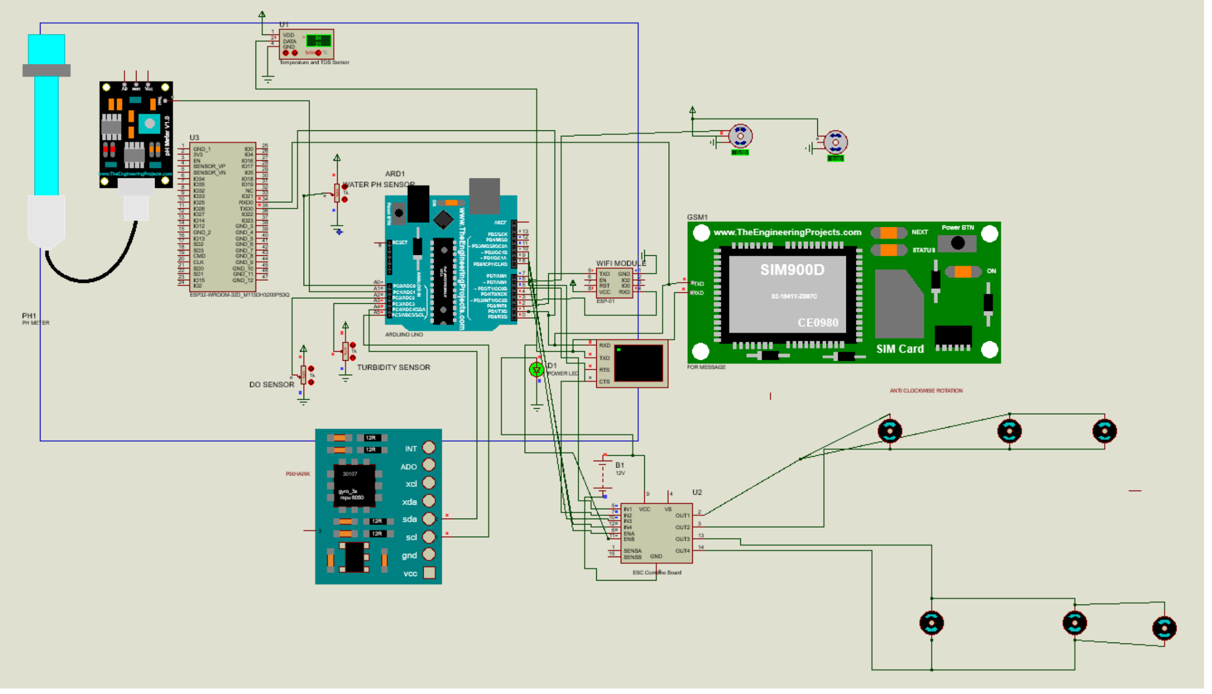

Fig.17. Proteus simulation for design approach 2.

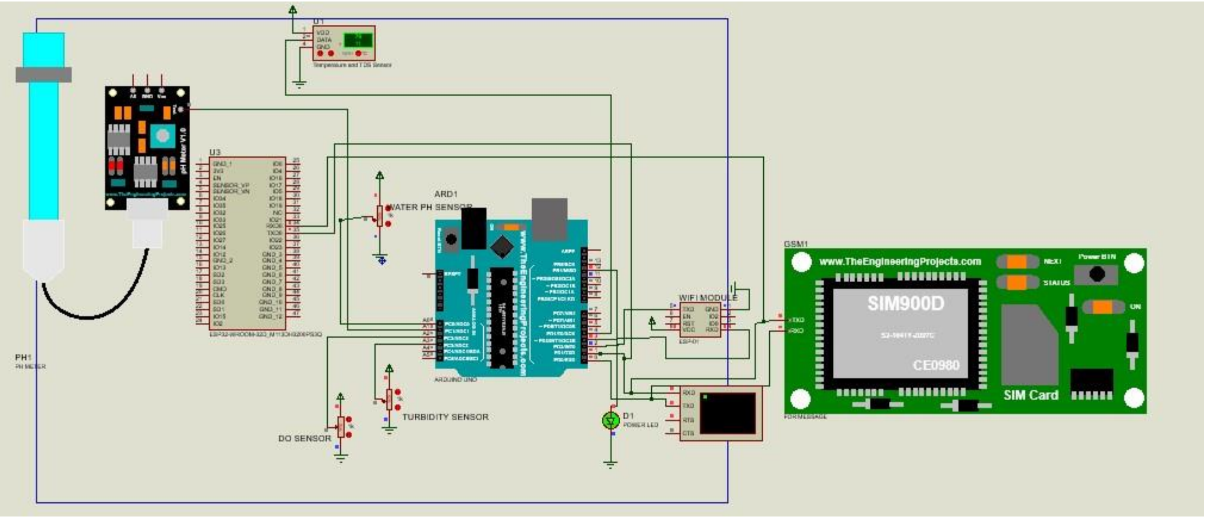

Fig.18. Proteus simulation for design approach 3.

Figure 16 contains the proteus simulation for design approach 1 where the circuit gives a clear visual representation of the design approach which is Unmanned Aerial Vehicle Based Water Sampler. Firstly, in the quadcopter, the main motherboard used here was an Arduino uno along with a gyroscope mpu6050 sensor; this sensor is used here for proper PID control of this quadcopter. The proportional, integration and differential controller is used here for proper stabilization of the quadcopter and the mpu6050 sensor value will play a significant role here. The ESC and four motors are connected with the signal pins of ESCs which are then connected to the Arduino uno microcontroller. By implementing proper PID in the code and using the sensor value the roll, yaw and pitch of the quadcopter is controlled. In the Proteus Simulation, this is represented by using four motors and driver circuit. Those two pairs are associated for controlling the clockwise and anticlockwise rotation. However, the onboard testing process is the major goal. In terms of ETP, various parameters of water are important such as Ph, Turbidity, Temperature, Total Dissolved Solid and Dissolved Oxygen. Hence sensors for all those parameters were used. But in proteus software some sensor libraries are unavailable. In that situation, potentiometer along with proper communication to Arduino uno was used as replacement. Using a virtual terminal an approximate output value was generated. Creating an Internet of Things (IoT) based solution for remote communication, a Wi-Fi module (ESP) and a camera (ESP32) must be connected with an Arduino Uno. Lastly, a green LED has been incorporated to signify the presence of a stable power supply within the circuit.

Figure 17 contains the proteus simulation for design approach 2 where the circuit gives us a clear visual representation of the design approach which is an autonomous underwater vehicle-based water sampler. First, it monitors and makes decisions for larger water recycling plants. It contains six motors, four of which move forward and backward and two move upward and downward inside the treatment plant. This rover's PID control relies on an Arduino uno motherboard and a gyroscope mpu6050 sensor. The proportional, integration, and differential controller stabilizes the rover, and the mpu6050 sensor value is important. While going upward and downward, the MPU6050 sensor's pressure value is used to decide movement. ESC signal pins connect the Arduino uno microcontroller to the ESC and six motors. This is represented by six motors and driver circuit in Proteus Simulation. Onboard testing is the main objective. Water characteristics including Ph, Turbidity, Temperature, Total Dissolved Solid and Dissolved Oxygen affect ETP. We employed sensors for all those parameters. But proteus software lacks some sensor libraries. Potentiometer and Arduino uno communication were utilized instead. After generating an estimated output value with a virtual terminal, a green LED was added to indicate a stable power supply.

As this rover will stay underwater, it must be watertight. This can be done by employing aluminum for the mechanical frame and acrylic that can withstand ETP pressure. A blend of acrylic and epoxy resin can make the rover chamber watertight for good operation. The biggest issue is getting a good signal from the ground station. Different communication frequencies are used underwater and on land with air. Submarines use enormous antennas to replicate satellite communication, avoiding this issue. NVIDIA Jetson Xavier microprocessor can be used as artificial intelligence as the rover will not be controlled manually. Proper AI and machine learning will allow the rover to make decisions. Arduino uno controls two servo motors to inject small amounts of chemical in the simulation. To stabilize water properties, ETP chambers may contain exogenous substances. If needed, the rover can make real-time judgments utilizing machine learning. This design approach requires good serial connectivity between Arduino uno and jetson Xavier.

Figure 18 contains the proteus simulation for design approach 3 where the circuit gives a clear visual representation of the design approach which is a fixed block water sampler. In terms of ETP, various parameters of water are important such as Ph, Turbidity, Temperature, Total Dissolved Solid and Dissolved Oxygen. Hence sensors for all those parameters were used. But in proteus software some sensor libraries are unavailable. In that situation, potentiometer along with proper communication to Arduino uno was used as replacement. Using a virtual terminal an approximate output value was generated. Creating an Internet of Things (IoT) based solution for remote communication, a Wi-Fi module (ESP) and a camera (ESP32) must be connected with an Arduino Uno. Lastly, a green LED has been incorporated to signify the presence of a stable power supply within the circuit. The box will be constructed using acrylic and will feature an aluminum frame for its mechanical structure. It will be designed to be watertight using epoxy resin. However, the sensor probes will be positioned inside the water, outside of the chamber. The GSM module along with IOT is used here for communication where it will directly notify the operator things like measured parameters or battery life status.

Analyzation of the simulation using proteus: The circuit designs for all the proteus simulation for all three of the design approaches are given in figure 16, 17 and 18 respectively. As shown in figure 19 the output for the proteus simulations for all three design approaches were same as all three approaches used the same water testing method with same sensors and microcontroller hence differentiating from this was inconclusive.

In the virtual terminal the outputs for the five different sensors will be displayed, this is the same for all the different approaches. In figure 19 several values can be seen; this is done by changing the value of the potentiometer to replicate the real time changes that might be seen. These are the values that will be stored and presented to the appropriate user/observer.

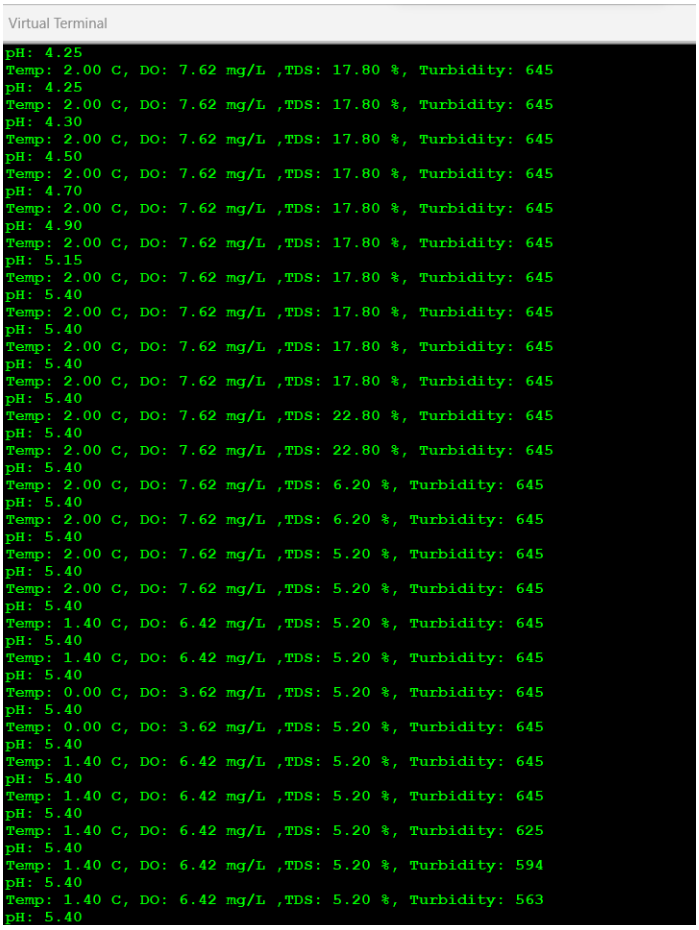


Fig.19. Output of proteus simulation for all the three approaches.

By doing the quadcopter simulation usin ArduPilot in real life weather conditions, from the graph it's visible how the quadcopter is going to behave in terms of roll, pitch and yaw while there is approximately three to five km of wind speed per hour. However, using this simulator, the flight of a UAV can be simulated where the velocity, altitude, roll, pitch and yaw can be seen changing and adjusting as the UAV moves from one designated position to another resembling the real-life change that might be observed through this software as shown in figure 20 and 21.

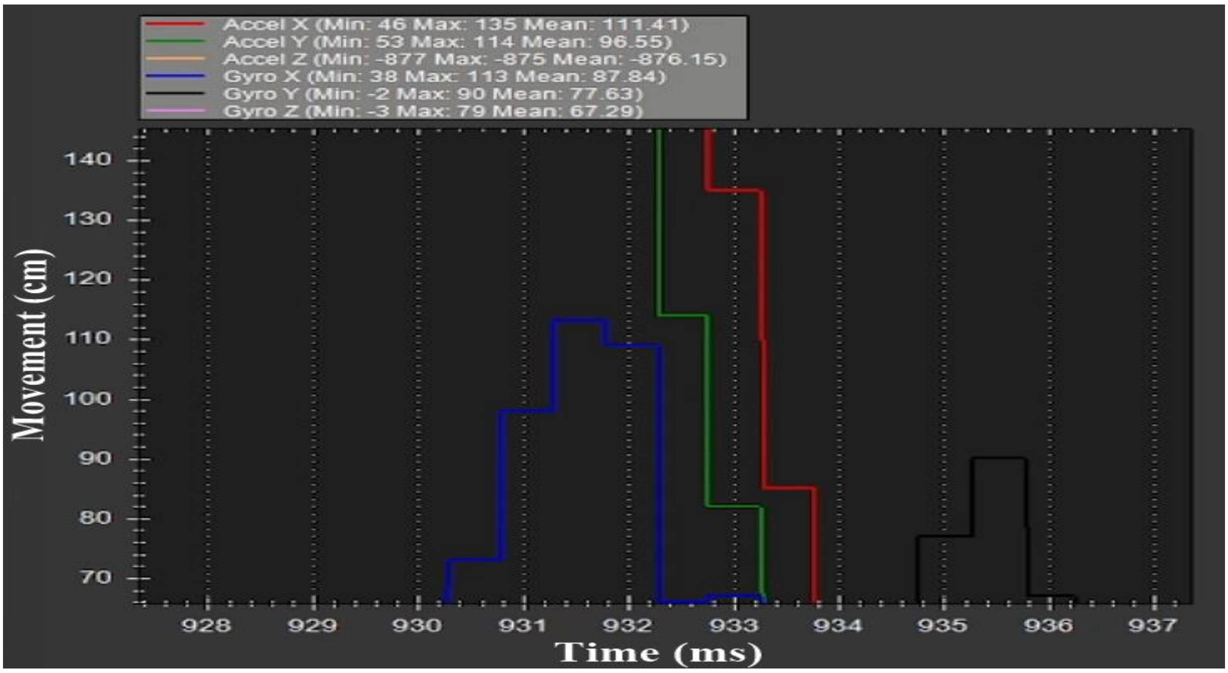


Fig.20. Output graph 1 form ArduPilot flight simulation for design approach 1.

