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Belagavi, Karnataka-590 018

A Project Report on

"Coral – A Smart Water Body Health Monitoring System"

A project report submitted in partial fulfillment of the requirement for the VIII semester degree of

Bachelor of Engineering
In
Electrical & Electronics Engineering

Submitted by

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2019-2020

CMR INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

AECS Layout, Bengaluru-560 037

Certificate

Certified that the project work entitled **"Coral – A Smart Water Body Health Monitoring System"** carried out by Mr. Nikhil Suresh, USN 1CR16EE050; Mr. Saket Vaibhav, USN 1CR16EE065; Mr. Shakthivel R, USN 1CR16EE072; Ms. Jyothsna S, USN 1CR16EE093 are bonafied students of CMR Institute of Technology, Bengaluru, in partial fulfillment for the award of Bachelor of Engineering in Electrical & Electronics Engineering of the Visvesvaraya Technological University, Belgaum, during the year 2019-2020. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library.

The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said Degree.

Signature of the Guide	*Signature of the HOD*	*Signature of the Principal*
Dr.Arijit Dutta, Assistant Professor EEE Department CMRIT, Bengaluru	Dr. K. Chitra Professor & HOD EEE Department CMRIT, Bengaluru	Dr. Sanjay Jain Principal, CMRIT, Bengaluru

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DECLARATION

We, [Mr.**Nikhil Suresh (1CR16EE050),** Mr. **Saket Vaibhav (1CR16EE065),** Mr. **Shakthivel R (1CR16EE072),** Ms. **Jyothsna S (1CR16EE093)**], hereby declare that the report entitled **"Coral – A Smart Water Body Health Monitoring System"** has been carried out by us under the guidance of **Dr. Arijit Dutta,** Assistant Professor, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirement for the degree of **BACHELOR OF ENGINEERING in ELECTRICAL & ELECTRONICS ENGINEERING**, of Visveswaraya Technological University, Belagaum during the academic year 2019-20.The work done in this report is original and it has not been submitted for any other degree in any university.

Place: Bengaluru	Nikhil Suresh	(1CR16EE050)
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Abstract

There is always talk about the current water crisis but despite this acute shortage of water, lakes all around the world are constantly being polluted. The people living near the lakes complain about pollution but aren't aware of just how dangerous or how polluted the lake actually is. Coral aims to monitor the lake health continuously by means of sensors and create awareness of the quality of water and helps improve the condition of the lake by alerting authorities and allowing people to bring about change. The sensors are connected to a microcontroller that continuously processes the data. This data is then sent to the servers. In the servers, a database is maintained. The database basically keeps a record of what the health of the lake has been like over time.

The data from lakes is displayed on a website. If the values change too sharply, a notification is sent to the authorities and a tweet is posted. This creates awareness and puts pressure on authorities to bring about change at the earliest.

Having clean lakes will increase beauty as well as marine life. The product is cost-effective and minimalistic yet very effective.

Acknowledgement

First of all, we are indebted to the GOD ALMIGHTY for giving us an opportunity to excel in our efforts to complete this project on time.

We are extremely grateful to ***Dr. Sanjay Jain****,* ***Principal, CMR Institute of Technology, Bengaluru*** *and* ***Dr. B Narasimha Murthy****, Vice-principal of CMR Institute of Technology and the whole* ***Management*** *for providing all the required resources for the successful completion of ourproject.*

We would like to convey our sincere gratitude to ***Dr. K Chitra****,* ***Head of Electrical and Electronics Engineering Department, CMR Institute of Technology, Bengaluru*** *for her invaluable guidance and encouragement and for providing good facilities to carry out this project work.*

Our heartfelt gratitude to ourproject guide ***Dr. Arijit Dutta, Assistant Professor, Electrical and Electronics Engineering, CMR Institute of Technology, Bengaluru****for his valuable suggestions and guidance in the preparation of the project report.*

We are thankful to all the faculties and laboratory staffs of ***Electrical and Electronics Engineering Department, CMR Institute of Technology, Bengaluru*** *for helping us in all possible manners during the entire period.*

We will be failing in duty if we do not acknowledge with grateful thanks to the authors of the references and other literatures referred to in this project.

Last but not the least; we are very much thankful to our parents who guided us in every step which we took.

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CHAPTER 1

INTRODUCTION

Basic Outline

One problem that is seen all over the world is the water crisis. There's a shortage of water in almost all the countries in the world and especially during the hotter seasons, the water crisis seems to be a very big issue.

Even though there is an issue such as water crisis, our freshwater sources are being polluted. Lakes and ponds in cities are being dumped with industrial wastes. The chemicals produced in the waste lead to a lot of destruction. The marine life of the water body suffers as well as water health. The chemicals affect the water in such a way that it is unusable for consumption or other use anymore.

The chemicals present in the water create froth. The froth is highly inflammable. On catching fire, there is a huge amount of chemicals released into the air. Air pollution makes life hard for all those living in the close vicinity of the water body. The polluted air also contributes to global warming in addition.

Marine life in a water body is very important as it feeds off the eggs and other insect eggs that are laid on the surface of any water body. They keep the population of insects such as mosquitoes in control. When the toxic chemicals are dumped into the lakes, marine life is effective very negatively. Most marine life dies and what is left of the marine life is in a very unhealthy condition. The dead fish contribute to more pollution of the water body.

If the water body is very polluted, it can cause various kinds of waterborne diseases. The chemical may not be biodegradable and may affect the underground water sources as well and cause a wide scale of health issues to

anyone living in close vicinity of the water body.

In a lot of cites, lakes, and ponds tend to be a recreational zone where people can go take a breath of fresh air. They are also known for sightseeing and leads to tourism which benefits the country.

The water bodies around us require immediate attention. Hence, there is an urgent need for an automated system that monitors the health of a water body and provides live data. This data must be accessible to everyone so that people know about the status of the water bodies around them. This will create awareness. Once people are aware, they can pressurize the government agencies to do something about cleaning the water bodies and imposing fines upon those who illegally dump wastes into them and also take individual steps.

What is IoT?

Figure 1. IoT (Internet of Things) Graphic

The Internet of things (IoT) is defined as a system of interrelated computing devices, mechanical and digital machines provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

In other words, the Internet of Things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. IoT is a convergence of multiple technologies such as real-time analytics, embedded systems, wireless sensor networks, control systems and automation.

It has a wide range of applications in multiple domains from consumer electronics, commercial, industrial and military equipment. The consumer electronics domain includes smart home, healthcare for the elderly and many

more. In the commercial and industrial domains the applications range from agriculture to transportation solutions and many more.

In the Internet of Things, all the things that are being connected to the internet can be put into three categories:

- Things that collect information and then send it.
- Things that receive information and then act on it.
- Things that do both.

Figure 2. Reach and Applications of IoT

Mesh Network

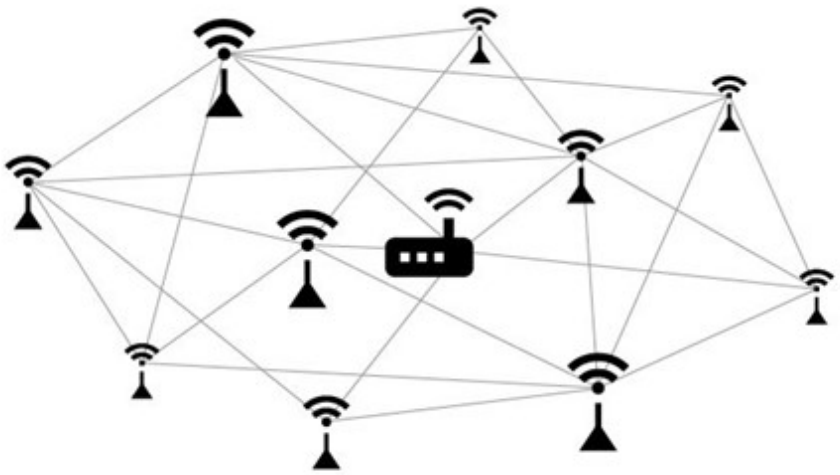

Figure 3. Mesh Network Diagram

A mesh network is a local network topology in which the infrastructure nodes (i.e. bridges, switches, and other infrastructure devices) connect directly, dynamically and non-hierarchically to as many other nodes as possible and cooperate with one another to efficiently route data from/to clients. This lack of dependency on one node allows for every node to participate in the relay of information. Mesh networks dynamically self-organize and self-configure, which can reduce installation overhead. The ability to self-configure enables dynamic distribution of workloads, particularly in the event a few nodes should fail. This in turn contributes to fault-tolerance and reduced maintenance costs.

A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes. Wireless mesh networks can self form and self heal. Wireless mesh networks work with different wireless technologies including 802.11, 802.15, 802.16, cellular technologies and need not be restricted to any one technology or protocol.