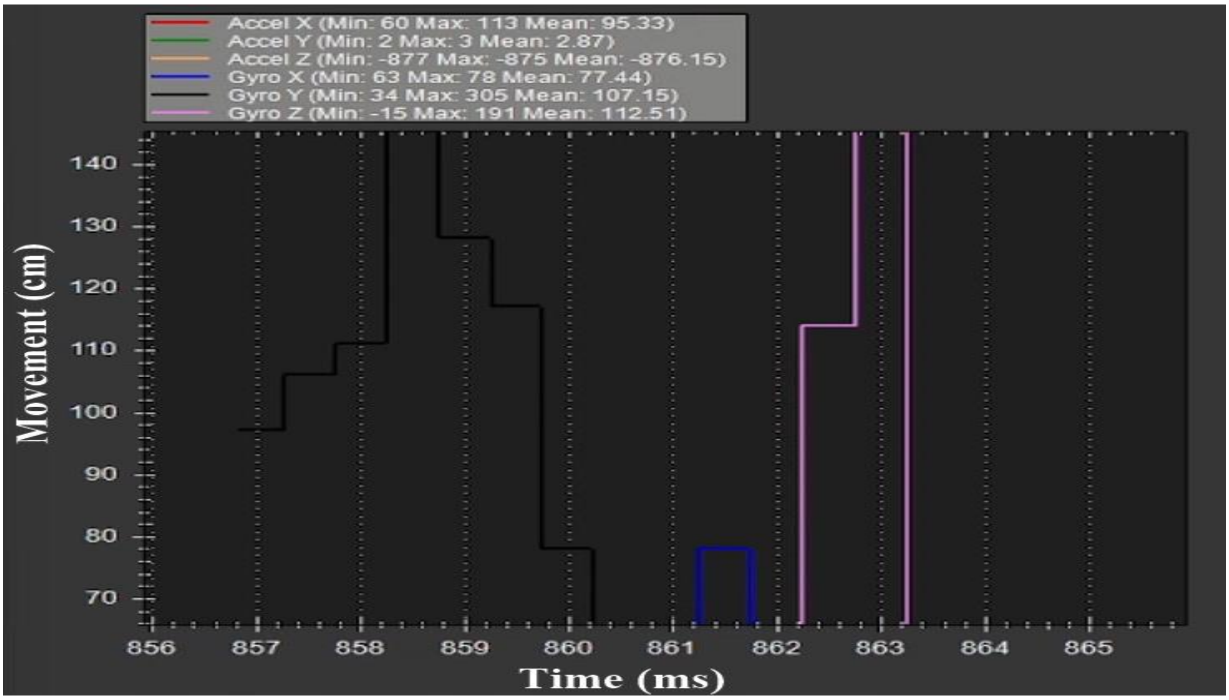


Fig.21. Output graph 2 form ArduPilot flight simulation for design approach 1.

Communication is crucial for the transfer of data from the on-board testing device to the user or operator. The UAV and the fixed block use the microcontroller ESP8266 to send data in real time but for AUV to send data back it would require a huge antenna, or it would require stable satellite communication. Hence, design approach 2 is clearly at a disadvantage.

Quantity of human labor differs for every design approach, for design approach 1 (UAV based water sampler) the human labor is very little as the UAV can test waters from all the ETP containers in one flight. For design approach 2 (AUV based water sampler) the human labor is relatively high as the AUV must be moved from one container to another which requires major human labor. For design approach 3 (fixed block sampler) also require very little human labor as they will be connected to the walls of the ETP containers.

Safety systems were incorporated for all the design approaches. For design approach 1 (UAV based water sampler) and design approach 2 (AUV based water sampler) both have safety switches which renders the device useless an any given moment however for design approach 3 (fixed block sampler) the main power button acts as the safety switch.

### 4.3 Identify optimal design approach

In all the design approaches the same water testing system was used hence it becomes redundant to compare this aspect of the approaches. They all differ in their ways of collecting the water, mobility, consumed power and cost effectiveness.

Design approach 1 (UAV based water sampler) collects the water through a pump while it is hovering over the water body. After the testing is done all the tested water is dropped back, the process can be repeated a few times to get a reliable result. However, both in design approach 2 (AUV based water sampler) and design approach 3 (fixed block sampler) water is not really collected, rather the sensor probes stick out of the device's which makes the readings unreliable due to the leftover residue for other water sources. Hence design approach 1 provides the most efficient and reliable way of collecting and testing the sample.

In terms of mobility, design approach 1 (UAV based water sampler) offers a free range where it can move in any direction and heights giving it the ability to take readings for multiple different ETP containers. On the other hand, design approach 2 (AUV based water sampler) also has exceptional mobility but it is restricted inside ETP containers and can only move around inside it. Lastly, design approach 3 (fixed block sampler) has zero mobility as the name suggests it is fixed inside the ETP container and provides continuous readings.

In addition to the power consumption trends observed in the three design approaches, it's highly important to look deeper into the complexities that influence these results. In design approach one, the initial surge in power requirement during liftoff is a direct consequence of the tremendous energy needed to overcome gravity and achieve flight. As it ascends to a sufficient altitude, the power consumption stabilizes, transitioning into a more sustainable and consistent mode. This steadiness is attributed to the fact that, at higher altitudes, it operates with reduced gravitational resistance, requiring less power to maintain its position. However, the transition from high to steady-state power consumption highlights the dynamic nature of its energy demands.

On the contrary, the design approach has a different set of challenges. The power consumption gain is exponential which is primarily driven because of underwater to ground serial communication demands. After that the Satellite communication or large antennas are needed because the underwater environment doesn’t match with frequency and needed more power to operate. Moreover, the continuous data processing in the microprocessor and the microcontroller's role in processing actions based on this result analysis further contribute to its elevated power consumption, illustrating the complexity of this design's operational demands.

In contrast, design approaches three goes for a simplified, specialized role within the treatment plant chamber and the main function is to analyze sensor data and then after proper filtration transmit the data to a cloud server. This design approach consumes more power without engaging in multiple chamber checking, which indicates its limited capability to monitor various water chambers simultaneously where the number of treatment chambers is multiple.

After that, in terms of calculating efficiency exhibited by design approach three, the decision-making process meets with the most sufficient economic factor. In terms of cost implications of each design approach, including manufacturing, operation, and maintenance, summarizes the final evaluation. By considering all these technical and economic factors, the usage of a UAV-based water sampler meets with the most practical and effective approach compared to the other two design approaches. It provides a combination of efficient power usage and proper functionality that meets the need of the project's objectives and considering resource constraints.

Lastly, design approach 1 (UAV based water sampler) has a price of about 70000 BDT, design approach 2 (AUV based water sampler) has a price of about 115000 BDT and design approach 3 (fixed block sampler) has a price of about 18000 BDT however if the effluent treatment plant has four containers it would take at least four of these, which increase the overall price. Hence design approach 1 is the most financially stable option.

### 4.4 Performance evaluation of developed solution

**Propeller and Motor Selection:** A popular formula for determining a quadcopter's minimal thrust is the rule of thumb. When calculating the weight of a quadcopter, be sure to account for the heaviest weight that is feasible, which includes the weight of a quadcopter that is completely outfitted with all parts. The computation is predicated on the generalization that a quadcopter requires at least 2 pounds of thrust to effectively maneuver through the atmosphere. For hovering or stable control, the quadcopter must produce 5 kg or 10 kg of force. This is approximately 2.5 kg of force per propeller when divided by four.

In this case, the estimated maximum weight of the quadcopter is 10 pounds [approx. 4.5kg] According to the rule of thumb,

Tmin = [(10/100) × 2] lbs of thrust = 0.2 lbs of thrust

This is the minimum thrust which is required.

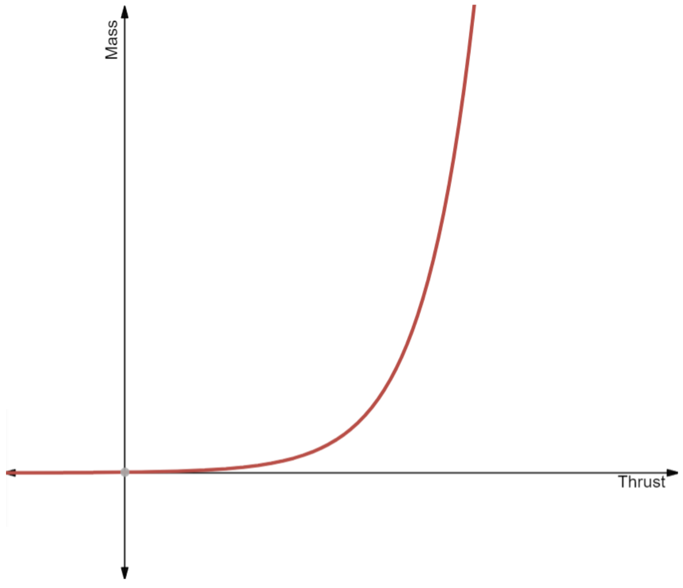


Fig.22. Graph of Mass against Thrust.

From the graph in figure 22, it is visible that the link between the minimum needed thrust and the mass of the quadcopter, as seen in the graph, implies that there is a proportional relationship between these two factors. The minimal thrust needed to drive grows proportionally as its mass does. This relationship makes sense because a heavier mass needs more thrust to be propelled. For the design of a quadcopter, this proportional connection has significant ramifications. The thrust mechanism must be made to produce enough thrust to move the quadcopter 's mass if the quadcopter is to be able to travel efficiently.

However, a 12V motor of 55 pounds or less thrust is needed.

For the quadcopter, by selecting the 12V BLDC Motor, whose name is XA2212 980 kV brushless outrunner BLDC Motor. The specification of this BLDC motor is given below:

V = 12V,

I = 20A,

Prated = 150W, kV = 980 RPM/V

RPM = kV × V = 980 × 12

RPM = 11760

However, a 2 blades propeller is suitable for this BLDC motor according to the motor specifications. Specification of the 1045 model propeller is given below:

Diameter, D = 10 inch

Propeller Pitch = 4.5 inch

According to Static Thrust Equation:

$$T = 4.392399 \times 10^{-8} \times \mathrm{RPM} \times \frac{\mathrm{d}^{3.5}}{\sqrt{\mathrm{pitch}}} \times 4.23333 \times 10^{-4} \times \mathrm{RPM} \times \mathrm{Pitch}$$

Here,

T = Thrust in Newton

d = Diameter of Propeller in inch = 10 inch

Propeller pitch = Pitch in inch = 4.5 inch

RPM = Speed of Motor

Then,

$$0.2 = 4.392399 \times 10^{-8} \times \mathrm{RPM} \times \frac{10^{3.5}}{\sqrt{4.5}} \times 4.23333 \times 10^{-4} \times \mathrm{RPM} \times 4.5$$

$$RPM^2 = 1603392.436$$

$$\therefore \mathrm{RPM} = 1266.25$$

According to the facts given, it appears that the decision to use a BLDC motor for the quadcopter's propulsion system is justifiable. The motor specification states that it can generate up to 11760 rpm, which is far more than the required minimum speed, and the calculation indicates that a motor speed of 1266.25 rpm is necessary to propel the rover through the water adequately. Therefore, using a BLDC motor is appropriate.

**Weight calculation for unmanned aerial vehicle (UAV) based water sampler:**

1 x Frame(Body) = 1100 gm
1 x RX(Receiver) Module = 30 gm
1 x Flight Controller(Pixhawk) = 50 gm
1 x Lipo Battery = 830 gram (4s)
1 x PCB = 67 gm
4x ESCs (4 x 75)gm = 300 gram
4 x Propellers (4 x 11)gm = 45 gm
4 x Motors (4 x 400)gm = 1600 gram
1 x Esp2866 = 145 gm
1 x GPS Module (1 x 16) = 16 gram
1 x IR Camera module (1 x 400) = 400 gm
50 mL water sample= 50gram

Micro Submersible Motor Pump= 60 gram
Others = 500 gram

Total Weight = 4800 gram

Total thrust = 4 x 5500 = 220000N

Therefore, weightlifting ratio = 4800/22000 = 0.21818

**Flight Time Calculation for unmanned aerial vehicle (UAV) based water sampler:**

According to the used motor specification sheet, the brushless motors direct current 9.42 Ampere (45-55% throttle) continuously. Linear model ratio is used, the assumption used is $9.42 \times 0.21818 = 2.6545\ A$ for each motor.

The maximum amount of required current is 10.61 A during a random flight. The approximate example of a lipo battery can provide 21000mAH. But a LiPo pack down should never be discharged past 85% of its capacity, to be safe.

This indicates in $20000 \times 0.85 = 17000 = 8.502\ A$, 17mAh for the battery.

Dividing this number by the energy used gives the approximate flight time in hours. $17/10.6182 = 90.0614\ min$

This indicates an approximate flight time of 90.0614 min.

### 4.5 Conclusion

This chapter comprehensively examines both the advantages and disadvantages associated with the offered project. The objective was to conduct a thorough evaluation of three distinct design approaches, ultimately it is proven that the first design approach unmanned aerial vehicle (UAV) based water sampler, stands out as the most effective, dependable, and economical choice among the other available options.

The assessment examined different parts and factors that were unique to each design approach. This entirety process of comparison was needed because the three approaches were not similar, which led to a thorough examination of many factors. Through this a full picture of the pros and cons of each design approach became clear.

In particular, this chapter goes over the first design approach in depth and stresses how much better it is. To back up this claim, a lot of math and graphs were used to show how well the UAV-based water sampler worked compared to the other methods.

# Chapter 5: Completion of Final Design and Validation. [CO8]

## 5.1 Introduction

An unmanned aerial vehicle (UAV) based water sampling prototype was constructed. This prototype was based on design approach 1, which had been selected during the previous design process. Which accomplished the majority of the desirable characteristics of the device that was envisioned in order to carry out all of its objectives to the best of its capabilities. Because the prototype is a little bit smaller than the original one, the weight that it is able to carry is less. As a result, the prototype has four sensors: temperature, total dissolved solids (TDS), turbidity, and pH. Using an aerodynamic container under the UAV to house the collected water sample and the sensor unit with the 5500 mAh battery. During the testing of the prototype, everything worked perfectly when the weather and wind flow were calm. However, when the prototype was subjected to heavy winds, it became exceedingly unstable throughout the testing process.

## 5.2 Completion of final design

The design of the prototype had two main parts the UAV and the sensor unit.

Firstly, to make the prototype an S500 quadcopter frame was used, which was purchased pre-made hence, according to the manufacturer's instructions, all four of the arms were securely screwed on to the body as shown in figure 23.

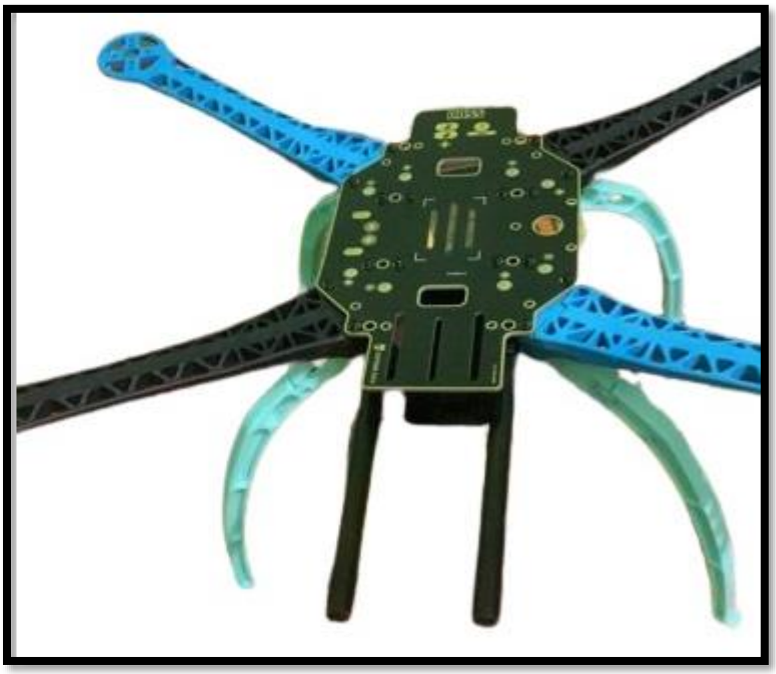

Fig.23. UAV frame after being assembled.

For the prototype local ESC (electronic speed control) was used to control and regulate the speed of the EMAX XA2212 UAV motors. The motors were attached into the motor mounts with the help of screw and each ESC was connected to the designated motor, securing them under the arms of the UAV using tape as shown in figure 24.

Fig.24. Mounting motors and ESCs.

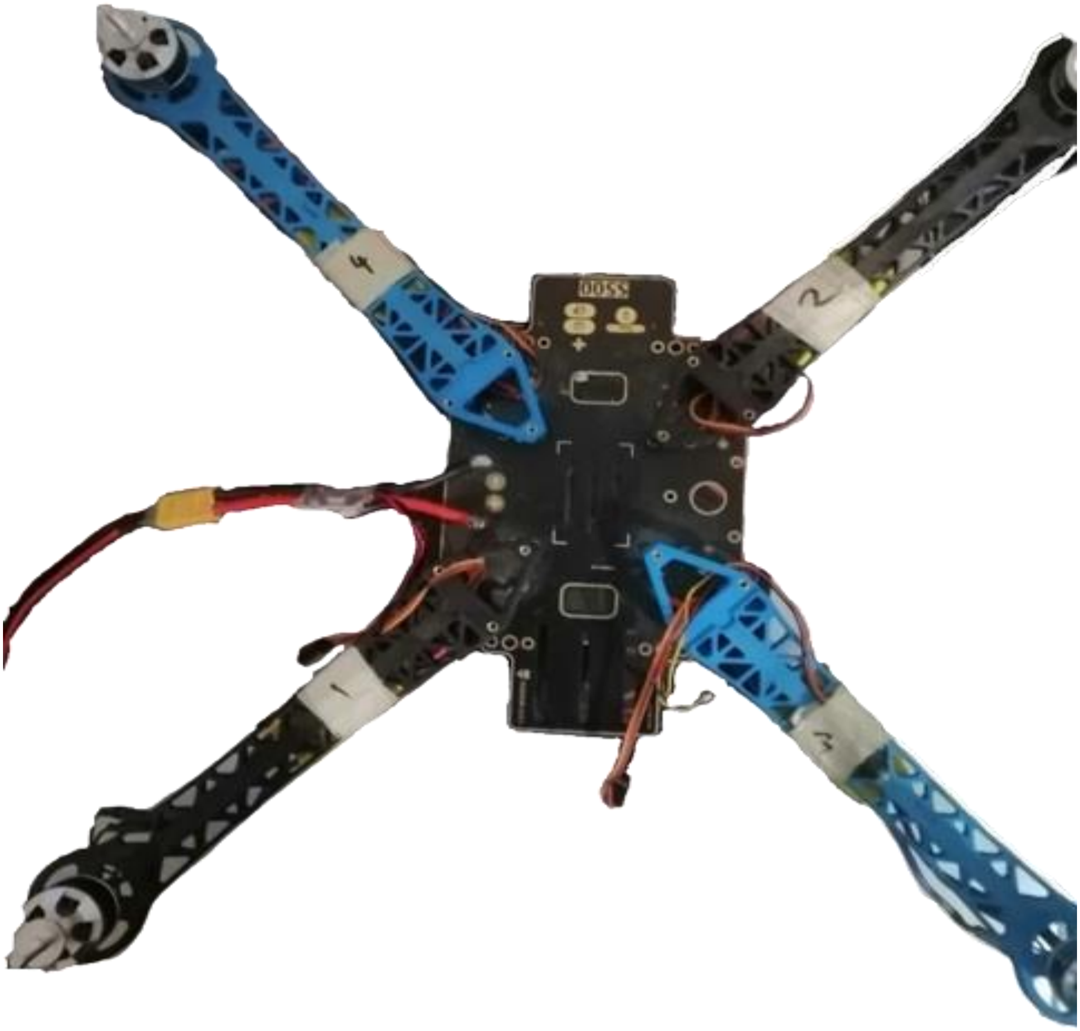

Fig.25. ESC pins and power connector soldered to the frame.

Fig.26. Addition of buzzer and shock absorber.

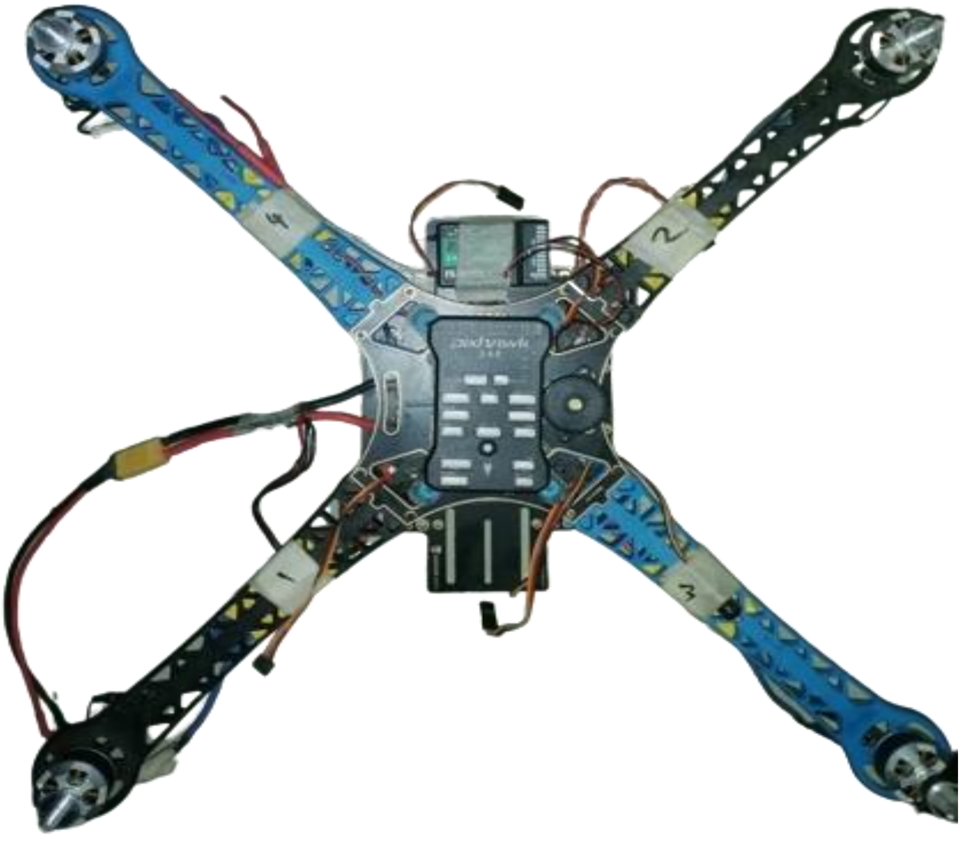

Fig.27. Addition of Pixhawk and RC receiver.

The ESC pins and power connector pin are soldered into to the integrated PCB of the UAV’s frame also a safety switch was tapped onto one of the arms as shown in figure 25. The brushless motors and ESC pins were connected by keeping in mind the rotational direction of the motors. Later the shock absorber was mounted on top to resist any shock or vibration generated during flight and a buzzer was added to the side of the frame as shown in figure 26. The flight controller or Pixhawk was mounted in the center of the frame on top of the shock absorber, and the RC receiver was tapped onto the side of the frame as it is responsible for communication purposes with the ground station as shown in figure 27.

Lastly, the radio link SE100 GPS and 10-inch propellers were added while maintaining proper connection of the wires with its designated ports. Here the correct orientation of the propeller to each motor was critical to maintain the propeller rotation direction. Afterwards the prototype looked like figure 28.

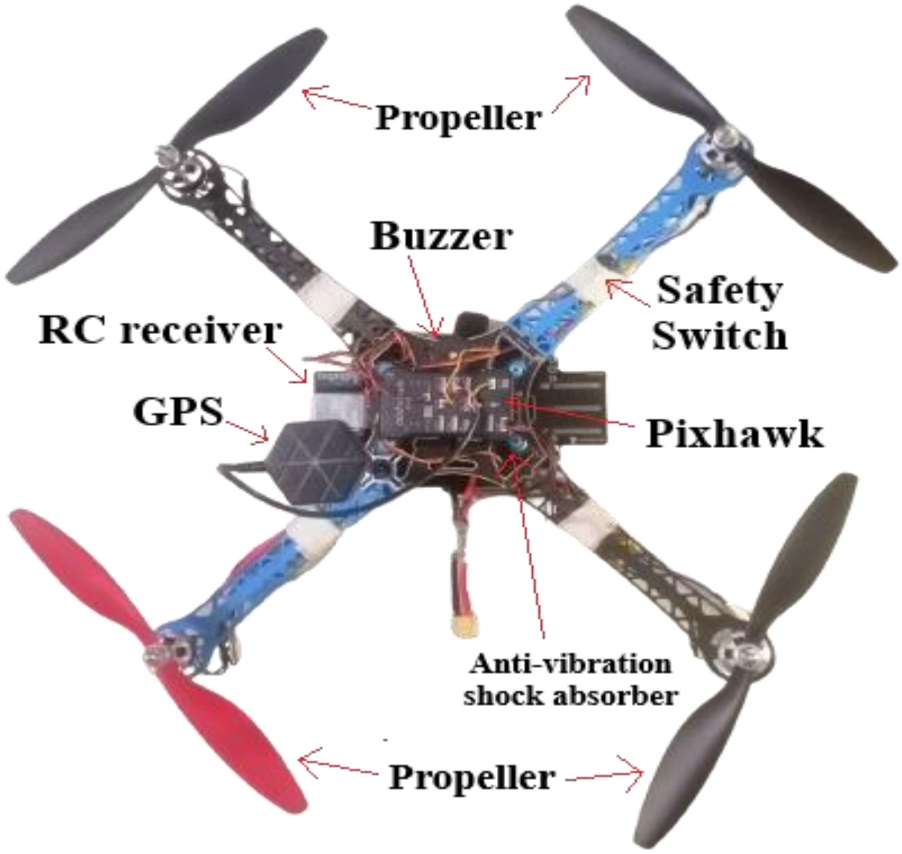


Fig.28. UAV after being assembled.

The battery shown in figure 29 is used as the main source of power for the prototype, these three cells 5500 mAh battery is connected to the power distribution board (PDB) of the UAV which provides power to the flight controller or Pixhawk and all the four ECSs this wiring was carefully laid out to minimize signal interference.


Fig.29. Power source used for the prototype.

After the UAV was assembled checking was done for all the connecting wires, making sure neither of the wires were overlapping or intact in the right place. Using Qgroundcontrol firmware and the UAV sensors like the gyroscope and accelerometer along the GPS was calibrated up to a satisfactory level. Later the UAV went through a pre-flight checklist of checking motor directions, flight controller orientation by taping paper on to the motors instead of propeller.

As the UAV is now functioning as required the next step for the construction of the prototype is the sensor unit. This unit consists of four sensors pH, turbidity, temperature and total dissolved solids (TDS) as shown in figure 30.

| | | | |
|---|---|---|---|
|  |  |  |  |
| **PH Sensor** | **TDS Sensor** | **Turbidity Sensor** | **Temperature Sensor** |

Fig.30. All four sensors used for this project.

Before the incorporation of these sensors in the sensor unit they were tested using saline water, mineral water and coca cola as shown in figure 31 to get an overall understanding of how the results will appear to the user.

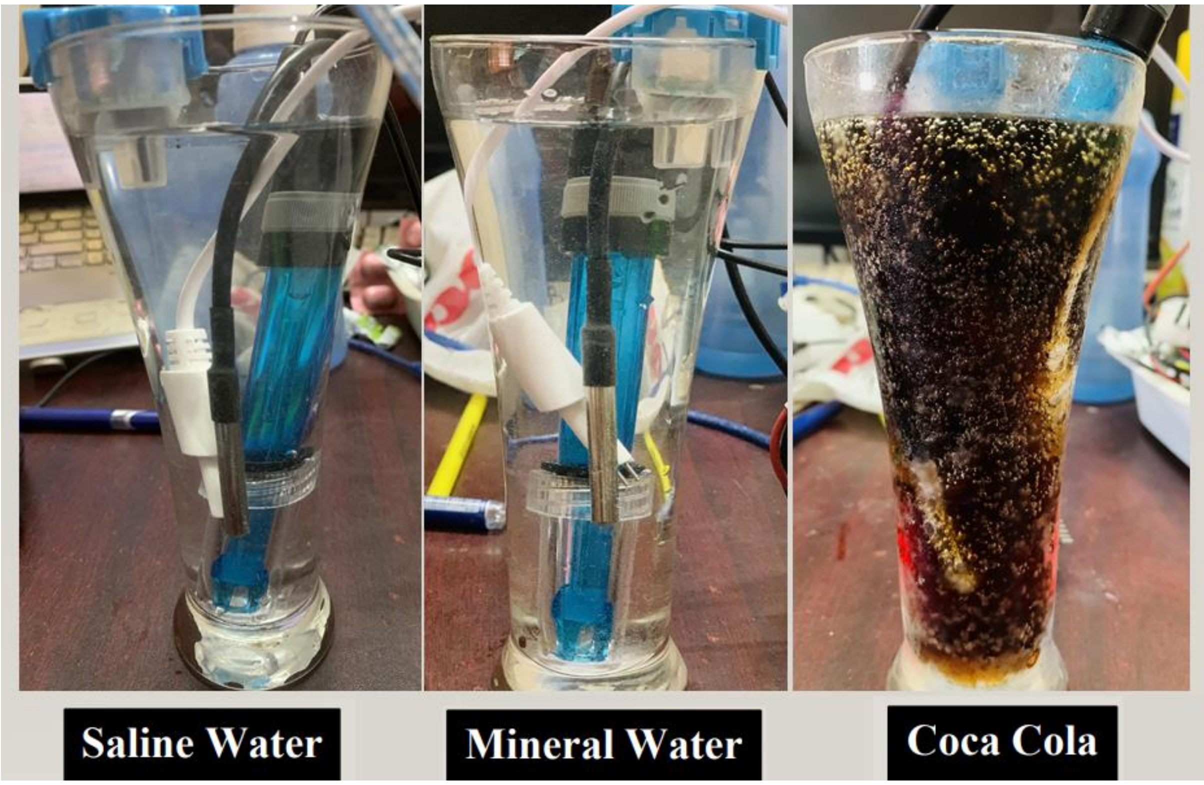


Fig.31. Preliminary test for the sensors.

The following table shows the results found from the preliminary testing of the sensors.

| Tested Parameters | Saline Water | Mineral Water | Coca Cola |
|---|---|---|---|
| pH | 8.1 | 6.8 | 2.4 |
| Turbidity in NTU | 2.1 | 0.6 | 12 |
| Temperature in °C | 26 | 26 | 21 |
| Total dissolved solids (TDS) in mg/L | 500 | 212 | 13 |

Table.2. Preliminary testing results of the sensors.

In order to perform onboard testing the prototype has to collect all the individual data from all four of these sensors and transfer them over to the user, a microcontroller will be required hence ESP8266 was used as it has an inbuilt Wi-Fi microchip which is essential for wireless data transfer. The PCB shown in figure 32 was designed using EasyEDA as explained earlier in figure 9, to minimize wire work inside the sensor unit while maintaining proper connection during motion.

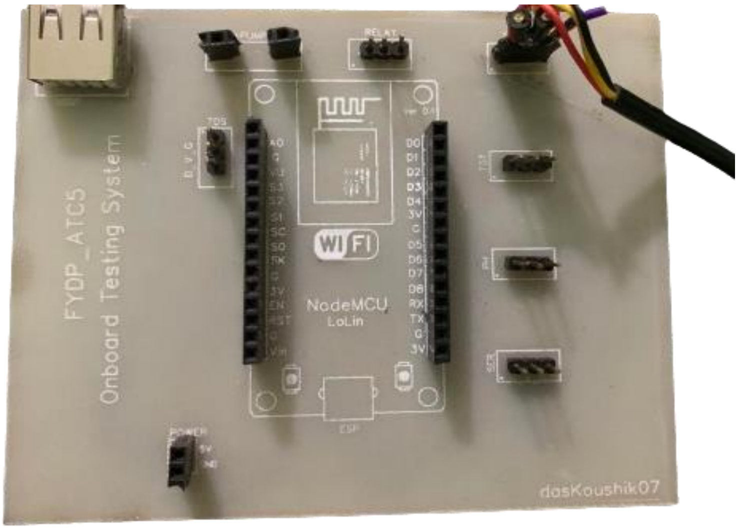


Fig.32. PCB used for the sensor unit.

In order to test the water parameters, the sample water had to be in contact with the sensor probes but at the same time it is very risky to bring water in contact with all the electronics. Hence the testing chamber was created with the help of polythene, epoxy and tape as shown in figure 33 where water remains out of reach from the other electronic components. The chamber is about 1 inch deep, 5 inches in length and 5 inches in width which brings it up to 0.000409 cubic meters in volume as a result about 400 milliliters of liquid can be stored inside.