Mesh networks can relay messages using either a flooding technique or a routing technique. With routing, the message is propagated along a path by hopping from node to node until it reaches its destination. To ensure that all its paths are available, the network must allow for continuous connections and must reconfigure itself around broken paths, using self-healing algorithms such as Shortest Path Bridging. Self-healing allows a routing-based network to operate when a node breaks down or when a connection becomes unreliable. As a result, the network is typically quite reliable, as there is often more than one path between a source and a destination in the network.

Technologies Used

NodeMCU

NodeMCU is an open source firmware with open source prototyping boards.The name "NodeMCU" combines "node" and "MCU" (micro-controller unit). The prototyping hardware typically used is a circuit board with an dual in-line package form factor which integrates a USB controller with a small surface mounted board containing the MCU and antenna. The choice of the DIP format allows for easy and rapid prototyping on bread boards. The design was initially based on the ESP-12 module of the ESP8266, which is a Wi-Fi SoC integrated with a TensilicaXtensa LX106 core, widely used in IoT applications.

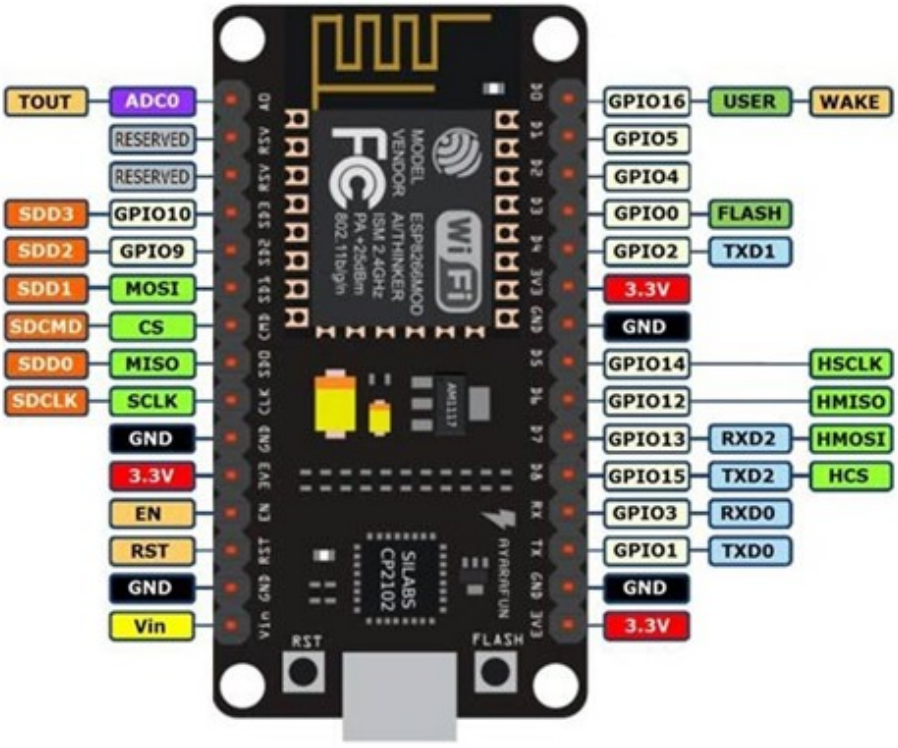

Figure 4. ESP8266 Circuit

Microcontroller	ESP8266-12F
Operating Voltage	3.3V
Digital I/O Pins	12
Analog Input Pins	1
Clock Speed	80MHz/160MHz
FLash	4M bytes
Length	64.3mm
Width	29.1mm

Table 1. ESP8266 Specifications

NodeMCU/ESP8266 has 17 GPIO pins which can be assigned to perform a multitude of functions. Each digital enabled GPIO can be configured to internal pull-up or pull-down, or set to high impedance. When configured as an input, it can also be set to edge-trigger or level-trigger to generate CPU interrupts.

pH Sensor

Potential of Hydrogen, which is abbreviated as pH, is a measure of acidity and alkalinity, or the caustic and base present in a given solution. It is generally expressed with a numeric scale ranging from 0-14. The value 7 represents neutrality. The numbers on the scale increase with increasing alkalinity, while the numbers on the scale decrease with increasing acidity with 14 being highly basic and 1 being highly acidic. In a water health monitoring system, pH sensor is used to measure the acidity and basicity of water.

The desirable pH of a water body is around 7 i.e., neutral. Acidic or basic nature of water is lethal to the aquatic habitat. Death of aquatic habitat, be it plants or animals, alters the aquatic cycle thereby causing an imbalance. This leads to contamination of the water body. Therefore, it is important to maintain the pH levels of a water body.

The conventional method to determine the pH of an unknown solution is by using a glass electrode method. In a glass electrode pH sensor, the pH is calculated by measuring the potential of the solution. In this method, the glass electrode is coupled with a standard calomel electrode which acts as the reference electrode. Both the electrodes are dipped in the solution whose pH is to be determined. The potential of the solution is measured by connecting a voltmeter across the two electrodes where the glass electrode acts as anode and standard calomel electrode acts as cathode. By knowing the potential of anode and cathode, the pH of the solution can be calculated.

Temperature Sensor

A temperature sensor is used to measure the temperature of the water. There are various temperature sensor types: a thermocouple, thermistor or a solid state temperature sensor.

Figure 5. Temperature Sensor

In our project, DS18B20 temperature sensor is employed to sense the temperature of water. The core functionality of the DS18B20 is its direct-to-digital temperature sensor. temperature directly determines which organisms, from zooplankton to fish, can live in the lake and in which parts they thrive. This is because each organism has an optimum temperature in which they can live, and therefore where they live, how well they thrive and their overall populations are determined by the temperature of the water body.

Temperature of water also determines which chemical reactions can take place, where they occur in the lake and when they happen. And these chemical reactions matter because they can result in the release of nutrients, potentially from the sediment, which can then go on to affect the rate of

significant events in the lake, such algal growth from increased phosphorus levels and mercury bioaccumulation in fish.

Conductivity Sensor

Conductivity sensor is employed to sense the number of ions present in the water The conductivity of water is an indication of the amount of ions and/or free flowing electrons that are present for the conduction of electricity.

The importance of finding conductivity of water in a health monitoring system is that the dissolved solvents and ions indicate that the water is impure.

Conductivity is usually measured in Siemens per meter (S/m) or micro-Siemens per centimeter (μS/cm). The conductivity sensor is designed using the two- or four electrode method and is based on Ohm's law. With a known resistor, voltage and current the resistance of the water solution can be calculated accordingly. The resistance of the water is measured by using two or four electrodes with a known cell constant. To determine the resistance between the electrodes, a voltage is applied across the electrodes.

Server and Data

In computing, a server is a computer program or a device that provides functionality for other programs or devices, called "clients". This architecture is called the client–server model, and a single overall computation is distributed across multiple processes or devices. Servers can provide various functionalities, often called "services", such as sharing data or resources among multiple clients, or performing computation for a client. A single server can serve multiple clients, and a single client can use multiple servers. A client process may run on the same device or may connect over a network to a server on a different device. Typical servers are database servers, file servers, mail servers, print servers, web servers, game servers, and application servers.

Client–server systems are today most frequently implemented by (and often identified with) the request–response model: a client sends a request to the

server, which performs some action and sends a response back to the client, typically with a result or acknowledgment. Designating a computer as "server-class hardware" implies that it is specialized for running servers on it. This often implies that it is more powerful and reliable than standard personal computers, but alternatively, large computing clusters may be composed of many relatively simple, replaceable server components.

Oftentimes, what is seen is that the servers are loaded up and can not serve a lot of clients which causes the server to crash and all the clients who are wanting to log into the website face errors and are unable to open up the website. One of the major causes of the loading of servers is too many requests.

The data we are using is in the form of JSON which stands for Javascript Object Notation. JSON is a lightweight format for storing and transporting data. JSON is often used when data is sent from a server to a web page. JSON is "self-describing" and easy to understand. This benefits us in multiple ways. The main ways being :-

1. Light weight hence amount of data that is transferred is small

2. It is easily modifiable. If we ever decide on adding more sensors, it can be done easily

3. JSON has a more compact style and it is often more readable. The lightweight approach of JSON can make significant improvements in RESTful APIs working with complex systems.

4. JSON uses less data overall, so the costs are reduced and the parsing speed is increased.

Due to the small data transfer, the loading on the server is minimal. Also, to reduce the loading on the server further we have kept a generous amount of periods before data is read from the server again. During the testing part of our project we gave it a period of 2 minutes before making any requests but in practical usage, the period is decided to be 30 minutes.

```
[
  {
    "NodeName":"NodeMCUone",
    "pH":"7",
    "Temperature":"30",
    "State":"Healthy"
  },
  {
    "NodeName":"ESP32one",
    "pH":"7",
    "Temperature":"28",
    "State":"Healthy"
  }
]
```

Figure 6. Water Quality Monitoring JSON Output Code Script

The server we are using now is GitHub to host our website and GithubGists are used for storing the JSON data. Since our website has been made with vanilla HTML, CSS and JS and since there has been no usage of any sort of framework, it is extremely light weight. This makes it easy for the users using weak connectivity devices or lesser powerful devices to also load up our page rather easily.

Website

The website is the Unique Selling Point of the project as it is the place where the live data is displayed. The different values that are read Apart from the live data information, the users that come to the website are given some information on how the project works and why it was made. The website also allows the user to post a tweet by clicking a button so as to increase the awareness about the condition of the different water bodies. The website can also display some information on how an unhealthy water body affects the health of people around it and how it is very important that we take steps towards keeping our water bodies clean.

Software Used

We've used different softwares for different parts of the project. The different softwares used in the making of this project are :-

1. Arduino IDE
2. Visual Studio Code
3. Firefox Browser (any browser could've been used)

Arduino IDE

The Arduino Integrated Development Environment (IDE) is an open source software. It is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. By default, avrdude is used as the uploading tool to flash the user code onto official Arduino boards.

With the rising popularity of Arduino as a software platform, other vendors started to implement custom open source compilers & tools (cores) that can build and upload sketches to other MCUs that are not supported by Arduino's official line of MCUs.

The version of the Arduino IDE used by us is Arduino 1.8.10.

Figure 7. Arduino IDE Screengrab

Visual Studio Code

Visual Studio Code (popularly known as VS Code) is an editor which is one of the most popular editors and is very widely used. It has a lot of add-on features which makes it very easy for any user to use. It has support for and features like Git support, support for debugging, emmet, intelligent code completion, auto beautification of code, snippets etc. It's also got different themes. The Dark Theme allows a user to use the editor for longer periods of time as the user's eye doesn't get as tired as to when using a brighter screen.

Git integration allows the user to use version control more easily. VS Code also has a built in terminal because of which you can easily access the terminal without ever having to leave the window, at the same time, the add-on known as "Live Server" lets the programmer visualise their changes instantly. Emmet is a feature in VS Code which allows writing big chunks of repetitive code in lesser time by automating, or easily generating it by using short hand. All this together makes for a very coding platform.

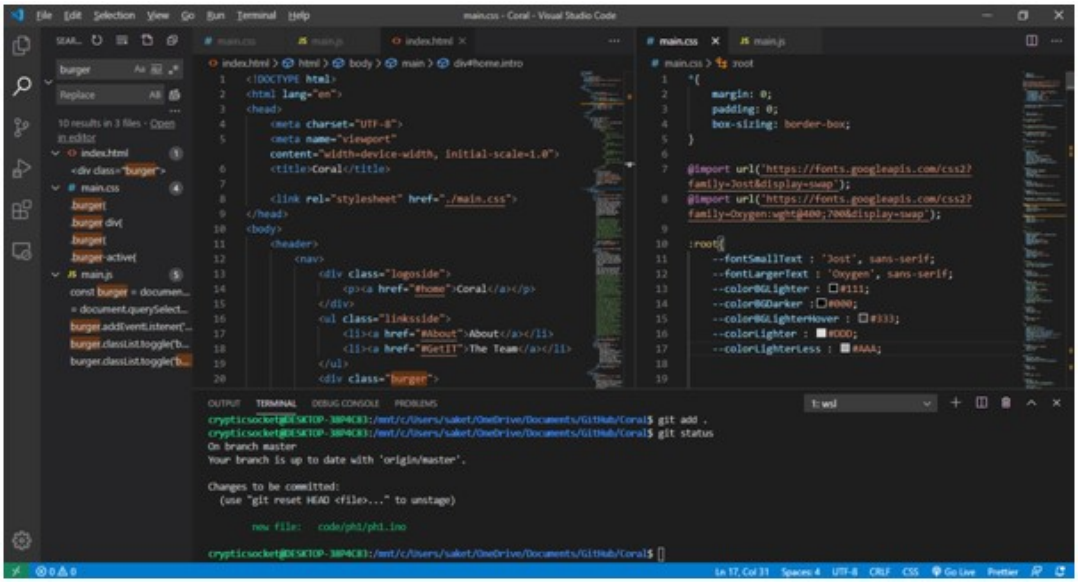

Figure 8. VS Code Interface Screengrab

VS Code is also a free and open source software and is released under the permissive MIT License. It is developed by Microsoft and is available for Windows, Linux and MacOS.

CHAPTER 2

LITERATURE REVIEW

It is true that the existence of the whole universe is dependent on water. Fresh and clean water is certainly a limited resource for every living being on Earth. The bodies of living elements consist 70% water and hence we use the phrase water is life. Human beings require water for many purposes and its need is felt more when there are occurrences such as droughts. The water bodies play an important role in maintaining ecological balance. They act as sources of drinking water, recharge groundwater, control floods, support biodiversity, and provide livelihood opportunities to a large number of people. It is important that these water bodies remain clean and healthy. One of the main reasons for water crisis is due to dearth of fresh and potable water.

From being known as “The City of Lakes”, Bangalore is now known as “The Forgotten City of Lakes”. This is because of the death of several lakes, mostly due to pollution and also because of construction of buildings on lake beds. There were around 280 lakes in the year 1960. Now the numbers have gone down significantly to 183, according to BBMP.

Water Pollution leads to death of aquatic habitat, which ultimately causes imbalance in the ecosystem. Pollution of water bodies also leads to water borne diseases and also becomes the breeding place for mosquitoes. The main reason for pollution of water bodies is human activities. Post industrialization and urbanization, the pollution of water bodies has seen a steep inclination due to discharge of industrial chemical waste and sewage into the water without treatment.

The idea to develop a device to monitor the health of the water body came to us due to the alarming rate of pollution of water bodies due to various reasons discussed above. A number of research efforts have been made

regarding the improvement of water quality. A literature survey of existing research in this domain will be discussed here, which is basically reviewing the background knowledge on practical approaches and sensors available for analyzing data.

CONSTRUCTION AND WORKING

UferahShafi et. al., in their paper "Surface Water Pollution Detection using Internet of Things", in IEEE, developed a real time embedded prototype, to record the water quality parameters from the water samples collected from various sources across the study area. The hardware solution sends data to the cloud for real time storage and processing. The processed data can be remotely monitored and water flow can be controlled using our developed software solution consisting of a mobile app and a dashboard.

An IoT based water quality monitoring system was developed that comprises hardware and software solutions. The proposed hardware solution consists of a microcontroller (ATMega328), water quality measuring sensors such as pH, turbidity and temperature sensors, solenoid valve for flow control, and WiFi shield for sending data to the cloud. The safe ranges of parameters are mentioned in the table below.

Sr#	Parameter	Safe Range
1	pH	6.5 to 8.5
2	Turbidity	0 to 5 NTU
3	Hardness as CaCo3	500 mg/l
4	Conductance	2000 µS/cm
5	Alkalinity	500mg/l
6	Dissolved Solids	1000mg/l
7	Nitrate as NO2	<1mg/l
8	Fecal Coliform	Nil Colonies/ 100ml
9	Calcium	200mg/l

Table 2. Measurable Safe Range Parameters

The software solution consists of a mobile app and dashboard to remotely monitor water quality and its flow control. The data collected from sensors is sent to the cloud for real time storage and analysis. WiFi protocol is used for communication between sensors and cloud. The processed data is compared against WHO defined standard safe ranges for water quality. The comparison specifies whether the collected sample complies with WHO standard or not. The end user can visualize the assessed water quality parameters on a mobile app.

Apart from monitoring, predictive analysis of data is done for training purposes using various Machine Learning Algorithms such as Support Vector Machines, Deep Neural Network etc.

The flow diagram of the process is shown in the figure below.