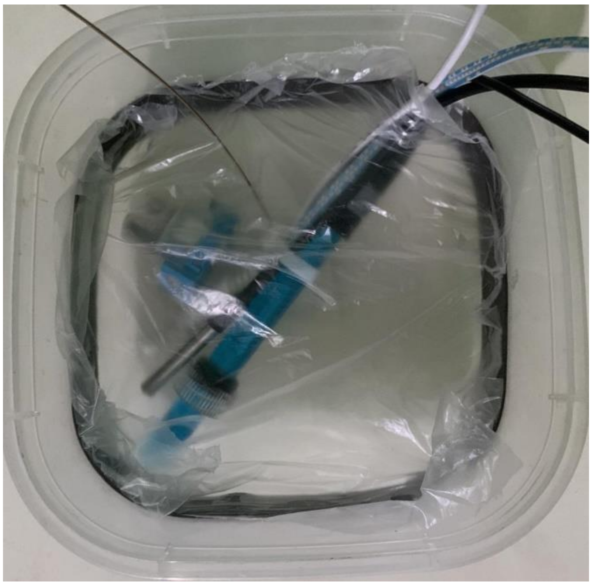

Fig.33. Testing chamber of the sensor box.

Afterwards the PCB is connected with the sensors on top of the testing chamber as shown in figure 34. Later all the wires are put inside the sensor unit which draws power from the 5500 mAh battery shown in figure 30.

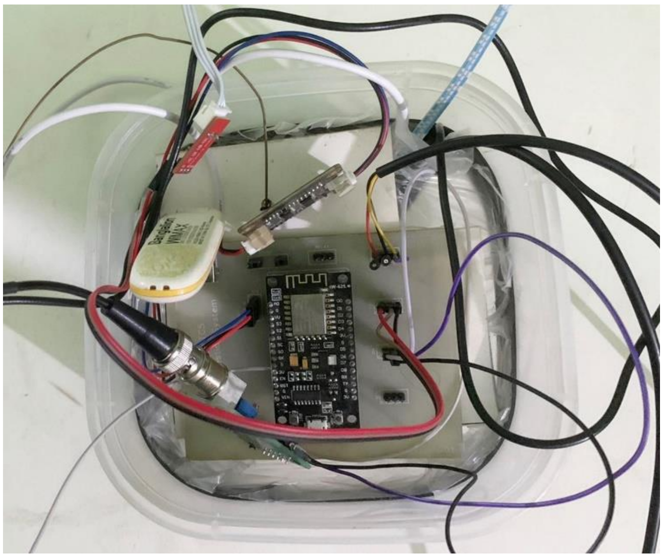

Fig.34. Top view of the used sensor box.

**Method of data collection:** The sample liquid is brought into the testing chamber with the help of a 5V dc water pump. Suction becomes pivotal for collecting water from the treatment chamber. However, the project's precise weight prohibits the use of a heavy suction pump. Consequently, connecting the pump to the pipe results in a substantial air gap, rendering the 5V pump inadequate for water collection beyond a height of 7 feet. To address this challenge, a reverse engineering approach is employed. Two typical solutions are considered. The first involves connecting the pump beneath the 6 feet pipe. However, this configuration poses aerodynamic challenges, potentially causing interruptions during flight and reduced efficiency due to increased power consumption in moving through the air.

Alternatively, the second solution entails injecting water through the pump's output port. This effectively eliminates the air gap in that section, maintaining optimal aerodynamics without compromising efficiency. The project implements both solutions through a trial-and-error method to determine the most effective approach. Through experimentation, it is observed that injecting water through the output significantly reduces the air gap, enabling proper suction for water collection at heights ranging from 6 to 7 feet.

With the use of Qgroundcontrol software we have access to different types of flight modes for multirotor UAVs as these offers different adeptness and are designed for predetermined purposes.

● Stabilize Mode: This is basically a fundamental mode for flight as it provides manual control on the UAVs roll and pitch angle. Meanwhile it maintains auto leveling for sturdiness and preferable for manual and practice flight purposes.

● Loiter Mode: This mode combines the GPS positioning and altitude hold together and enables the UAV to hold its position and loftiness autonomously. This mode is very useful for surveying and inspection purposes as it facilitates the pilot to hold the UAV in a fixed position. In this project this mode was used during the sample collection.

● RTL (Return to Launch) Mode: When this mode is activated the UAV will automatically return to its launching point and land, it is a most important mode that ensures safety if the operator loses control of the copter.

The main purpose was to check the parameters of sample water. For this, the Blynk application was used to store real-time data and it also allows the user to visualize that data from anywhere in the world as shown in figure 35.

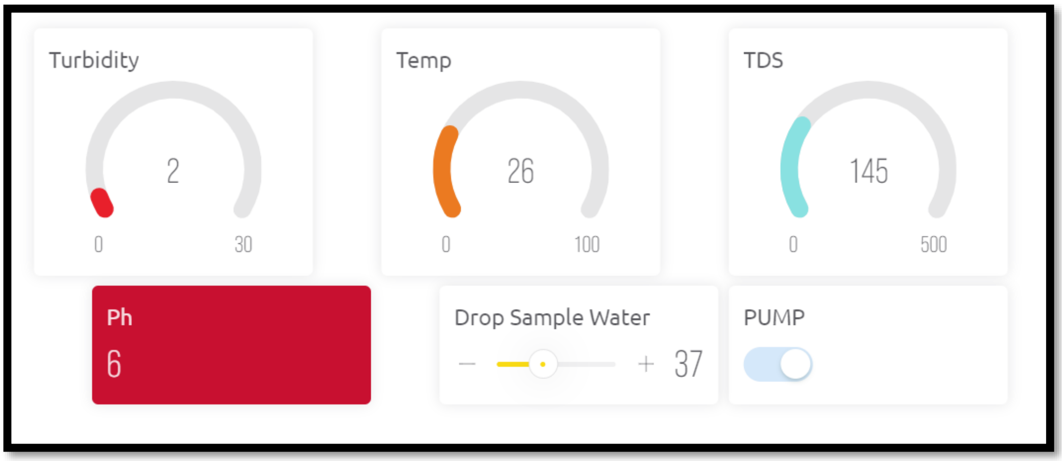


Fig.35. Blynk interface from the ground station.

**Final look of the prototype:**

Fig.36. Prototype of design approach 1 unmanned aerial vehicle (UAV) based water sampler.

### 5.3 Evaluate the solution to meet desired need

Testing of the prototype was done by taking a small amount of the sample water out of the water body into a small bucket, while wind speed was relatively low. The prototype was flown above this bucket in a way that the suction pipe comes in contact with the sample water as shown in figure 37. This way the sample water was taken up to the testing chamber where the sensor probs are housed, this live data was then collected.

Fig.37. Sample testing using the prototype.

Initially two tests were conducted to check the prototypes usability and overall accuracy of the on-board testing feature. One sample was for local tap water and the other sample was from the river behind a factory with a running ETP. The output values given by the onboard sensors can be seen using Blynk application. The results for the tap water are given in figure 38 and the results for lake water are given in figure 39. However, the values collected were in range. Although the parameter readings displayed in blynk where unstable and frequently changing, this might have occurred as the UAV is in constant motion.

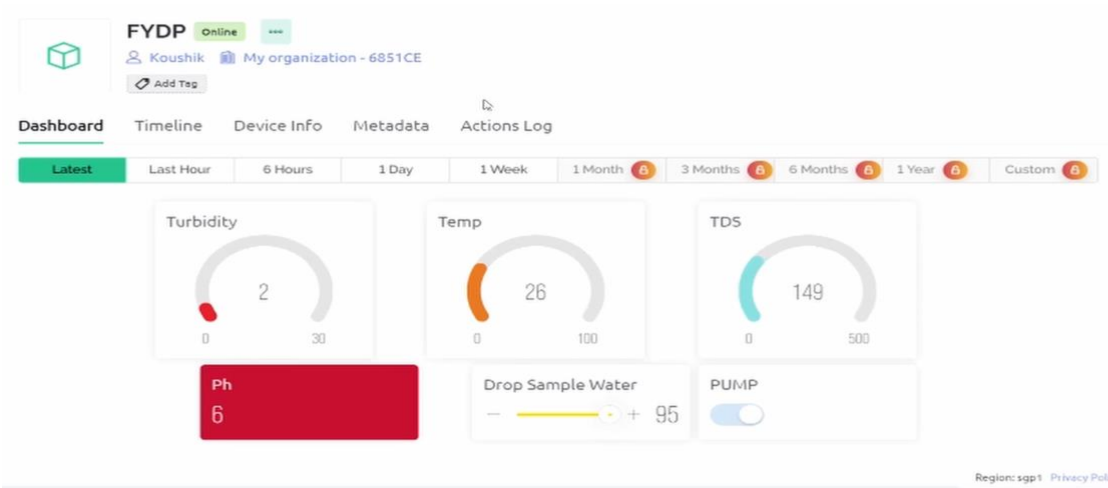


Fig.38. Results shown in Blynk application using tap water as sample.

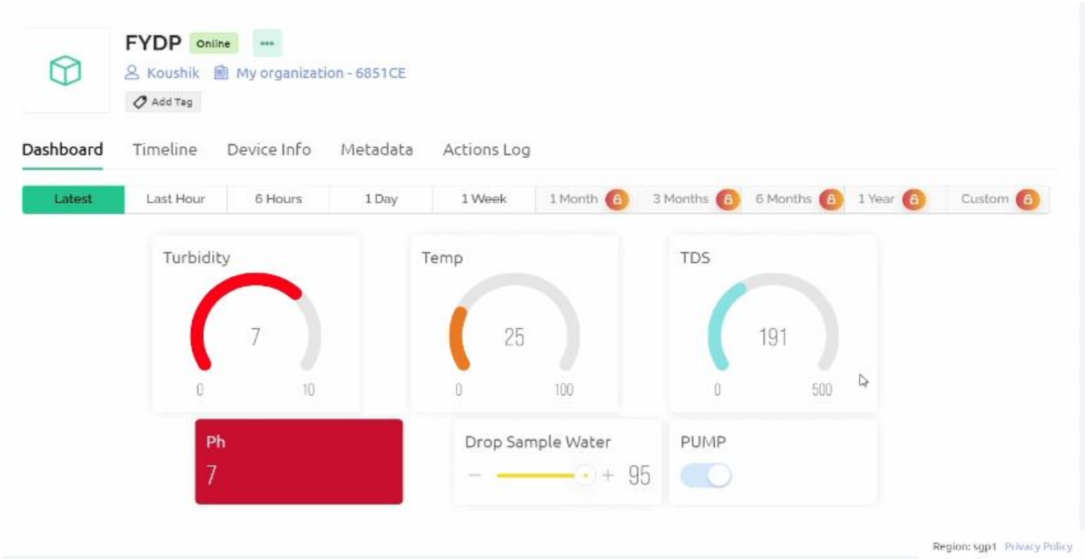


Fig.39. Results shown in Blynk application using lake water as sample.

| Source of Sample Water | pH | | Total Dissolved Solids (TDS) in mg/L | | Turbidity in NTU | | Temperature in °C |
|---|---|---|---|---|---|---|---|
| | TV | RV | TV | RV | TV | RV | TV |
| **Tap Water** | 06 | 6.5-8.5 | 149 | 50-150 | 02 | 01-05 | 26 |
| **Lake** | 07 | 06-08 | 191 | 50-250 | 07 | 02-15 | 25 |

Note: TV: Tested Value & RV: Reference Value [16] [17] [18].

Table.3. Data table highlighting the findings during on board testing.

**Analysis of the results collected:** The values collected from the sensors are within the acceptable range. However, the value of total dissolved solids (TDS) for tap water is very close to the maximum reference value, the reference value used here is taken from google but in reality, the TDS value depends on many factors. Any form of dissolved solid can increase the value at the same time missing such dissolved solids can decrease the value, these solids can be essential minerals or wastes unfit for human use. On the other hand, any TDS value of less than 500 mg/L is acceptable in Bangladesh [16]. For ETP testing each facility has its own standards and as long as they can see the overall TDS value it is enough to come to a conclusion.

The turbidity value refers to the clarity of the tested water in simple terms. The less the turbidity value the less amounts of organic or inorganic substances are present in the water [17]. From the above table the turbidity of lake water is more than the tap water which verifies the above claim as lake water usually contains more amounts of organic or inorganic substances.

This project is capable of remotely monitoring parameters of the sample water with the use of this prototype. Using the Blynk and IOT ESP8266 module the sample water can be monitored in real-time with all the values for different parameters thus providing the level of contamination. As this method of collecting and testing is faster than the traditional way it is safe to say this method is more efficient.

### 5.3.1 Testing with treated water released form ETP into a river

The project was also tested in practical conditions. Previously it was tested with tap and lake water parameters. After that to properly justify the proper working of the project it was tested in practical weather near Kushtia under the restricted area of the Bangladesh Water Development Board. A well-known industrial company discharges the wastewater after the treatment process in that area and the water is released into the river shown in figure 40.

Fig.40. Source of sampled water.

Afterwards using the same testing method as figure 37, on 22nd December a sample of this water was brought in for testing with the help of BWDB.

Fig.41. Test sample form river water where the treated water is released.

The test was repeated a few more times giving a much more reliable set of results as given in the table below.

| Test Count. | pH | Total Dissolved Solids (TDS) in mg/L | Turbidity in NTU | Temperature in °C |
|---|---|---|---|---|
| 1 | 6 | 165 | 3 | 25 |
| 2 | 6 | 163 | 5 | 25 |
| 3 | 8 | 168 | 5 | 25 |
| 4 | 8 | 164 | 6 | 25 |
| 5 | 7 | 163 | 4 | 25 |
| 6 | 7 | 163 | 7 | 25 |
| 7 | 6 | 163 | 4 | 26 |
| 8 | 7 | 165 | 4 | 25 |
| 9 | 7 | 163 | 7 | 25 |
| 10 | 7 | 163 | 4 | 25 |
| **Average Values** | 6.9 | 164 | 4.9 | 25.1 |

Table.4. Data table of all repeated readings found during testing.

The average values of the tested parameters are well under the limit, and it is safe to assume that this lake's water is not contaminated. However, this water needs some further purification before it is drinkable as currently it is not good for health [18]. Comparing this after treated lake water with tap water shows the pH value is still similar to the generic lake water value; this might have occurred due to the pre-existing water in the lake. The TDS and turbidity values are lower than the generic lake water value, but it is still higher than the tap water value. For the TDS value it is 10.07% more than the tap water value while it is 16.46% lower than the generic lake water value. For the turbidity value it is 145% more than the tap water value while it is 30% lower than the generic lake water value. Moreover, taking World Health Organization (WHO) and Bangladesh Standard Parameters as reference, the normal parameters are of pH should be 6.5-8.5, turbidity should be 1-10 NTU, TDS not more than 1000 and temperature should be 20-30 C [18]. As the water is released into a river it is bound to have a high turbidity value however it still maintains the WHO standards [18]. So, from this real-life cross checking it can be said that first of all this project is working perfectly to check parameters of water from ETP and secondly that renowned company is also following the proper steps to ensure the proper treatment process.

The final design chosen is an unmanned aerial vehicle (UAV)-based water sampler that enables remote monitoring as well as multiple source checks in a single flight and necessitates both theoretical and practical study. As the project progressed, it was discovered that certain equivalent requirements for the simulated UAV and prototypes. Here is a comparison of these:

| Evaluation Criteria | Theoretical Solution | Prototype Solution |
|---|---|---|
| Made of | Carbon fiber | Glass Fiber |
| Flight time | 80 minutes | 25.5 minutes |
| Flight Planning | Less Complex | Complex |
| Opt./Max. speed | 6m/s | 4-5 m/s |
| Vertical takeoff | Yes | Yes |
| Maneuverability | Best | Better |
| Payload | 1 kg | 600-800 gm |
| Stability | Highest | Good |
| Mechanical complexity | Medium | Highest |
| Energy efficient | Average | Average |
| Maintenance | less extensive | less extensive |
| Range | 21.6km | 18 km |
| Probe Clearance | NA | Better |
| Storage of sample water | 200 ml | 200-400 ml |
| Cost | 68,670 Taka | 80,000 Taka |

Table.5. Difference between theoretical solution and prototype solution.

We intended for a carbon fiber body and frame for our copter in our theoretical simulations, but this was not available in the present market, therefore we had to compromise our design with glass fiber. The flight time differed significantly because the vehicle's prototype consumed a large amount of power when maneuvering, so the ultimate flight time was up to 25.5 minutes. However, the budget increased due to numerous tests run failures, which required us to repurchase several components such as GPS, propellers, and motor.