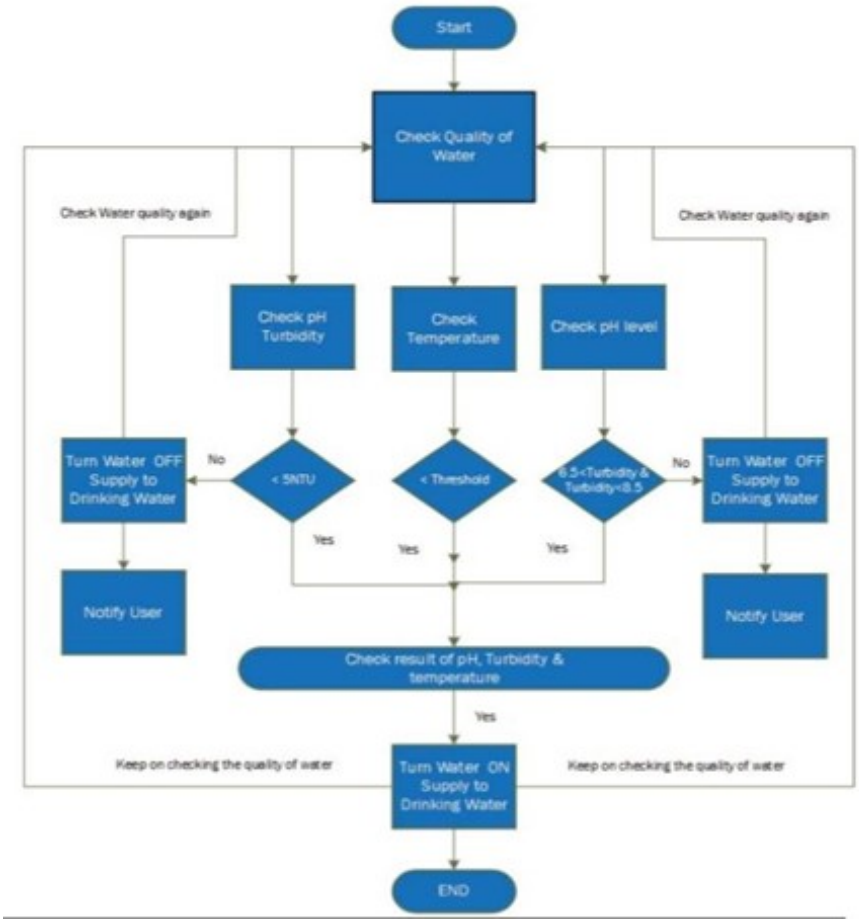

Figure 9. Flowchart for Algorithm to assess Water Quality

U. Shafi, R. Mumtaz, H. Anwar, A. M. Qamar and H. Khurshid, "Surface Water Pollution Detection using Internet of Things," 2018 15th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT (HONET-ICT), Islamabad, 2018, pp. 92-96, doi: 10.1109/HONET.2018.8551341.

Rizqi Putri NourmaBudiarti et. al., in their paper "Development of IoT for Automated Water Quality Monitoring System", in IEEE, create an integrated system based on Internet of Things to measure water quality by developing an environmental water management monitoring system using sensors. The use of raspberry pi as an embedded system will help in the manufacture of detecting sensor devices and the use of remote communications technology can help the interaction of sending data between things.

By implementing the use of Internet of Things (IoT) technology supported by data retrieval methods using sensors, embedded systems and the use of remote communication technology can help simplify the water quality parameters. They collect the data from sensors and send the data to the cloud. After data retrieval, the preparation of infrastructure and creating Web UI (User Interface), then create database system for IoT Platform.

After the development of the database system is done, then get the data from a passive sensor using Web Scraping technique and also get the data from an active sensor using Python serial programming. The data retrieved is transferred via serial communication using RS232. SQLite, a software library that provides a relational database management system, is used to directly read and write on disk storage. SQLite can run well on limited memory environments such as raspberry pi 3. For the development of the database system, they used MariaDB which is an open source RDBMS that supports high availability, security, interoperability, etc. For efficient data transfer for Internet of Things system, we used the MQTT protocol (Message Queue Telemetry Transport Protocol). The MQTT protocol is a network protocol that uses the publish/ subscribe concept in its data transmission, usually for sending messages between "Internet of Things" devices.

The flow chart of the system is shown in the figure below.

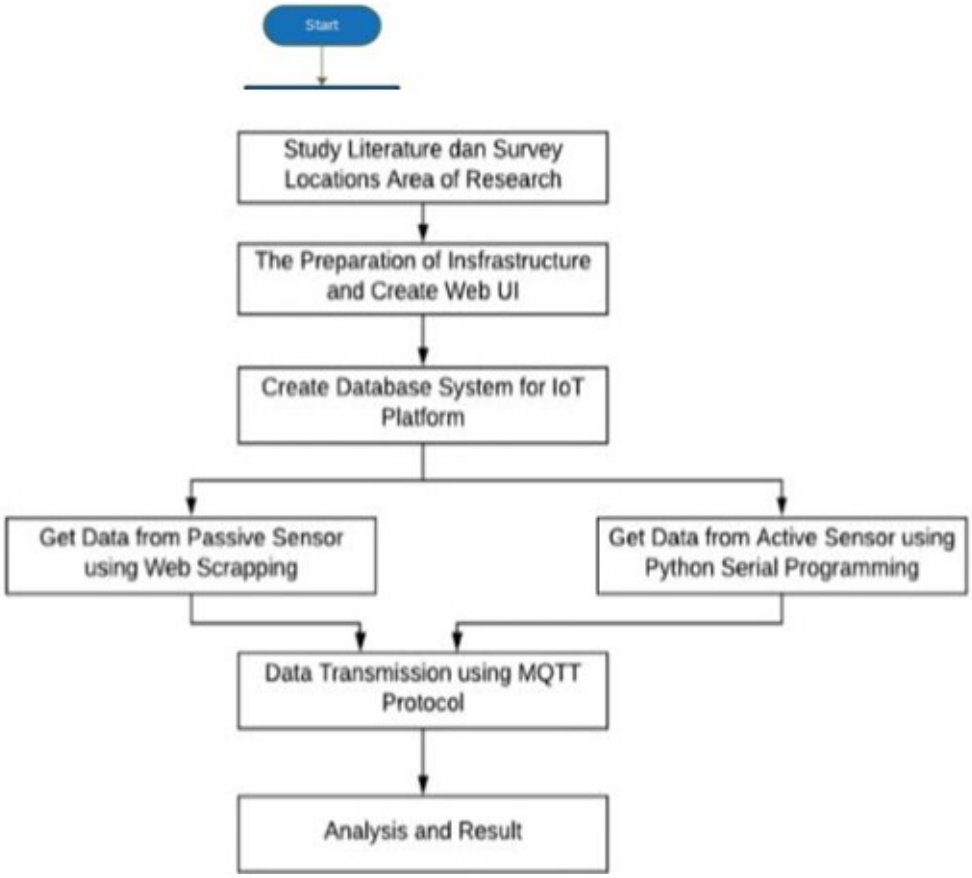

Figure 10. Flowchart for Data Logging using DBMS

R. P. N. Budiarti, A. Tjahjono, M. Hariadi and M. H. Purnomo, "Development of IoT for Automated Water Quality Monitoring System," 2019 International Conference on Computer Science, Information Technology, and Electrical Engineering (ICOMITEE), Jember, Indonesia, 2019, pp. 211-216, doi: 10.1109/ICOMITEE.2019.8920900.

Sujay Dandekar et. al., in their paper “IOT based Real Time Water Grade Tracking System using Solar Energy”, in IEEE, have designed an economical and robust system that can check water grade and update organization on water condition. Water quality measurement using GPRS and web based monitoring is proposed to control water pollution and human diagnosis due to the water pollution. Solar panels are used to save electricity. Different sensors are used such as pH, temperature, conductivity etc are used to measure different parameters of water.

A smart and low cost system for real time monitoring of water quality by using ARM 7, has been proposed, which provides global testing. They have used 4 sensors for monitoring water quality. Temperature sensor, Turbidity sensor, pH sensor and conductivity sensor individually check the water parameters as per their specifications. First for working sensors, they are submerged in the water storage. Then parameters like temperature, turbidity, pH value and conductivity of water are checked. The data acquisition process takes place. This data is supposed to be converted into digital. LPC 2148 development board has on chip 10 bit ADC for conversion. When all the data is converted into digital, we get a parameter display on LCD.

For wireless communication, the GPRS module (SIM 800L)has been used. This GPRS module is installed on the MAX 232 board. MAX232 IC consists of 16-pins which are used in voltage level signal problems. GPRS, that is General Packet Radio Service, makes use of packet switched data. It does not require any end to end connection. Generally MAX 232 needs to be connected to the controller by RS232. Recommended Standard 232 (RS-232) is a serial communication standard introduced in 1960, for transmission of data. It defines a connection between a DCE (Data Communication Equipment) like a modem and DTE (Data Terminal Equipment) like a computer terminal. It is a commonly used standard for computer serial ports.