### 5.4 Conclusion

During this project we learned many new things, this was mandatory as every step of the way we faced new challenges and obstacles where learning was necessary to overcome and move forward. The newfound hardware and software knowledge were crucial in building the prototype as things like soldering and calibrating are not common knowledge.

The prototype was also used several times to test water parameters where the weather was the biggest challenge that we came across forcing us to adapt and learn. Finally, the prototype was successful in measuring the water parameter for any given sample without much hassle as planned during the previous stages of this project.

# Chapter 6: Impact Analysis and Project Sustainability. [CO3, CO4]

## 6.1 Introduction

Today, we live in an interconnected society, where the impact of a project is so valuable. We are designing the project, not as a short-term solution but also for a better sustainable future, as an engineer, we should consider the entire perspective. The project's durability and alignment with the principles of social justice is included in the project sustainability. Water quality monitoring in the treatment plants will be easier by UAV – based system that provides instant data on some water quality parameters. The UAV- based monitoring system takes samples from the treated water and gathers data to provide us with information whether the water is treated or polluted. The main purpose of the whole process is to save natural resources.

## 6.2 Assess the impact of solution

We are going to discuss the societal, health, safety, legal and cultural revolution of the UAV-based remote monitoring and detraction of water contamination at effluent treatment plants below:

**Societal:** Using the UAV- based remote monitoring and detection system has opened a new revolution in the water quality management system of effluent treatment plants. This technology has a lot of societal benefits, and which is so helpful for the people of the society. UAV- based water quality management system plays a vital role in protecting public health of the society. When the drone tests the water instantly and provides real time data, the UAV helps the effluent treatment plant operator to detect and save the people's health from polluted water. Also, it will be beneficial for them to stop the hazardous contaminants into drinking water source. It reduces the chance of people to be exposed to aquatic pathogens and protects children, elderly people as well as the vulnerable group people of the society from various waterborne diseases, for example, cholera, typhoid, dysentery etc. So, it is clear that it safeguards the public health of society. As it helps the effluent treatment plant operator to reduce the number of pollutants in the environment, this project helps to protect the balance of the ecosystem and save aquatic life in a healthy way. Lastly, UAV based water quality monitoring system helps to bring long term growth and economic gains to society.

**Health:** A wide range of health effects are done by the UAV-based water quality monitoring system in the effluent treatment plants. We have discussed previously that it helps the authority to limit the discharge of the harmful chemicals into the drinking water and recreational water bodies by providing instant data of the water quality parameters which help the effluent treatment plant operator to detect the contamination level quickly. It's known that waterborne diseases are a serious global threat, affecting billions of people worldwide. Among of them the underdeveloped countries who don't have proper sanitation systems, water treatment process is most common. After consuming or using this contaminated water it is obvious that people will suffer from minor infection to serious diseases which can be fatal. The world health organization (WHO) evaluates the poor water, sanitation system and hygiene of about 420000 fatalities annually, where there are children under the age of five who are usually affected.

Children and the pregnant women are mainly affected by the chemicals found in the water bodies. As these pregnant women exposes in the toxins, there can be birth defects, delay in the development and other health issues in the fetus. This UAV-based water quality monitoring system helps to prevent these diseases by guaranteeing the water quality. We all know that it is our fundamental right as a human being to get clean drinking water. It is necessary for us for wellbeing and to keep good health.

**Safety:** After introducing the UAV based water quality monitoring system in the effluent treatment plants, the whole safety landscape will be changed. This will open a new era for the workers of the effluent treatment plant protection, protecting the environment and more effectively prevent the hazardous. This has the ability to provide instant data, which is beneficial to avoid human interaction with chemicals. Also, it will be helpful to increase safety and reduce accidents in the effluent treatment plants. In the traditional method, the workers have to go to dangerous places to collect the sample to test if the water is treated or not. The workers who have done this job have a risk to get touch with the contaminated water, the toxic gas and other dangerous chemicals. By using UAV-based water quality monitoring system in the effluent treatment plants, we can reduce the need of workers in those dangerous places and avoid injuries, occupational diseases etc. The article " Working Conditions at the Water Treatment Plants: Activities, Hazards, and Proactive Measures" can be found on the website, Research Gate. UAVs with different types of sensors can monitor the hazardous situation regularly and up to date the authority about the leak places and chemical concentration. This proactive process helps a lot to reduce the chance of hazardous chemicals escaping into the green environment, saving the ecosystem nearby and stopping the water pollution by taking immediate steps by the effluent treatment plant authority.

**Legal:** As this whole project is operating using UAV, the aviation law which includes the regulations for using the airspace and flight safety is applicable here. To operate the UAV more safely operator, have to follow the limitations. There are other benefits too, among them reducing the risk of UAV accidents, protection nearby people and the property of the ground are most common. It is most essential to follow the guidelines, get all the necessary authorization. Also, the operator has to make sure that the UAV operations are safe while the UAV is monitoring the water in effluent treatment plants. A comprehensive regulatory compliance framework for the specific operation should be developed by the interested parties in UAV- based water quality monitoring system. Also, authorities have to verify that the UAV operators are trained properly to fly the UAV following all the regulations and standard operating procedure. Privacy concerns arise as the case of the water monitoring UAV take pictures of collect data that contains personal information. The authority should set privacy and data protection rules to make sure the data collected by the UAV is used appropriately. To avoid unauthorized access, utilization or revelation of obtained data, robust data security systems can be introduced. To ensure the data is properly used, keeping data gathering limited is a good step. There is a good chance of having local or municipal regulations operating the UAV, which should be followed. For example, there are some local UAV flying zone rules, such as no fly over the significant infrastructure or public gatherings areas. Also, these regulations will help to make sure UAV is not breaking someone's privacy or becoming a threat to safety. Reducing UAV flying noise, especially in the residential or educational institution where noise is an issue.

**Culture:** It is true that the UAV based water quality monitoring system has a lot of technological facilities and efficiency in the operation. But we cannot deny the cultural impact of this project. It includes sharing water conservation and protection which helps to be responsible to the environment. As it has culture of transparency of data, accountability of the work and consciousness about the environment which not only help the communities to safeguard the water source. Also, becoming more conscious about the ecology and a good future. This UAV based water quality monitoring system helps to come up with innovative and sustainable water management system. Sustainable behavior and attitude in person and communities came from the UAV based water quality monitoring system which is a good example of the cultural impact. UAV is a good tool to change behavior and promote environmental awareness as they can understand the water contamination. The communities can use the data to raise campaigns which will increase awareness. Communities can come up with different water conservation initiatives. Make sure people are living more ecologically friendly. UAV technology is helping how we interact with the water resources and becoming more conscious about the environment for a good future by empowering the communities, increasing the awareness, increasing sustainable practices and by saving cultural heritage.

The tentative impacts of UAV-based remote monitoring and detection of water contamination at the effluent treatment plants in terms of various concerns are discussed below upon a SWOT analysis:

| **Strengths** | **Weaknesses** |
|---|---|
| • Increase the accessibility with coverage.<br>• Data gathering and analysis it instantly.<br>• Cost-effectiveness<br>• Increased security<br>• Quick reaction to any contamination incidents.<br>• Increasing efficiency of monitoring<br>• Environmentally friendly project.<br>• Data administration system and analysis of it have been better. | • Weather restrictions.<br>Battery life is limited.<br>• Sensor constraints.<br>• Limitations in data interpretation.<br>• Compliance with regulations.<br>• Public opinion.<br>• Connection to current monitoring systems.<br>• Possibility of abuse. |
| **Opportunities** | **Threats** |
| • Better treatment management monitoring.<br>• Contamination is detected quickly.<br>• Improved regulatory compliance.<br>• Less operational expenses of monitoring Better public safety.<br>• Better decision-making based on instant data.<br>• Water quality research is developing. New monitoring procedures are being developed.<br>• Water quality research is progressing. | • Concerns about personal privacy<br>• Risks to data security<br>• Data misinterpretation<br>• Over-reliance on technology Limitations of technology<br>• Limitations of the technology<br>• Error due to human error<br>• Integration difficulties<br>• The cost of upkeep and training |

Table.6. SWOT analysis.

**Potential Strength:** Some places in the effluent treatment plants, that are hard to access can be investigated by the UAV based water quality monitoring system more easily. Sensors that are used in the UAV can provide water quality indicator data instantly. This will help to identify any pollution as fast as possible. As the authorities are not going to monitor the water traditionally, it will less the labor cost. As the UAV is reducing the need for workers entering hazardous areas, it is potentially lowering the risk of exposure to hazardous chemicals. UAV can take high resolution pictures, which will help to find out the risk areas more effectively. UAV will make sure that the water is treated right way. Which means, it will lessen the chance of water contamination.

**Tentative Weaknesses:** The operation of UAV can be disrupted by unfavorable weather conditions arrive. For example, we can talk about intense rain, intense fog or strong gusts etc. This is one of the main limits of the UAV based water quality monitoring system in effluent treatment plants. The battery life of the UAV can reduce the duration of the monitoring system. This will reduce the flight time. The sensitivity and accuracy of the water quality monitoring system's sensors can be changed according to the specific chemicals and condition of the surroundings. At the case of the complex indicators of the water quality, expertise may be needed. To run the UAV activity, government approval of some regulations may be needed. For making sure the community involvement and confidence it can be a necessary thing to address the people's acceptance of UAV based water quality monitoring system. To integrate data in the monitoring system from the UAV, additional software and hardware may be needed. There is a good possibility of unauthorized use of UAV for data collection. Increasing security of the UAV data will prevent the risk of unauthorized access to the UAV.

**Possible Opportunities:** With more efficiently UAV can provide data instantly by monitoring the treatment process. This comes up with new chances for remote monitoring and water contamination detection at effluent treatment plants using UAV. Using the instant data getting from the UAV, the treatment process can get better, and the chance of pollution can be less. UAVs can detect pollution quickly before they have a bad impact on the environment or the people's health. The spread of the pollution can be stopped if the detection is done early. If the routine monitoring system is automated, the manual sampling is lessening, UAV will definitely cut the operation expenses. As a result, the operation efficiency will be increased. UAV will help the field of water quality research by providing high resolution data on the patterns and water contamination sources. The development of novel therapeutic strategies can be done if the knowledge is applied there. The sustainable water management system is done when the UAV identifies the source of water contamination. By preserving water resources, it can safeguard the ecological systems. As communities are involved in monitoring the quality of water the healthy water habit and the increase of knowledge of bad impact of using contaminated water will be increased.

**Tentative Threats:** Privacy concerns are being raised as the authorities may collect sensitive data and photos of human and private property. Endangering the security of the data, hacking the system, unlawful access to the data, can be a serious threat to the data collected by the UAV. Contamination events may be misleading or false positive information may be spread if there is a misinterpretation in the data of the UAV. The environment and the finances may suffer for this. The traditional monitoring method may become stale because of the over reliance on the UAV based water quality monitoring system. As a result, masking hidden issues or equipment failure can happen. In the part of the effectiveness of the UAV based monitoring system, issues with sensors, data transfer issues, software problem might have an impact. Human error happens during the operation or interpretation of the data can be misled the data gathered by the UAV. Concerns about privacy, noise issues, and lack of transparency can be a reason that people will oppose the UAV based water quality monitoring system. At the time of combination of UAV generated data with present monitoring system integration challenge may came up. The reason behind it can be lack of standards or problem with data compatibility. There always have to be a available fund as UAV maintenance and operation may need sudden investment in the sector of personal training, hardware and software.

### 6.3 Evaluate the sustainability

If the UAV based water contamination monitoring system is used for remote monitoring and water pollution finding at effluent treatment plants, the traditional way that water resources are managed and protected may change. Some of the advantages of this technology are, increased regulatory compliance, instant data collection, more efficiently monitoring system.

**Environmental Sustainability:** Promoting a more sustainable approach to water resources management, there are a lot of environmental advantages from UAV based water contamination and pollution detection in the effluent treatment plants. This procedure will reduce the impact on the environment if we compare it with other methods which we have used in monitoring systems. When we have used UAV to monitor, the carbon footprint of monitoring water contamination is lessened. In the other methods where we have used ground vehicles which use fossil fuels, the UAV used a battery, which is rechargeable. Promoting eco-friendly practice, there will be less greenhouse gas emissions when we have shifted to green energy sources. Now, people do not need to enter sensitive places to collect data, which make sure there is no damage to wildlife habitats and plants. Which is beneficial to the ecosystem. The ecosystem will be upset, and the environment will be destroyed if the traditional methods are used, as they use large aerial photography and ground sampling. UAVs can cover large areas and transfer high resolution data instantly, which is much more beneficial than traditional methods. Which results in less fuel, less labor and a small environmental impact. With the help of UAV based monitoring system, frequent data collection is possible which helps to better decision making. As UAV gives the authority real time data of the water, it helps a lot to identify the potential problem. The main outcome of this system is lessening the water pollution and efficient water management system.

**Economical Sustainability:** If we compare this UAV based water quality monitoring system with the other traditional methods it has cut the cost in every sector, and collect data more efficiently, so there is no doubt that it is more economically sustainable project. The worker that has to go in hazardous areas to collect samples simply doesn't need in the case of UAV based monitoring system. UAV saves people from waiting several times to test the sample and going for the place hard to reach out as UAV don't need to test the sample on the ground and send worker in the hazardous place to collect sample. Personal expenses are lessened, resource allocation is optimized, and efficiency of the operation is increased because of the system. UAV increased the comprehensive monitoring system of a large area. As it gives the data instantly, the authority is getting real time up to date data. As the problem is early recognized, the environmental damage can be avoided. This will help to reduce the fine, penalties, legal issues to the company by monitoring and maintaining the water quality. Also, this is helpful to keep the good name of the company. Effluent treatment plant authority can increase treatment operation by getting the real time data. This results in a more sustainable approach to the environment, treatment more effectively and lowering the cost. It is a affordable and long term using method to monitor the treated water. This process has reduced the contamination system, more efficient treatment process, increased regulatory compliance and monitoring area and lessen the cost.

**Social Sustainability:** Public participation and openness to water quality management is most important now a days and this can only be boosted by UAV based monitoring system. The UAV collects data and gives the data instantly, and the communities can be informed about the supply water they are using. Transparency makes a good bond between the public and the treatment plant owners by sharing the information to them. The risk of waterborne illness will be reduced by early detection of water pollution which safeguards the health of the public. By lessening the number of workers entering potentially dangerous areas, UAVs have increased safety and enable a secure and environmentally good monitoring system. Using safe water can be promoted through awareness campaigns that show data from UAV-based monitoring systems. Knowing about the causes and impacts of water pollution, reducing the overall load on the treatment system, and then communities can adopt more sustainable patterns of water consumption. To create a long-lasting water management system, UAV technology can cooperate among local governments, community organizations, city corporations and treatment plants owners.

## 6.4 Conclusion

The most sustainable and responsible step to the water management system is the utilization of UAV to monitor remotely and identifying water contamination level at effluent treatment plants is very important. With a balance between environmental, economic, and social sustainability, UAV based water quality monitoring system makes a way for a future in which water resources will be maintained, managed in an appropriate manner, and made available to all the people.

# Chapter 7: Engineering Project Management. [CO11, CO14]

## 7.1 Introduction

Three stages make up the Final Year Design Project: Design Report (D), Completion (C), and Proposal Writing (P). Shaping an idea into a physical object is a task that cannot be done alone, it requires the help of other members in the group. The combined efforts of many smart brains to overcome initial obstacles. This idea is reflected in the engineering project, which highlights the need of planning and team management within a group dynamic. Without a proper plan, efficient management, and cohesive teamwork any project is set up for failure. As a result, each team member was given a specific job, which was shown on a Gantt chart that was given to every member of the group. Throughout the project, strict adherence to this schedule was upheld. Despite the defined roles, mutual support was given as required to guarantee the best results at every step of the project.