The block diagram of the system is shown in the figure below

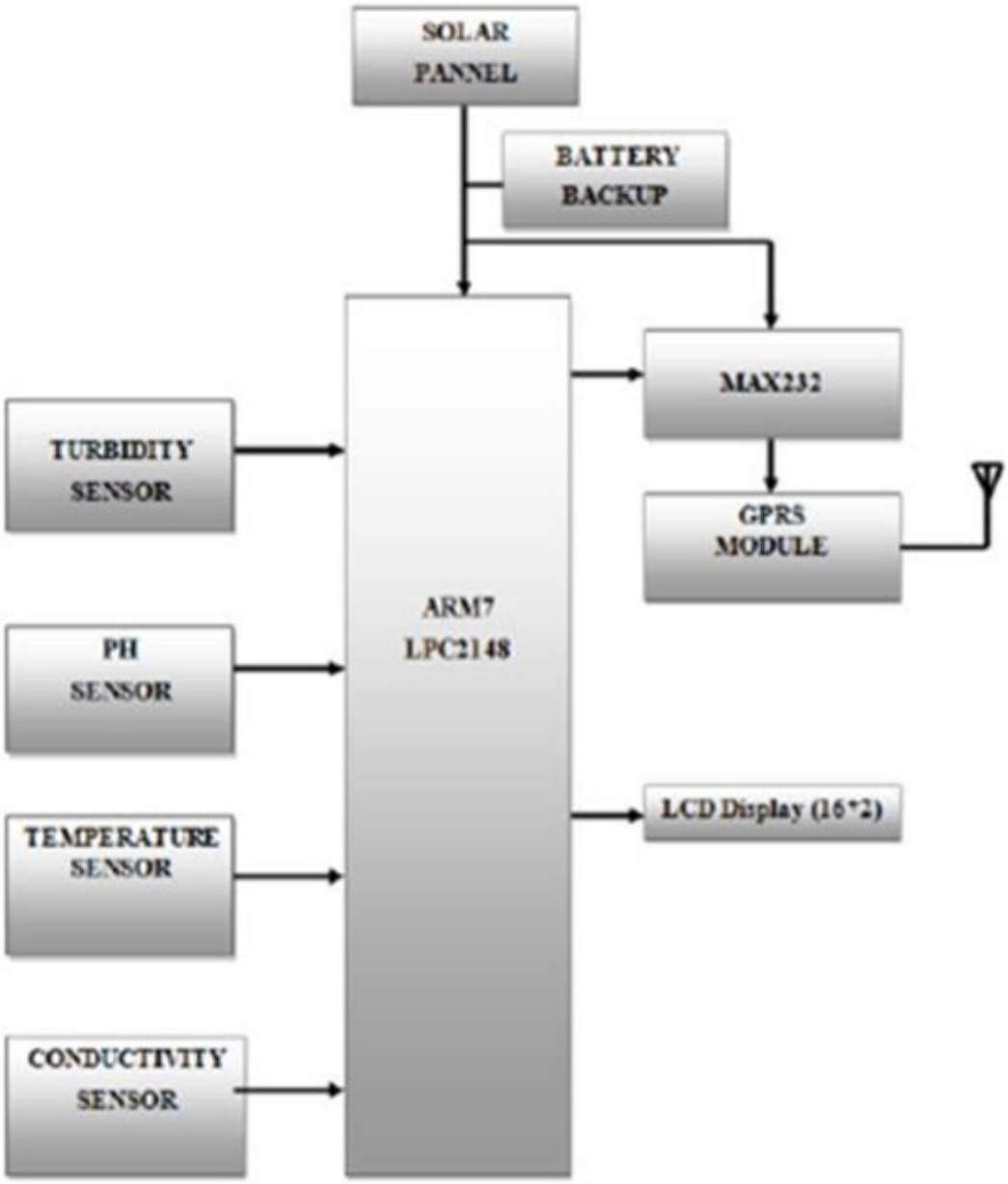

Figure 11. Block Diagram for Water Quality Monitoring using ARM7

S. Dandekar, S. S. Kadam, R. N. Choudhary, S. S. Vaidya and V. S. Rajderkar, "IOT based Real Time Water Grade Tracking System using Solar Energy," 2018 3rd International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2018, pp. 773-775, doi: 10.1109/CESYS.2018.8723874.

Brinda Das and P.C. Jain, in their paper “Real-Time Water Quality

Monitoring System using Internet of Things", in IEEE, talk about implementation of a water quality measuring system that checks the quality of water in real time through various sensors (one for each parameter: pH, conductivity, temperature) to measure the quality of water. The ZigBee module in the system transfers data collected by the sensors to the microcontroller wirelessly, and a GSM module transfers wirelessly the data further from the microcontroller to the smart phone/PC. The system also has proximity sensors to alert the officials by sending a message to them via the GSM module in case someone tries to pollute the water body.

This system makes use of three sensors (pH, conductivity, temperature), processing module microcontroller (LPC2148), and two data transmission modules, Zigbee and GSM. The three sensors capture the data in the form of analog signals. The ADC converts these signals into the digital format. These digital signals are sent to the microcontroller via a Zigbee module. The microcontroller will process the digital information, analyze it, and further communication is done by the GSM module, which sends an SMS with the water quality parameters onto the smart phone/PC, which is also displayed on the LCD of the microcontroller. Microcontroller accepts and processes the data collected from the sensors to the Web page via Wi-Fi module (ESP8266). This is carried out with the help of coding. The code is written in Embedded-C and using the Keil uVision software to simulate the code. We have used the evaluation version of MDK-ARM v4 for C programming. Flash magic is a software tool used for burning the .hex files to NXP Controllers.

ThingSpeak, an IoT applications open source (OS) which can store and retrieve data from sensors or things using Local Area Network (LAN) or HTTP over the Internet, has been used to transmit data to the cloud as it provides easy access to the stored data.

The system design is shown in the figure below.

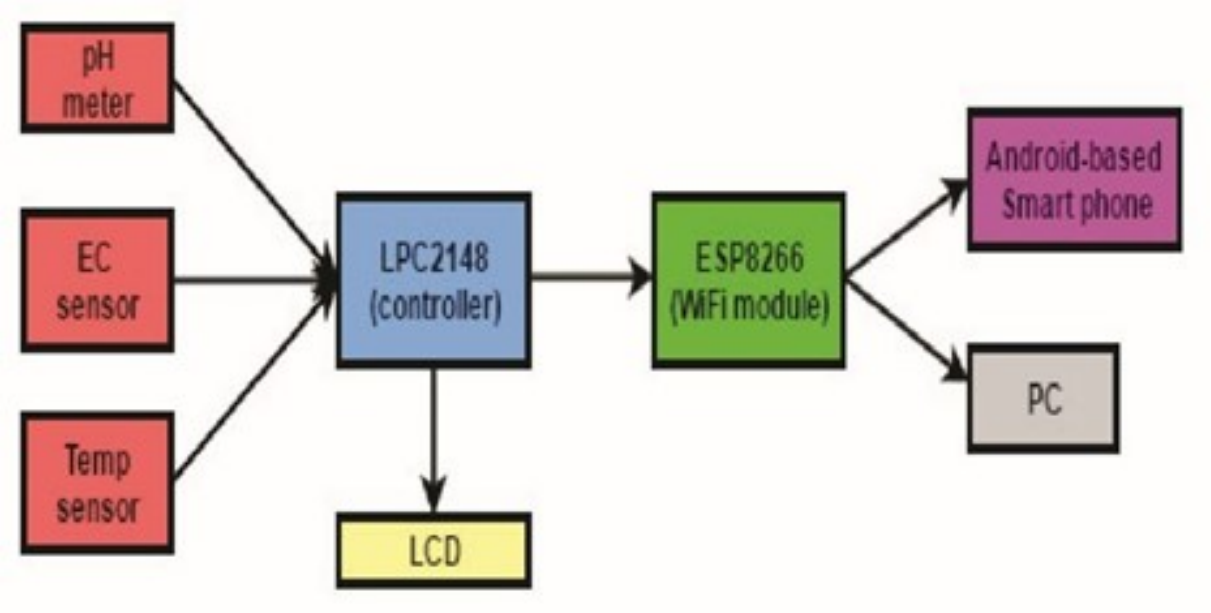

Figure 12. Block Diagram for IoT based system

B. Das and P. C. Jain, "Real-time water quality monitoring system using Internet of Things," 2017 International Conference on Computer, Communications and Electronics (Comptelix), Jaipur, 2017, pp. 78-82, doi: 10.1109/COMPTELIX.2017.8003942.

Md. Omar Faruq et. al., in their paper “Design and Implementation of Cost Effective Water Quality Evaluation System”, in IEEE, illustrate a microcontroller based water quality monitoring system with high degree of accuracy and susceptible to determine several parameters of water such as temperature, turbidity and potential of hydrogen (pH). Detection of those parameters of water is very important and indispensable in order to lead a healthy life as different sources of water are being tainted due to excess population. Various analytical schemes subsist for ascertainment of the quality of water where several are time-consuming and few are used for industrial applications that are not applicable for simple water quality monitoring systems.

The developed water quality monitoring system is portable and consists of a microcontroller, some simple sensors as well as a display unit which is very

useful for detecting the appropriate pH, temperature and turbidity of water.

The implemented device performs based on the electrical properties of water and consists of a microcontroller, LCD display, differential amplifier, power amplifier, thermistor, turbidity sensor, pH electrode and other components.

Microcontroller is the major part of the developed system used for measuring water quality. Voltage difference across the sensor is collected through the port A of the microcontroller and port B of the microcontroller is connected to the LCD display which expresses the value of the parameter of water as a digital number. An oscillator is used to give a clock pulse to the microcontroller.

In addition, the implemented system is highly efficient, cost effective and consequently, the accuracy of the measuring device is at a convenient level.

The block diagram of the system is shown in the figure below

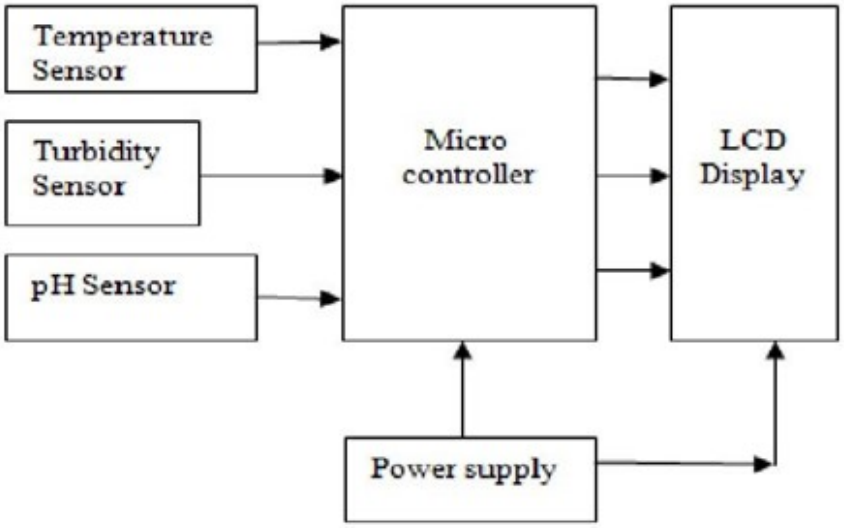

Figure 13. Block Diagram for Water Quality Monitoring System

M. O. Faruq, I. H. Emu, M. N. Haque, M. Dey, N. K. Das and M. Dey, "Design and implementation of cost effective water quality evaluation system," 2017 IEEE Region 10 Humanitarian Technology Conference (R10-HTC), Dhaka, 2017, pp. 860-863, doi: 10.1109/R10-HTC.2017.8289089.

Indu .K et. al., in their paper "Modeling, Development & Analysis of Low Cost Device for Water Quality Testing", in IEEE, focus on modelling and developing a low cost water quality testing device and analysing its performance with the currently available products. The developed device can measure the parameters like pH, Total Dissolved Solids, Conductivity and Temperature. The system consists of four sub-systems namely pH measuring sub-system, Conductivity measuring sub-system, TDS measuring sub-system and Temperature sub-system. The outputs from these subsystems are sent to the Analog to Digital Converter (ADC) of the microcontroller and output is displayed on the screen.

The circuits for measuring pH, Conductivity, TDS, Temperature are implemented on hardware and performance is analyzed. Microcontroller used in the design is the Arduino UNO. To measure the temperature of water, LM35 is converted to a waterproof sensor.

The block diagram of each sub system is developed and simulated results are obtained which is shown in the figure below.

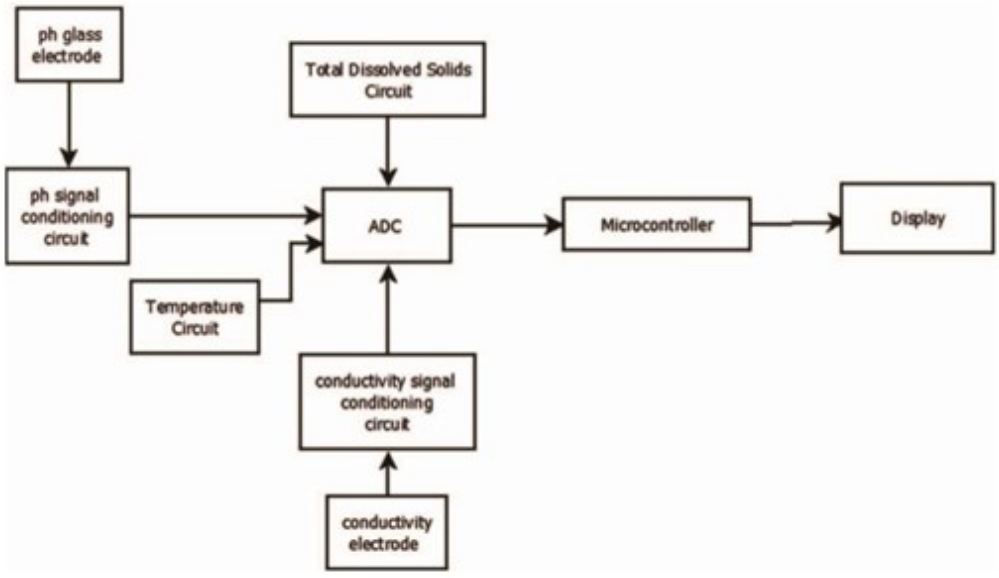

Figure 14. Block Diagram for Water Quality Monitoring system using ADC

The simulated results are compared with Hardware test results to calculate error and accuracy of the developed system.

By comparing pH measurements of design and product, it was found that both results were stable (with a deviation of not more than 0.04) for pH value 7 but at lower and higher pH, the variation in readings was more for product when compared to designed circuit and the mean value was found to be unstable at the lower and higher values of ph for product. Error in conductivity measurement from the designed circuit was considerably reduced to 0.07, stable enough without much deviation from mean when compared to the product's measurement which produces an error of 0.15. TDS of water varies linearly with conductivity, hence the designed system gives TDS results with an error of 0.07 compared to commercially available products with error of 0.015.

Cost for implementing the design was within 60USD when compared to products in market which starts from 100USD and goes upto 2000USD.

K. Indu and J. J. Choondal, "Modeling, development & analysis of low cost device for water quality testing," 2016 IEEE Annual India Conference (INDICON), Bangalore, 2016, pp. 1-6, doi: 10.1109/INDICON.2016.7839131.

Manish Kumar Jha et. al., in their paper "Smart Water Monitoring System for Real-time water quality and usage monitoring", in IEEE, aim at designing a Smart Water Monitoring System (SWMS) for real-time water quality and usage monitoring. It consists of two parts: Smart Water Quantity meter and Smart Water Quality meter. The objective of designing Smart Water Quantity Meter is to ensure water conservation by monitoring the amount of water consumed by a household, notifying the same to the consumer and the authority. A three-slab billing system generates consumption bills according to the quantity consumed. The Smart Water Quality meter checks the purity of portable water that the consumer receives, by measuring five qualitative parameters of water viz. pH, temperature, turbidity, dissolved oxygen and conductivity. The system ensures to prevent any health hazards or potential

threats caused due to accidental seepage of sewage or farm release into the potable water.

The system consists of a microprocessor which processes all the input data and based on them it takes decisions. Raspberry Pi (RPi) acts as the microprocessor and the various sensors - pH sensor, Temperature sensor, Turbidity sensor and water flow sensor act as input sources to the RPi. Based on the input data from these sensors, the RPi sends actuating signals to the Solenoid valve and LCD Display. The Solenoid valve acts as water flow control mechanism. It allows the flow of water when open, and terminates the supply when closed. LCD Display is used to display appropriate messages at different instances.

A web portal is designed for real-time remote monitoring of the SWMS system. The water quality data is periodically updated on the portal, with graphical representations demonstrating the safety level of water based on individual physical parameters of water.

The flowchart of the Smart Water Monitoring System is shown in the figure below.

Figure 15. Flowchart for Smart Water Monitoring System

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

DESIGN

We gathered insight to build our project by studying and researching on the kind of developments that have already been made on the design and build of Buoy's or other Water Quality Monitoring Systems.

In the first paper we studied titled "Study of Backward Bent Duct Buoy", conducted by Yoshio Masuda, Tetuo Yamazaki, Yoshiyuko in conjunction

with Michael E. McCormick in the city of Tokyo, Japan, A study was conducted to test the working of a backward bent duct buoy which resulted in improved power generation when the turbine and generator was mounted on top of the Buoy.