## 7.2 Define, plan and manage engineering project

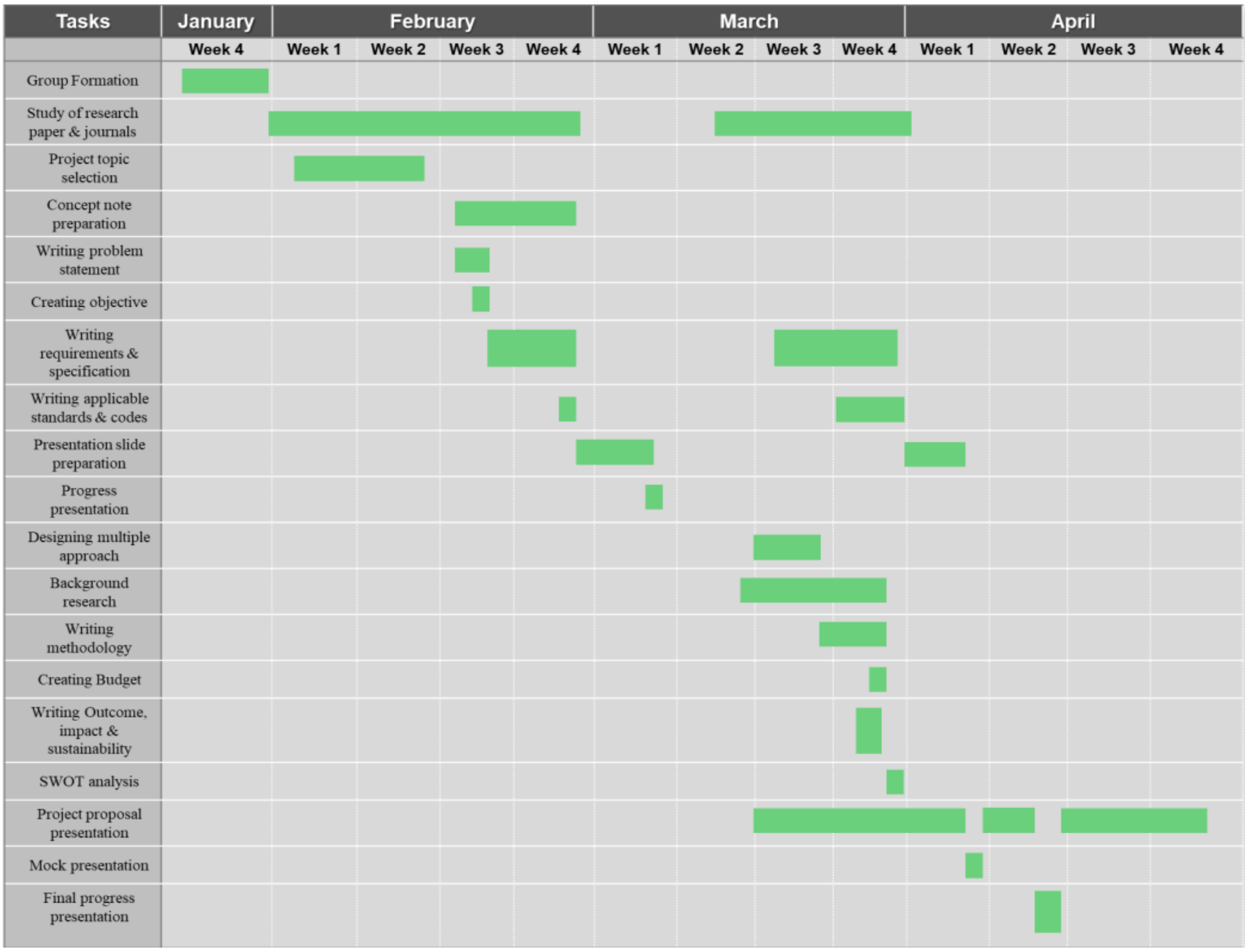


Fig.42. Gantt chart for EEE400P.

| Task | Start Date | End Date | Duration (Days) |
|---|---|---|---|
| Group formation | 19.01.23 | 26.01.23 | 7 |
| Study of research paper & journals | 01.02.2023 | 28.02.23 | 28 |
| Project topic selection | 04.02.2023 | 16.02.23 | 12 |
| Concept note preparation | 18.02.2023 | 28.02.23 | 10 |
| Writing problem statement | 19.02.2023 | 22.02.23 | 3 |
| Creating objective | 22.02.23 | 22.02.23 | 1 |
| Writing requirements and specification | 21.02.23 | 28.02.23 | 7 |
| Writing applicable standard and codes | 28.02.23 | 28.02.23 | 1 |
| Presentation slide preparation | 01.03.23 | 08.03.23 | 7 |
| Progress presentation | 09.03.23 | 09.03.23 | 1 |
| Designing multiple approach | 09.03.23 | 16.03.23 | 13 |
| Background research | 09.03.23 | 30.03.23 | 21 |
| Writing methodology | 23.03.23 | 30.03.23 | 7 |
| Creating budget | 30.03.23 | 30.03.23 | 1 |
| Writing outcome, impact & sustainability | 28.03.23 | 30.03.23 | 2 |
| SWOT analysis | 31.03.23 | 31.03.23 | 1 |
| Project proposal presentation | 18.03.23 | 06.04.23 | 20 |
| Mock presentation | 06.04.23 | 06.04.23 | 1 |
| Final presentation | 13.04.23 | 13.04.23 | 1 |

Table.7. FYDP-P project plan breakdown.

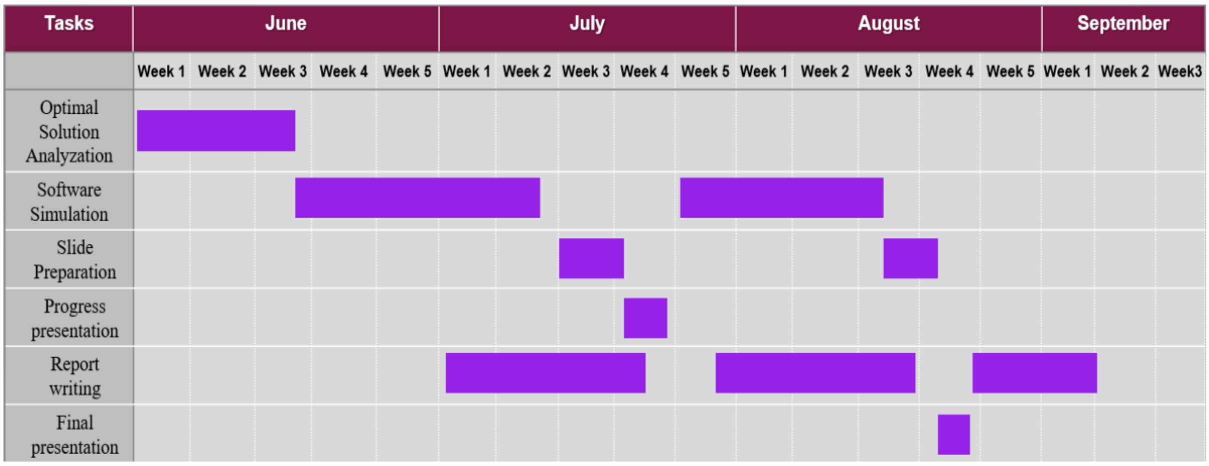


Fig.43. Gantt chart for EEE400D.

| Task | Start Date | End Date | Duration (Days) |
|---|---|---|---|
| Optimal solution analyzation | 03.06.23 | 22.06.23 | 19 |
| Software simulation | 22.06.23 | 13.07.23 | 22 |
| Slide presentation | 14.07.23 | 20.07.23 | 6 |
| Progress presentation | 27.07.23 | 27.07.23 | 1 |
| Report Writing | 01.08.23 | 07.09.23 | 38 |
| Final presentation | 31.08.23 | 31.08.23 | 1 |

Table.8. FYDP-D project plan breakdown.


Fig.44. Gantt chart for EEE400C.

| **Task** | **Start Date** | **End Date** | **Duration (Days)** |
|---|---|---|---|
| Equipment acquiring and testing | 23.09.23 | 13.10.23 | 20 |
| Development | 13.10.23 | 01.11.23 | 19 |
| Testing phase 1 | 01.11.23 | 07.11.23 | 6 |
| Testing phase 2 | 11.11.23 | 09.12.23 | 28 |
| Data collection | 10.12.23 | 23.12.23 | 13 |
| Slide preparation | 30.10.23 | 01.11.23 | 2 |
| Progress presentation | 02.11.23 | 02.11.23 | 1 |
| Report writing | 26.11.23 | 25.12.23 | 29 |
| Project showcase and final presentation | 14.12.23 | 14.12.23 | 1 |

Table.9. FYDP-C project plan breakdown.

## 7.3 Evaluate project progress

| Duration | Tentative plan | Actual progress | Progress status | Comment |
|---|---|---|---|---|
| 23.09.23 To 13.10.23 | Equipment acquiring | • Bought from different online website and local vendors. | Completed | Runing the functional tests for the components. |
| | Equipment testing | • Tested the sensors with different types of water. <br>• Tested the components of the UAV individually. | Completed. | N/A |
| 13.10.23 To 01.11.23 | Development | • Assembly of all the components for both the UAV and the sensor box. | Completed. | N/A |
| 01.11.23 To 07.11.23 | Testing phase 1 | • The sensor box was working as planed but the UAV could not take off due to a malfunctioning GPS. | Partially Completed. | N/A |
| 11.11.23 To 09.12.23 | Testing phase 2 | • The prototype as a whole was working as planned but the flight was not stable in harsh weather. | Completed. | N/A |
| 10.12.23 To 13.12.23 | Data collection | • Two sets of data were collected using tap water and lake water. | Partially Completed. | More sets of data need to be collected. |
| 13.12.23 To 23.12.23 | Data collection | • Ten more sets of data were collected using lake water from behind a factory. | Completed. | N/A |
| 30.10.23 To 01.11.23 | Slide Preparation | • Finalizing the progress result. <br>• Preparing progress report. | Completed. | N/A |
| 02.11.23 | Progress presentation | • Progress presentation in front of the ATC panel members. | Completed. | N/A |
| 26.11.23 To 25.12.23 | Report writing | • Compiling all the work done so far affording to the given format. | Completed. | N/A |
| 14.12.23 | Final presentation & Project showcase | • Finalizing the overall project. <br>• Preparing poster for the showcase. | Completed. | Cost based analysis missing. |

Table.10. Project progress evaluation.

**GPS Malfunction During Test Phase 1:** The store-bought GPS had a fault connector pin as a result the GPS could not properly connect to the Pixhawk, during calibration it would take long periods of time for it to detect its location. At the end through the Pixhawk's light it was confirmed, the Pixhawk shines blue light when it is armed without a GPS. Afterwards it was replaced with a new GPS which worked exactly as planned. This was confirmed through the Pixhawk's light, the Pixhawk shines green light when it is armed with a GPS.

**Unstable Flight During test phase 2:** The flight was unbalanced as the new GPS was heavier than the old one causing the UAV to tip on its side eventually due to this problem the UAV crashed and broke its propeller a few times as shown in figure 45.

Fig.45. Crashed UAV during test phase 2.

After this major setback new 10-inch propellers were used to replace them, and the components were moved around to distribute the weight evenly. Because of this setback the data collecting phase was delayed further. The UAV could have been made more stable with the use of a 3DR telemetry but during the equipment acquiring phase the specific model of telemetry could not be found however a replacement was bought but it was near impossible to set up with the Pixhawk that was being used.

**Setback During Data Collection Phase:** As no one in the project's group was an experienced UAV operator and the UAV used here had a testing unit at the bottom with a long pipe attached to it no one was confident enough to fly it over open water with the prior history of the UAV crashing on land. A different solution was used where the water was collected into a bucket and testing was done over it. During all this Bangladesh faced heavy rain fall which worked against us and delayed the data collection phase even further.

The lipo battery used for the prototype required a balance charger which would have been available in the university lab however due to the campus shift the labs were closed as a result the battery was charged using an alumni's personal balance charger but every time someone form the group had to travel to the alumni's place to charge the batter causing a huge waste of valuable time.

The lesson learned through all these setbacks was that better planning should have been made for potential failures in this project, all the setbacks came up very suddenly and unexpectedly causing all the group members to be baffled. However, without losing hope all the group members stayed focused and solved all the mishaps. Prioritizing the progress of the project above all, from making the UAV flyable and connecting the testing unit successfully with it to making the prototype serve its purpose by taking in water samples and providing output using the Blynk application. Now the prototype can perform onboard testing and provide real-time data of the parameters that were to be tested.

### 7.4 Conclusion

Project management is essential for engineers to realize their ideas from the ground up. It acts as a tool to simplify their daily lives and keep them on course. All the components that need to be found for a better success rate are covered by well-planned project management. The duties and the names of the employees assigned to them were first included in a timeline diagram. All members discussed, decided, and distributed this. By adhering to the schedule diagram, the 400P jobs were finished on time. Consequently, the procedure was carried out once more in 400D, and everyone had access to the Gantt chart. Everything went according to plan and was carried out in a methodical manner. To get similar positive results, the team is currently operating in 400C under the same conditions.

# Chapter 8: Economical Analysis. [CO12]

## 8.1 Introduction

When it comes to water, cleanliness matters. It is now crucial for society to integrate cutting-edge technologies to protect the most valuable resource, water. The financial implications of keeping an eye out for and identifying water contamination cannot be understated when calculating the price of water purification plants. It is crucial to acknowledge the economic context that shapes the importance of this research before delving into the specifics of the technology. Water is essential to various industries and is a vital component of agriculture. Given the nation's reputation as the "country of rivers," it might be assumed that there is an excess of water. However, considering current and future demands, it becomes apparent that there is an insufficient supply of clean water sources. In this context, recycling tainted water becomes a profitable and necessary business endeavor. Water quality monitoring has traditionally relied on labor-intensive and time-consuming procedures that often entail significant financial costs. Nevertheless, with remote water quality monitoring, the costs will be considerably lower, and the process will be more efficient, resulting in a significant positive economic impact on the project.

## 8.2 Economic analysis

Remote monitoring and water pollution detection have critical economic implications. This project's viability and relevance must be understood considering Bangladesh's water uses.

| Sector | Current Demand 2011 in $km^3$ |
|---|---|
| Agricultural | 33 |
| Domestic | 2.7 |
| Industrial | 0.08 |
| Forest | 2.9 |
| Fisheries | 5.2 |
| Environmental Flows | 106 |

Table.11. Water distribution in Bangladesh.

Despite the country's wealth of rivers, the main uses of water in the nation are for residential, agricultural, and fishery purposes, as the above table illustrates. Despite having the lowest water needs, industry has a major impact on water contamination. Water bodies now need to have their water quality regularly checked in order to make educated decisions, which has made the need for water purification plants necessary. With over 4000 million cases of waterborne illnesses, Bangladesh faces significant yet necessary associated costs.

In this field, the suggested project represents a novel approach. A relatively small capital need makes the initial investment more manageable and less hazardous. Because of the low operating costs, the investment can be recovered after a few years of use. There is an upfront cost associated with the implementation of remote monitoring, which includes sensor technology, communication infrastructure, and system integration. Although this requires financial investment, it sets the stage for a revolutionary change in the way that water quality monitoring is conducted.

This project's low maintenance requirements are its most economic feature. By using a remote water quality tester, operational costs can be cut by half when taking into account the costs of labor-intensive tasks including physical labor, transportation for collecting water samples, and laboratory testing for routine water quality checks.

### 8.3 Cost benefit analysis

Their attempt to put in place a remote monitoring and detection system for water contamination within the constraints of a limited budget is a tribute to resource optimization and the quest for economical technological solutions. They will look at how much conventional water quality testing costs and how their project can change the game. The table below gives the budget of the UAV based water monitoring system from this project.

| Components name | Quantity | Unit Price | Line Total in BDT |
|---|---|---|---|
| Frame | 1 | 12000 | 12000 |
| Propellers | 4 | 250 | 1000 |
| Servo motor | 1 | 600 | 600 |
| Brushless DC Motor | 4 | 2000 | 8000 |
| Electronic Speed Controller | 4 | 2400 | 9600 |
| PDB | 1 | 600 | 600 |
| Flight Controller | 1 | 9000 | 9000 |
| Microcontroller -ESP8266 | 1 | 420 | 420 |
| Camera | 1 | 5000 | 5000 |
| Radio Controller | 1 | 12000 | 12000 |
| Lipo battery | 1 | 8000 | 4000 |
| DC Pump | 1 | 300 | 300 |
| Ph Sensor | 1 | 1200 | 1200 |
| TDS Sensor | 1 | 3000 | 3000 |
| Turbidity Sensor | 1 | 1400 | 1400 |
| Temperature Sensor | 1 | 550 | 550 |
| **Total budget** | | | **68,670** |

Table.12. Total budget of the prototype.