Backward bent duct buoy is a new type of duct buoy which has a horizontal duct opening to the backward of the buoy structure to aid in proper weight distribution. The Backward Bent duct Buoy(BBDB),is an air chamber bent backwards from the wave direction. Frontward Facing ucts were first studied with no plans to test a backward facing duct. Since there is no vertical center pipe the duct can be employed in y & MOORING CHAIN waters of any depth greater than the draft of the host buoy.

Y. Masuda, T. Yamazaki, Y. Outa and M. McCormick, "Study of Backward Bent Duct Buoy," OCEANS '87, Halifax, NS, Canada, 1987, pp. 384-389, doi: 10.1109/OCEANS.1987.1160750.

In another research conducted, in a paper titled “Smart Floating Balls: 3D Printed Spherical Antennas and Sensors for Water Quality Monitoring”, by Smart Floating Balls: 3D Printed Spherical Antennas and Sensors for Water Quality Monitoring of Georgia Institute of Technology, A spherical design for a buoy structure built with an antenna was developed for monitoring of wind pressure, and water body contamination and telemetry was done through the antenna present on board the buoy structure. This paper proposes a novel additively manufactured floating ball sensor for water monitoring applications. A chipless RFID phase modulation configuration is used along with spherical patch antennas and phase delay micro striplines that are sensitive to the liquid content. The spherical patch antenna array provides omni-directional gain in the water level plane and can be used in MIMO applications in the water. The phase delay line utilizes a microfluidic channel embedded into the microstripline so that the phase introduced by the line can be reconfigured by the liquid inside the channel. Due to its complex shape, the floating ball fabrication process combines both 3D printing and 3D stamping, which enables selective 3D metalization using the same platform. The smart floating ball can monitor reservoir water quality while preserving

its original function as a “shadow ball” featuring low-cost, light-weight and battery-less, which are important features for massively scalable “smart” systems.

W. Su, S. Wang, R. Bahr and M. M. Tentzeris, "Smart Floating Balls: 3D Printed Spherical Antennas and Sensors for Water Quality Monitoring," 2018 IEEE/MTT-S International Microwave Symposium - IMS, Philadelphia, PA, 2018, pp. 55-58, doi: 10.1109/MWSYM.2018.8439350.

SENSORS

Thu Hien Nguyen, ThillainathanVenugopalan, Tong Sun, and Kenneth T. V. Grattan, in their paper “Intrinsic Fiber Optic pH Sensor for Measurement of pH Values in the Range of 0.5–6” talk about the use of an optical fiber pH sensor which can measure a low range of pH values from 0.5 to 6. This is done based on fluorescence using a dye known as “coumarin dye”, which is covalently immobilized onto the end surface of an optical fiber is described. The sensor is fast and provides a response in 25 seconds over the given range and has a very good stability for a long duration of time. The time mentioned was said to be about a few months. The sensor is also insensitive to ionic stability and has excellent photostability when tested out in the laboratory.

In the paper, the authors state that there are several advantages of using a Fiber Optic approach of pH sensor. Some of the advantages are :-

- Smaller size
- Unhindered by electromagnetic interferences
- Remote sensing capabilities
- Resistance to chemicals
- And, Biocompatibility

Although this kind of a pH sensor can be very accurate in theory, practically there are also a lot of problems that can affect the accuracy of the readings,

such as :-

- Temperature fluctuations
- Stress
- Vibrations
- Chemical Interferences

Since we are looking for a cheap and accurate pH sensor, one of these kinds might come in handy to us.

T. H. Nguyen, T. Venugopalan, T. Sun and K. T. V. Grattan, "Intrinsic Fiber Optic pH Sensor for Measurement of pH Values in the Range of 0.5–6," in IEEE Sensors Journal, vol. 16, no. 4, pp. 881-887, Feb.15, 2016, doi: 10.1109/JSEN.2015.2490583.

Niel Andre Cloete1 , Reza Malekian, and Lakshmi Nair of University of Pretoria in their research paper titled “Design of Smart Sensors for Real-Time Water Quality Monitoring” talk about the development of monitoring real time water quality parameters by developing a low cost, wireless, multi sensor network for measuring the physiochemical parameters such as pH, which is used to check the nature of the water whether it is acidic or basic, making the water safe for marine life.

- A temperature sensor that keeps a check if the water isn’t too warm
- A turbidity sensor that monitors sediment suspension in the lake, which will indicate the amount of contamination present in the water.
- A conductivity sensor will determine the number of ions present in the water.
- A flow sensor which will determine the rate of flow of water in the lakes.

pH sensor: For this study the pH sensor will consist of a conventional glass electrode as these electrodes are more reliable and economical for long term monitoring. The pH electrode acts like a single cell battery and there is a direct correlation between the voltage output of the electrode and the pH of the measured water.

The pH of water is an important parameter to monitor because high and low pH levels can have dangerous effects on human health. The pH of a solution can range from 1 to 14. One method of measuring pH is through the use of a conventional glass electrode with a reference electrode setup, the other is using an Ion-Selective-FieldEffect-Transistor (ISFET).

Temperature Sensor: A temperature sensor is used to measure the temperature of the water. There are various temperature sensor types: a thermocouple, thermistor or a solid state temperature sensor. A thermistor temperature sensor is considered in this study as there is better design control and designing such a sensor from first principles is easier. Thermistors are generally used for applications below 300 ◦C and would therefore be sufficient for a system that operates at ambient temperatures. A thermistor is essentially a resistor with a temperature dependent resistance. Due to its resistive nature, an excitation source is required to read the voltage across the terminals.

Conductivity Sensor: Conductivity Sensor: The conductivity of water is an indication of the amount of ions and/or free flowing electrons that are present for the conduction of electricity. The pH electrode sensor used to carry out measurements. measured in Siemens per meter (S/m) or micro-Siemens per centimeter (µS/cm). The conductivity sensor is designed using the two- or four electrode method based on Ohms law. With a known resistor, voltage and current the resistance of the water solution can be calculated accordingly.

N. A. Cloete, R. Malekian and L. Nair, "Design of Smart Sensors for Real-Time Water Quality Monitoring," in IEEE Access, vol. 4, pp. 3975-3990, 2016, doi: 10.1109/ACCESS.2016.2592958.

In the second paper we referred to, two researchers Mst Shamim Ara Shawkat

and Nicole McFarlane of University of Tennessee conducted a research on A Single-Chip ISFET based pH Sensor. Conventional pH sensors use a glass bulb electrode which are both delicate and heavy, the two researchers have developed a low cost low power consuming ISFET (ion-sensitive field-effect transistors) pH sensor which can be developed by studying the recent advancements in CMOS (Complementary Metal-Oxide Semiconductor).

The design of a single-chip ISFET based pH sensor using differential measurements between a matched pair of pISFETs has been presented. The sensor has been designed in a 180nm standard CMOS process. Simulation results show an ISFET sensitivity of 50 mV/pH. The sensor uses a power supply of 0.9 V and consumes 31.3 ɜW of power. The sensor does not require extensive post-CMOS processing and is capable of rejecting the common-mode noise from solution and reference electrodes due to differential measurement technique. Furthermore, the sensor is suitable for low power applications.

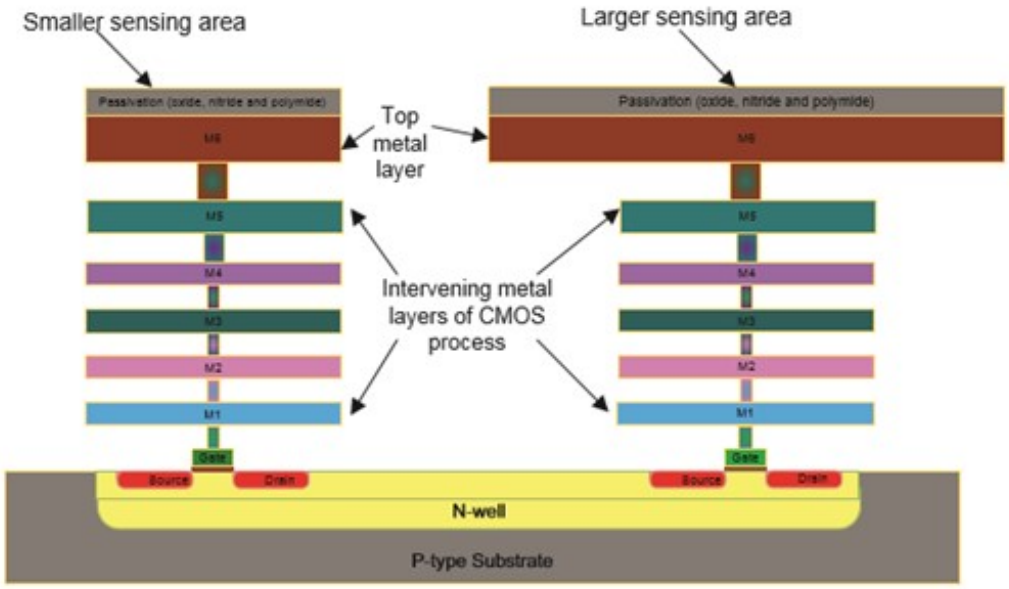

Figure 16. ISFET Ph sensor Diagram

"A Single-Chip ISFET based pH Sensor" Mst Shamim Ara Shawkat and Nicole McFarlane Electrical Engineering and Computer Science University of Tennessee Knoxville, USA mshawkat@vols.utk.edu

CHAPTER 3

PROPOSED MODEL WITH THEORETICAL BACKGROUND

Coral is an IoT solution that serves water body monitoring universally. It measures a wide range of parameters using the sensors attached to each node.