The table below shows the approximate lifetime and the cost needed to replace them.

| Equipment | Approximate Lifespan | Unit Price |
|---|---|---|
| Frame | Lifetime | 12000 |
| Propellers | Lifetime | 250 |
| Servo motor | 30,000 hours (3.4 years) | 60 (bearing) |
| Brushless DC Motor | 20,000 hours (2.3 years) | 1550 |
| Lipo battery | 500 charge cycles | 4000 |
| DC pump | 20,000 hours (2.3 years) | 300 |
| pH sensor | 12960 hours (1.5 years) | 1200 |
| TDS sensor | 17,520 hours (2 years) | 3000 |
| Turbidity sensor | 17,520 hours (2 years) | 1400 |
| Temperature sensor | 35,040 hours (4 years) | 550 |

Table.13. Approximate lifetime and cost for replacement of various components.

The table below shows the total cost for ten different companies and provides an understanding of the amount of money spent for every set of these four tests.

| Test name | Cost 1 | Cost 2 | Cost 3 | Cost 4 | Cost 5 | Cost 6 | Cost 7 | Cost 8 | Cost 9 | Cost 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **PH** | 50 | 200 | 300 | 600 | 920 | 400 | 500 | 375 | 400 | 200 |
| **Temperature** | 50 | 150 | N/A | N/A | 575 | N/A | N/A | N/A | N/A | N/A |
| **Turbidity** | 50 | 200 | 300 | 700 | N/A | 400 | 1000 | 375 | 600 | 200 |
| **TDS** | 50 | 400 | 500 | 1200 | 1495 | 400 | N/A | 825 | 1000 | 750 |
| **Total Cost** | 200 | 950 | 1100 | 2500 | 2990 | 1200 | 1500 | 1575 | 2000 | 1150 |
| **Average Cost** | (Summation of all cost/10) = **1518.5 BDT** | | | | | | | | | |

Table.14. Average cost for testing in labs.

The 10 companies below were used to find these 10 individual costs.

**Company 1:** Government of the People's Republic of Bangladesh, Department of Public Health Engineering (DPHE), Water Quality Monitoring & Surveillance Circle

**Company 2:** Eco Technology BD

**Company 3:** WQTL, NGO Forum for Public Health & CoxLab

**Company 4:** BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA, DEPARTMENT OF CIVIL ENGINEERING

**Company 5:** Bangladesh reference institute for chemical measurements (BRICM)

**Company 6:** International Centre for Diarrheal Disease Research, Bangladesh (ICDDR,B)

**Company 7:** Jashore University of Science and Technology

**Company 8:** River Research Institute, Bangladesh.

**Company 9:** Khulna University of Engineering & Technology

**Company 10:** Center for Research, Testing and Consultancy, Department of Civil and Environmental Engineering, Shahjalal University of Science and Technology

There are four government institutions, two private institutions, and four government universities among them. All of these test's range in price from 200 BDT to 2990 BDT. The lesser the price, the longer the test result delivery time. It is around 1518.5 BDT on average for all four of these tests. If the treatment facility tests their treated water everyday for a year straight it will cost them 5,54,252.5 BDT on average. However, with only 70,000 BDT the facility can run tests every day for a year straight saving them 4,84,252.5 BDT yearly assuming the device is not harmed or crashed at all. In reality whenever the facility runs a test on their treated water, they have to wait for the lab to perform the test and come back to them with the results. But the prototype provides real-time data saving time. Only two ways the prototype can cost more money; if the prototype crashes it will cost money and the battery.

The 5500 mAh lipo battery gives a minimum of about 20 minutes of flight time on a single charge. With 500 cycles of charge, it can last up to 10,000 minutes, if every test takes 10 minutes each battery will be able to complete 1000 tests in its lifetime. So, one test a day gives the battery about 2.7 years of total life span. The only problem is the battery needs to charge. However, in a facility with an ETP plant this cost will be insignificant.

This prototype will not only save money but also save time while also saving manpower of all the sample collection transport cost and time.

### 8.4 Evaluate economic and financial aspects

Because the budget is so small, less than 70,000 BDT, it is necessary to distribute the available resources in a planned manner. The project has been optimized with components that are readily available in the local area, which has allowed the cost to remain within the restrictions of the budget. The components that are utilized have a long operational life value, and about maintenance, it is possible to be certain that the expenses of operation and maintenance are kept to a minimum. The project has been positioned as a potential economic success because of these two components of the project. While financially saving about 4,84,252.5 BDT yearly.

### 8.5 Conclusion

Considering the financial aspects of remote monitoring and real-time data collection, this project highlights the potential inherent in the suggested technology solution. Prudence, economy, and efficiency are shown on the financial landscape tour. The project's capacity to maximize financial restrictions is demonstrated by the thoughtful allocation of resources within the allocated budget. The project's emphasis on low-maintenance design is evidence of its dedication to sustainability as well as its alignment with fiscal constraints. The well-considered utilization of resources is shown in the outcome-driven approach to ROI optimization within the allocated budget. The project's attention to an economical and environmentally friendly method of energy consumption is demonstrated by its commitment to cost-effective regulatory compliance. This helps to improve the state of the economy in addition to avoiding possible penalties. The economic horizons are expanded as they forge ahead with innovation, making a strong argument for the general adoption of this game-changing technology.

# Chapter 9: Ethics and Professional Responsibilities CO13, CO2

## 9.1 Introduction

Engineers are professionals with moral obligations based on a dedication to improving public welfare. Their goals are well-founded on self-control and the advancement of general welfare. They believe that technology is made to make people's lives easier. No matter how well-intentioned, the initiative must not stray from morality, inconvenience unconnected parties, or result in unfavorable outcomes. Following moral principles is thought to be a more humanitarian course of action that can avert future legal problems and prevent possible harm. A professional engineer guarantees integrity and accountability for both financial and environmental benefits, being aware of potential harm and unethical behavior. The team was able to accomplish the project's goal by carrying out its duties with integrity and respect for all available resources.

## 9.2 Identify ethical issues and professional responsibility

The first and for most ethical issue that arises is how to use the prototype, it offers a very cheap solution for a very expensive problem which will definitely attract the new companies with ETP or the ones that are having financial problems. This is a very risky device where without proper control over it can cause serious financial and physical harm. Here it is the professional responsibility to warn the user of this potential risk.

Secondly the safety of the client's data where they will have data logs of all the stored parameters should be kept private as this is their private information where the rival companies can use this opportunity to defame them. Here the professional responsibility is to keep their data safe with them.

Lastly the lifetime presented earlier was an approximate lifetime, components may turn out to be faulty so regular testing and maintenance of the device must be done to avoid such an occurrence as it is neither the intention of the project nor the ethical way of doing this. Here the professional responsibility is to be open about this responsibility.

## 9.3 Apply ethical issues and professional responsibility

In terms of flying a UAV on its own is a very difficult job, let alone with a testing unit underneath can make the task even more complex hence having a dedicated personal who is professional at controlling the UAV is crucial for the proper utilization of this project. However, the operator must also abide the guidelines of the Bangladesh Aviation Committee which are also given below:

- The operator of a UAV must be at least 18 years old to operate the UAV.
- Any person operating a UAV in a unconscious manner that can damage or is likely to commit danger to the life or asset of another person is prohibited.
- Liability insurance for UAV operations is required to minimize the risks of danger to the person or property issue.

- The operator will not be continuing to fly a UAV within eight to nine hours of drinking alcohol, while in terms of the effect of alcohol, or while consuming any drugs that may impair judgment to the point where the mission's safety is jeopardized in any way.
- When the parameters of water are fluctuating more, it's important to check it at least 2 times.
- In accordance with airspace conditions and limitations, UAVs are restricted from flying over army camps, emergency medical camps, stadiums, national Gathering spots and important government buildings (like the President's Home).
- UAV operations at 400-500 feet or less. In the country, the approximate altitude in the air from ground is 250 feet.
- If there is reason to believe that the operator operating such machines is damaged or is likely to be fatigued soon, or if the user had other conditions that would render him critical to perform the duties, the pilot will not continue to operate the UAV.
- Bangladesh permits the use of unmanned aerial vehicles (UAVs), but any decisions need to be approved by the air traffic control authority.
- The person operating the UAV must have a hand-held fire extinguisher nearby in case of an emergency.

In order to protect the client's data, it is possible for the user to have their own Blynk account where no one else has access to providing full control and power over the found data. The lifetime of the components is guaranteed by the manufacturers they are not made in the project so the components should be bought directly from the manufacturers as a result is things do not work out reaching out to them will be an option.

### 9.4 Conclusion

The task at hand is to construct a machine that is not just efficient but also compassionate. The examination of moral dilemmas and professional obligations in the field of remote monitoring and collection of real-time data of water contamination in effluent treatment plants emphasizes how important it is to strike a balance between technological advancement and a responsible commitment to environmental and societal obligations. By addressing privacy and data security concerns, the project shows its dedication to stakeholders and reassures them that confidential data will be protected. This level of priority given to ethical and professional responsibility in this project proves its dedication towards a safely regulated device that respects ethics and personal privacy.

# Chapter 10: Conclusion and Future Work.

## 10.1 Project summary/Conclusion

In conclusion the project's main goal is to observe water quality in effluent treatment plants (ETPs), this will be done remotely and through this the user will be aware of the significant properties of the water. This project is done keeping in mind the importance of water and the dangers caused if not maintained properly. With the combination of onboard testing and water sampling using UAV a different solution was proposed to the already existing problem.

A detailed comparison among all three approaches revealed that the UAV-based water sampler proposed in approach 1, comes out as the most efficient and reliable choice. This approach grants the ability to collect and test samples from different sources in one flight with minimal threats to the environment and the prototype itself. Moreover, the allocated budget substantiates the feasibility of this option. While design approach 2 involves underwater vehicles, it faces challenges like waterproofing and communication. Design approach 3 emphasizes continuous water quality monitoring but lacks the ability to collect additional samples.

In this project a prototype of the design approach 1 UAV based water sampler was constructed to perform remote monitoring of water samples found in effluent treatment plants. This was done by utilizing four sensors pH, TDS, turbidity and temperature. Using ESP8266 module the values of all these individual sensors are transferred to the user through blynk. The sensor box itself is placed under the UAV for better mobility, through the pump the sample water it taken in the sensor unit. With multiple samples the readings for all four sensors are collected and cross checked with reference. Hence the objective of remotely monitoring real-time data and providing an understanding of the level of contamination has been properly fulfilled.

## 10.2 Future work

**Increasing monitored parameters:** It will be possible for the unmanned aerial vehicle (UAV) to carry more sensors if the propeller size is increased, and more powerful motors are used. This will allow for the monitoring of a greater number of parameters.

**Odour monitoring around the ETP:** This device can be integrated with odour monitoring system by using UAV based chemical sensor system that can monitor odour in the effluent treatment plant [12].

**Pattern analyzing and predicting:** Using the data that has been collected, a machine learning algorithm may be constructed. This algorithm can forecast the future water quality based on the current condition, which provides the user or corporation with additional time to remedy any mistakes that they may have made. In general, enhancing the water quality throughout the ecosystem as a whole.

**Prioritizing ETP container by image processing:** It is also possible to integrate this device with image processing, which provides it with complete access and the freedom to choose which ETP container to monitor and which to ignore based solely on the color and texture of the waters in question.

## 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

Table.15. Attributes of Complex Engineering Problems (EP).

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

**Reasons for selecting P1: Depth of knowledge required:** Basic and specialized engineering knowledge was used to create the project. While planning the project, a lot of research was done to find the right information using research papers and studies. We also had to utilize the STEM knowledge for implementing our project.

**Reasons for selecting P3: Depth of analysis required:** The assembly and simulation of the UAV and the sensors using IOT ESP8266 to transfer wireless data requires in detail analysis on pre-existing works and papers. Examining data from research papers and comprehending them to identify the shortcomings in previous works. Based on this understanding, three alternative designs were generated.

**Reasons for selecting P6: Extent of stakeholder involvement and needs:** This initiative is important to any companies or factories with a functional ETP, it can also be used for survey.

**Reasons for selecting P7: Interdependence:** All the separate parts and subcomponents used in the project's prototype must work together for both construction of the prototype and to obtain the desirable output. Through this interdependence the whole project was able to stand on its feet.

### 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

Table.16. Attributes of Complex Engineering Activities (EA).

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

**Reasons for selecting A1: Range of resources:** Wide range of resources were essential for both the hardware and software implementations. To make the prototype resources for software like qgroundcontrol where required. Adequate knowledge of microcontroller programing was required. On the other hand, knowledge of various physical components such as ESC, Pixhawk, ESP8266 and many more were needed for the hardware prototype.

**Reasons for selecting A2: Level of interaction:** The project requires a great amount of social interaction both during the construction of the hardware, and knowledge assimilation.

**Reasons for selecting A4: Consequences for society and the environment:** There will be a significant reduction in the unintentional release of chemicals for ETP's to the ecosystem. This will not only raise the standards for water purification but also raise awareness among the locals.

# References


[1] Y. Hu and H. Cheng, “Water pollution during China’s industrial transition,” *Environmental Development*, vol. 8, pp. 57–73, Oct. 2013, doi: 10.1016/j.envdev.2013.06.001.

[2] M. Haseena *et al.*, “Water pollution and human health.,” *Environ Risk Assess Remediat*, vol. 01, no. 03,2017, doi: 10.4066/2529-8046.100020.

[3] R. Singh Asiwal, S. Kumar Sar, S. Singh, and M. Sahu, “Wastewater Treatment by Effluent Treatment Plants,” *IJCE*, vol. 3, no. 12, pp. 19–24, Dec. 2016, doi: 10.14445/23488352/IJCE-V3I12P105.

[4] M. Dunbabin, A. Grinham, and J. Udy, “An autonomous surface vehicle for water quality monitoring,” in *IEEE International Conference on Robotics and Automation* 2009, Available: https://api.semanticscholar.org/CorpusID:13027579

[5] H.-C. Chang, Y.-L. Hsu, S.-S. Hung, G.-R. Ou, J.-R. Wu, and C. Hsu, “Autonomous Water Quality Monitoring and Water Surface Cleaning for Unmanned Surface Vehicle,” *Sensors*, vol. 21, no. 4, p. 1102, Feb. 2021, doi: 10.3390/s21041102.

[6] N. A. Cruz and A. C. Matos, “The MARES AUV, a Modular Autonomous Robot for Environment Sampling,” in *OCEANS 2008*, Quebec City, QC, Canada: IEEE, 2008, pp. 1–6. doi: 10.1109/OCEANS.2008.5152096.

[7] M. S. U. Chowdury *et al.*, “IoT Based Real-time River Water Quality Monitoring System,” *Procedia Computer Science*, vol. 155, pp. 161–168, 2019, doi: 10.1016/j.procs.2019.08.025.

[8] C. Cavalhieri, “Water sampling with drones,” *XXIII Brazilian Symposium on Wate Resources Jan. 2019,* Available: https://www.academia.edu/43290682

[9] C. Koparan, “UAV-Assisted Water Quality Monitoring,” Clemson University 2020 Available: https://core.ac.uk/download/pdf/354492827.pdf

[10] M. Sibanda *et al.*, “Application of Drone Technologies in Surface Water Resources Monitoring andAssessment: A Systematic Review of Progress, Challenges, and Opportunities in the Global South,”*Drones*, vol. 5, no. 3, p. 84, Aug. 2021, doi: 10.3390/drones5030084.

[11] P. Agarwal and M. K. Singh, "A multipurpose drone for water sampling & video surveillance," 2019 International Conference on Advanced Computational and Communication Paradigms (ICACCP), Gangtok, India, 2019, pp. 1-5, doi: 10.1109/ICACCP.2019.8883017.

[12] J. Burgués, S. Doñate, M. D. Esclapez, L. Saúco, and S. Marco, “Characterization of odour emissionsin a wastewater treatment plant using a drone-based chemical sensor system,” *Science of The Total Environment*, vol. 846, p. 157290, Nov. 2022, doi: 10.1016/j.scitotenv.2022.157290.

[13] J.-P. Ore, S. Elbaum, A. Burgin, and C. Detweiler, “Autonomous Aerial Water Sampling,” *Journal of Field Robotics*, vol. 32, no. 8, pp. 1095–1113, May 2015, doi: https://doi.org/10.1002/rob.21591.

[14] “IEEE Standard for an Architectural Framework for the Internet of Things (IoT),” IEEE. doi:10.1109/IEEESTD.2020.9032420.

[15] "Drone Laws in Bangladesh [Updated March 16, 2023]," *https://drone-laws.com/*. https://drone- laws.com/drone-laws-in-bangladesh/ (accessed Apr. 03, 2023

[16] M. Rafiqul Islam, "A Study on the TDS Level of Drinking Mineral Water in Bangladesh," *American Journal of Applied Chemistry*, vol. 4, no. 5, p. 164, 2016, doi: https://doi.org/10.11648/j.ajac.20160405.11.

[17] Md. R. Hasan, H. Bosu, and R. Ahamed, "Study of Water Quality Parameters of Buriganga River Adjacent to Dhaka City," Jun. 2022, Available: https://www.researchgate.net/publication/363312025

[18] Md. I. Hossain and Md. A. R. Bhuiyan, "Assessment of Water Quality Parameters and Associated Health Impacts of Supplied Drinking Water in Mohakhali and Banani Area of Dhaka City, Bangladesh," Jun. 2021, doi: https://doi.org/10.9790/2402-1506025966.

# Appendix

**Related code:**

```
#include <ESP8266WiFi.h>
#include <SoftwareSerial.h>

SoftwareSerial sensorSerial(3, 1);

const char* ssid = "YourWiFiSSID";
const char* password = "YourWiFiPassword";
const char* serverHost = "yourserver.com";
const int serverPort = 80;

const int pHPin = 0;
const int temperaturePin = 4;
const int turbidityPin = 5;
const int dissolvedOxygenPin = 6;
const int pumpRelayPin = 13;

bool pumpOn = false;

void setup() {
  Serial.begin(9600);
  sensorSerial.begin(9600);

  pinMode(pHPin, INPUT);
  pinMode(temperaturePin, INPUT);
  pinMode(turbidityPin, INPUT);
  pinMode(dissolvedOxygenPin, INPUT);
  pinMode(pumpRelayPin, OUTPUT);
```

```
  // Turn off the pump initially
  digitalWrite(pumpRelayPin, LOW);

  connectToWiFi();
}

void loop() {
  float pHValue = readpHValue();
  float temperature = readTemperature();
  float turbidity = readTurbidity();
  float dissolvedOxygen = readDissolvedOxygen();

  Serial.print("pH Value: ");
  Serial.println(pHValue, 2);
  Serial.print("Temperature: ");
  Serial.println(temperature, 2);
  Serial.print("Turbidity: ");
  Serial.println(turbidity, 2);
  Serial.print("Dissolved Oxygen: ");
  Serial.println(dissolvedOxygen, 2);

  sendSensorData(pHValue, temperature, turbidity, dissolvedOxygen);

  if (pumpOn) {
    if (shouldTurnOffPump(pHValue, temperature, turbidity, dissolvedOxygen)) {
      turnOffPump();
    }
  } else {
    if (shouldTurnOnPump(pHValue, temperature, turbidity, dissolvedOxygen)) {
      turnOnPump();
    }
```

```
  }

  // Check for remote commands to control the pump
  checkRemoteCommands();

  delay(1000);  // Delay between readings
}

float readpHValue() {
  int pHRawValue = analogRead(pHPin);  // Read analog value from the pH sensor
  float pHValue = map(pHRawValue, 0, 1023, 0, 14);
  return pHValue;
}

float readTemperature() {
  int temperatureRawValue = analogRead(temperaturePin);  // Read analog value from the temperature
sensor
  float temperature = temperatureRawValue * 0.48875855;
  return temperature;
}

float readTurbidity() {
  int turbidityRawValue = analogRead(turbidityPin);  // Read analog value from the turbidity sensor
  float turbidity = turbidityRawValue / 10.23;
  return turbidity;
}

float readDissolvedOxygen() {
  int dissolvedOxygenRawValue = analogRead(dissolvedOxygenPin);  // Read analog value from the
dissolved oxygen sensor
  float dissolvedOxygen = dissolvedOxygenRawValue / 10.23;
  return dissolvedOxygen;
```

```
}

void connectToWiFi() {
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
  }

  Serial.println("Connected to WiFi");
}

void sendSensorData(float pHValue, float temperature, float turbidity, float dissolvedOxygen) {
  WiFiClient client;

  if (client.connect(serverHost, serverPort)) {
    String url = "/api/?";
    url += "pH=" + String(pHValue, 2);
    url += "&temperature=" + String(temperature, 2);
    url += "&turbidity=" + String(turbidity, 2);
    url += "&dissolvedOxygen=" + String(dissolvedOxygen, 2);

    Serial.print("Sending data to server: ");
    Serial.println(url);

    String request = "GET " + url + " HTTP/1.1\r\n" +
                     "Host: " + serverHost + "\r\n" +
                     "Connection: close\r\n\r\n";

    client.print(request);
```

```
    Serial.println("Data sent to server");

    while (client.connected()) {
      if (client.available()) {
        String response = client.readStringUntil('\n');
        Serial.println(response);
      }
    }
    client.stop();
    Serial.println("Server connection closed");
  } else {
    Serial.println("Failed to connect to server");
  }
}

bool shouldTurnOnPump(float pHValue, float temperature, float turbidity, float dissolvedOxygen) {
  if (pHValue < 6.5) {
    return true;
  }
  return false;
}

bool shouldTurnOffPump(float pHValue, float temperature, float turbidity, float dissolvedOxygen) {
  if (pHValue > 7.5) {
    return true;
  }
  return false;
}

void turnOnPump() {
```

```
  digitalWrite(pumpRelayPin, HIGH); // Activate the relay to turn on the pump
  pumpOn = true;
  Serial.println("Pump turned on");
}

void turnOffPump() {
  digitalWrite(pumpRelayPin, LOW); // Deactivate the relay to turn off the pump
  pumpOn = false;
  Serial.println("Pump turned off");
}

void checkRemoteCommands() {
  WiFiClient client;

  if (client.connect(serverHost, serverPort)) {
    String request = "GET /api/pumpstate HTTP/1.1\r\n"+"Host: " + serverHost + "\r\n"+"Connection: close\r\n\r\n";
    client.print(request);

    while (client.connected()) {
      if (client.available()) {
        String response = client.readStringUntil('\n');
        response.trim();

        if (response.startsWith("PumpState:")) {
          String state = response.substring(response.indexOf(":") + 1);
          state.trim();

          if (state.equalsIgnoreCase("ON")) {
            if (!pumpOn) {
              turnOnPump();
```

```
        }
      } else if (state.equalsIgnoreCase("OFF")) {
        if (pumpOn) {
          turnOffPump();
        }
      }
    }
  }
}
client.stop();
}
}
```

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REMOTE MONITORING AND DETECTION OF WATER CONTAMINATION IN EFFLUENT TREATMENT PLANTS

**Group: 5**

| NAME | ID |
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| Koushik Das | 19221007 |
| Mishkat Abir | 19121089 |
| Taskia Galiba | 19321015 |

**This is a testimony to acknowledge that FYDP Group:5 has been permitted for testing across the area under**

বাংলাদেশ পানি উন্নয়ন বোর্ড, কুষ্টিয়া

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BWDB Bheramara, Kushtia.

**Signature (Designated Authority)**

# FYDP (P) Spring 2023 Summary of Team Log Book/ Journal

| | **Final Year Design Project (P) Spring 2023** | | |
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**General Notes:**

1. In addition to detail journal/logbook fill out the summary/key steps and progress of your work
2. Reflect planning assignments, who has what responsibilities.
3. The logbook should contain all activities performed by the team members (Individual and team activities).

# FYDP (P) Spring 2023 Summary of Team Log Book/ Journal

| Date/Time /Place | Attendee | Summary of Meeting Minutes | Responsible | Comment by ATC |
|---|---|---|---|---|
| February 9, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Project Shortlisting and Selection | Koushik Das<br>Akib Hossain<br>Taskia Galiba<br>Mishkat Abir | Finalized to start working on ETP Monitoring |
| February 23, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Got advised regarding how to do background research and received some resources from the meeting. | Koushik das<br>Akib Hossain | Talked about background research<br>Start Preparing for Concept Note |
| March 2, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Discussed regarding literature gaps Got ideas regarding the title of the project and how to make difference between approaches. | Akib Hossain<br>Koushik Das<br>Taskia Galiba | Decided Title and start Research for Multiple Design Approaches |
| March 9, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Talked about specifications and finalized functional and non functional requirements | Akib Hossain<br>Koushik Das | Searching Data For Requirements, specification |
| March 16, 202 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | .Finalizing Concept Note | Mishkat Abir<br>Taskia galiba | Advised to do some change in scope and objectives |
| March 17, 202 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Preparing Presentation Slide | Koushik Das<br>Akib Hossain<br>Taskia Galiba<br>Mishkat Abir | Discussed slides and major things to do in time of presentation. |
| March 23, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Preparing Presentation Slide | Akib Hossain<br>Koushik Das<br>Taskia Galiba<br>Mishkat Abir | Progress Presentation |
| March 26, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Layout of Project Proposal | Koushik Das<br>Akib Hossain<br>Taskia Galiba<br>Mishkat Abir | Directed us to follow perfect format and to do some changes in background research |
| March 30, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Methodology Writing | Akib Hossain<br>Koushik Das | Advised us to do focus on flow chart and to show proper differences between design approaches |
| March 31, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Applicable Codes, Attributes, Impact Analyzing | Akib Hossain<br>Koushik Das | |
| April 4, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Budget making and problems in flow charts were discussed. | Koushik Das<br>Akib Hossain<br>Taskia Galiba<br>Mishkat Abir | some issues regarding requirements and specifications |
| April 4, 2023 | 1.Mishkat Abir<br>2.Akib Hossain | SWOT Analysis | Mishkat Abir | |

| | | | | |
|---|---|---|---|---|
| April 6, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Mock Presentation | Koushik Das<br>Akib Hossain<br>Taskia Galiba<br>Mishkat Abir | Advised us to revise the slide (problems with format ) and improve coordination among group mates. |
| April 12, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Final Presentation preparation | Koushik Das<br>Akib Hossain<br>Taskia Galiba<br>Mishkat Abir | Directed us in slide making over email. |
| April 20, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Updating Project Proposal | Taskia Galiba<br>Koushik Das | Doing some changes in impacts and log book. |
| April 26, 202 | 1.Koushik Das<br>2.Akib Hossain<br>3.Mishkat Abir<br>4.Taskia Galiba | Finalizing Project Proposal. | Koushik Das<br>Akib Hossain<br>Taskia Galiba<br>Mishkat Abir | |

# FYDP (D) Summer 2023 Summary of Team Log Book/ Journal

| | **Final Year Design Project (D) Summer 2023** | | |
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| | | | |

**General Notes:**

1. In addition to detail journal/logbook fill out the summary/key steps and progress of your work
2. Reflect planning assignments, who has what responsibilities.
3. The logbook should contain all activities performed by the team members (Individual and team activities).

# FYDP (D) Summer 2023 Summary of Team Log Book/ Journal

| Date/Time /Place | Attendee | Summary of Meeting Minutes | Responsible | Comment by ATC |
|---|---|---|---|---|
| June 8, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3.Taskia Galiba | Overview of the different simulation ways, different parameters to consider within the simulations and ways for 3d rendition of the simulations. | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | N/A |
| June 22, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | Selection of tools, and review of ways for simulation. | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | 3D simulation not clear, Proteus debug issue. |
| July 2, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | Presented the new 3D simulations with circuit diagrams but proteus issue was still there. | 1.Koushik Das<br>2.Akib Hossain | Identify the optimal approach comparing technical difficulty, sustainability, efficiency, economic analysis, and environmental analysis perspective. |
| July 4, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | Slide preparation for progress presentation. | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | N/A |
| August 3, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | Verification of simulations done for design approach 1 and 3. | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | Proteus simulation can be improved, lack of simulation regarding flight of the UAV. |
| August 4, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3. Taskia Galiba | Working in proteus to solve the problem in design approach 1 and 3. Also creating simulation for UAV flight simulation. | 1.Koushik Das<br>2.Akib Hossain | N/A |
| August 5, 2023 | 1.Koushik Das | Verification of simulations done for design approach 1, 2 and 3 with flight simulation for UAV. | 1.Koushik Das<br>2.Akib Hossain | N/A |
| August 16, 2023 | 1.Akib Hossain | Slide preparation for final presentation. | 1.Akib Hossain | Problem in title for 2 slides. Lack of quantative information |
| August 17, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | Mock presentation given. | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | Proper time management, better explanation of output from the Proteus simulation. |

# FYDP (D) Summer 2023 Summary of Team Log Book/ Journal

| | | | | |
|---|---|---|---|---|
| August 27, 2023 | 1. Mishkat Abir<br>2. Taskia Galiba | SWOT Analysis, ethical consideration, risk management and contingency plan. | 1. Mishkat Abir<br>2. Taskia Galiba | N/A |
| August 28, 2023 | 1.Koushik Das<br>2.Akib Hossain | Analyze the Multiple Design Solutions to Find the Optimal Solution and calculation. | 1.Koushik Das<br>2.Akib Hossain | N/A |
| August 29, 2023 | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | Report writing | 1.Koushik Das<br>2.Akib Hossain<br>3. Mishkat Abir<br>4. Taskia Galiba | N/A |

# FYDP (C) Fall 2023 Summary of Team Log Book/ Journal

| | **Final Year Design Project (C) Fall 2023** | | |
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| | | | |

**General Notes:**

1. In addition to detail journal/logbook fill out the summary/key steps and progress of your work
2. Reflect planning assignments, who has what responsibilities.
3. The logbook should contain all activities performed by the team members (Individual and team activities).

# FYDP (C) Fall 2023 Summary of Team Log Book/ Journal

| Date/Time/ Place | Attendee | Summary of Meeting Minutes | Responsible | Comment by ATC |
|---|---|---|---|---|
| October 5, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Overview of the entire project and how it is going to done. | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | To forward some pictures of our device. |
| October 26, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Testing of the sensors with Cocacola, Saline water and Mineral water using breadboard. | 1. Koushik Das<br>2. Akib Hossain | Testing was ok but the system had to be done using PCB rather than breadboard. |
| October 30, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Finalized the design of the PCB and order was placed on TechshopBD | 1. Koushik Das | N/A |
| November 1, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Preparation for progress presentation. | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Stepwise development pictures were missing. We were also instructed to remove simulation from the slide. |
| November 9, 2023 | 1. Koushik Das<br>2. Akib Hossain | Delivery of the PCB and started soldering. | 1. Koushik Das<br>2. Akib Hossain | N/A |
| November 23, 2023 | 1. Akib Hossain<br>2. Taskia Galiba<br>3. Mishkat Abir | Discussion on report and update on the prototype | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Speed up the report writing and prototype development. |
| November 30, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Discussion on how to solve the failed the test run for the prototype. | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | N/A |
| December 7, 2023 | 1. Akib Hossain<br>2. Taskia Galiba<br>3. Mishkat Abir | Discussion on the functional video and how to incorporate it in the report and poster. | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Scheduled another meeting to review on the poster for the final presentation. |
| December 12, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Mock defense. Poster and functional video demonstration. | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Economic analysis and objectives need to be in the poster. Functional videos needs to be more clear as the displayed Blynk data was not. |

# FYDP (C) Fall 2023 Summary of Team Log Book/ Journal

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| December 14, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Final presentation (defense) | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Economic analysis still needs work, more test runs should be made with proper analysis. |
| December 22, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Water collected for testing from a river where after treated water is released. | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | N/A |
| December 26, 2023 | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Submission of the first draft of the final report. | 1. Koushik Das<br>2. Akib Hossain<br>3. Taskia Galiba<br>4. Mishkat Abir | Contents of chapter 3 and 4 were mixed, Chapter 5 required more pictures of practical data. Project evaluation required more explanation, cost benefit analysis and ethical part required more work |