The project basically consists of two main parts:

- The Scouts
- The Motherbot

The scouts and the Motherbot are identical in design, only there are a few differences in both of them in terms of working. The basic unit, whether the scout or the Motherbot is referred to as a bot. Scouts are basically the bots that are dispersed around the water body. They collect data from the sensors and relay it to the other units.

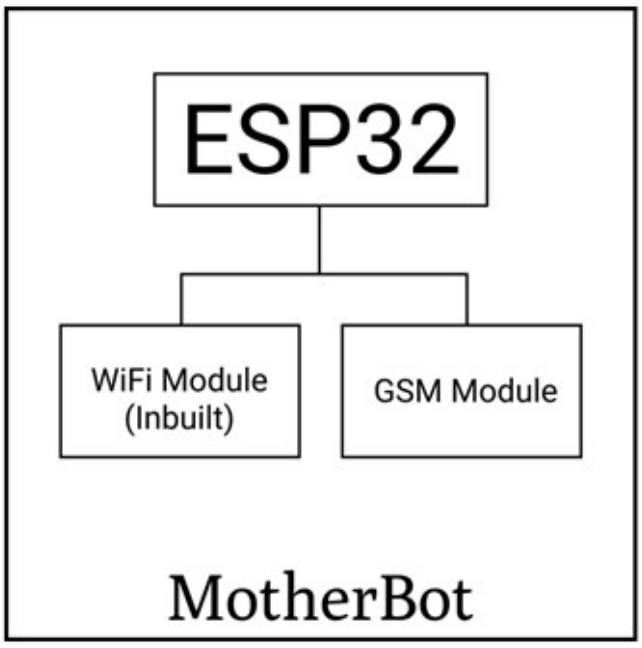

Figure 17. MotherBot Block Diagram

The Motherbot will be an ESP 32 development board which consists of an inbuilt wifi module and multiple ADC pins unlike the NodeMCU, which is why it is ideal for this application. The mother bot will have an additional unit, which is the GSM module, which allows for the posting of data to the server. This happens because the GSM module connects the Motherbot to the internet.

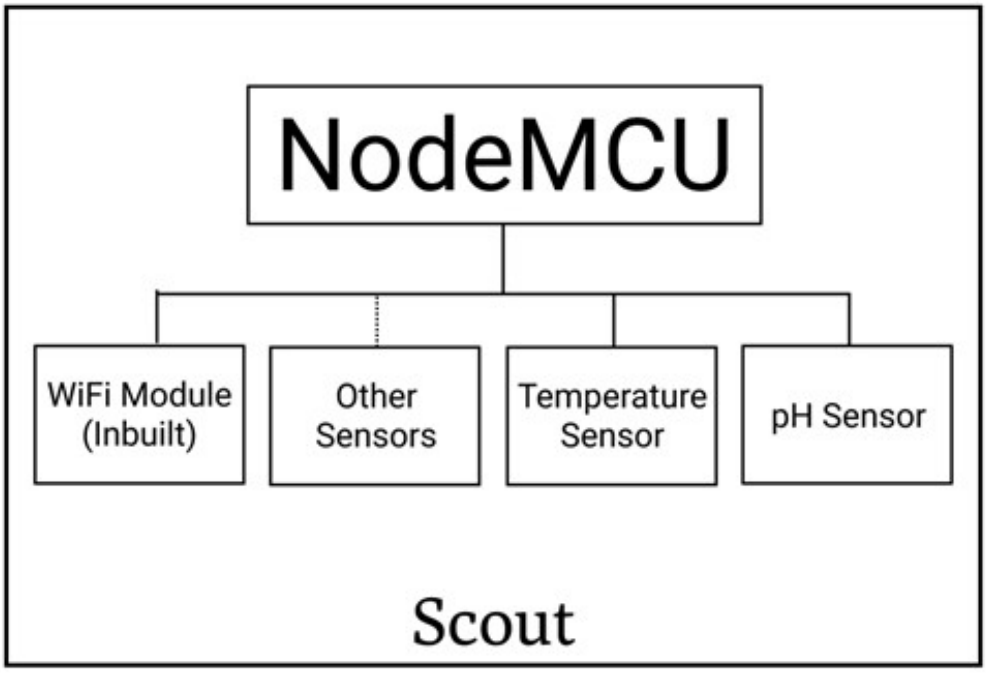

Figure 18. Scout Block Diagram

The scouts are NodeMCU development boards which are all equipped with various sensors such as the temperature sensor, pH sensor and in addition to this, they have in-built WiFi chips. The number of sensors can be added as and when needed.

The scouts essentially collect the data from the probes and sensors deployed into the water, store it in a JSON format and send the data out, relaying it through the network and to the mother bot where it is collected and stored before being sent to the server.

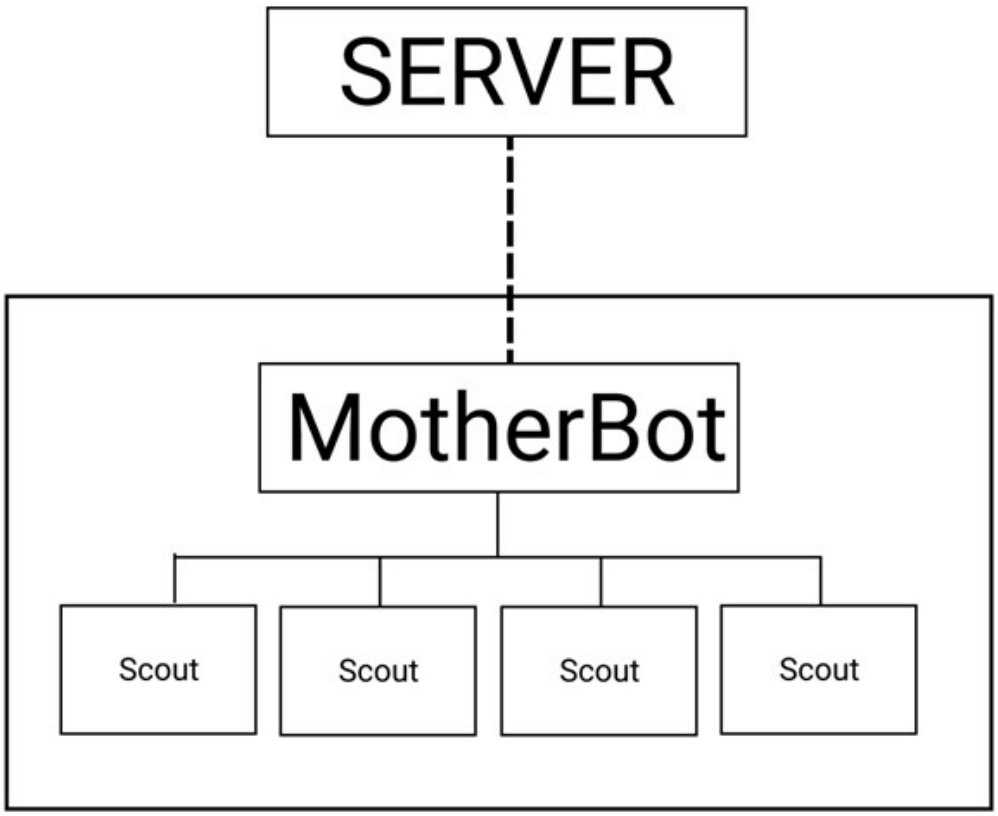

Figure 19. Server Linking Block Diagram

The scouts spread across the entire area under study or surveillance will collect the data using the equipped sensors. The live sensor data is then condensed into a packet and relayed to the motherbot. The mother bot collects all the data and sends a report along with its location data to the server every 30 minutes.

The scouts depending on their physical position behave both as a station and an access point or only as a station. The bots acting as only a station are mostly located on the outer periphery of the mesh network and only collect data and push it towards the mother bot. The bots which act as a station as well as an access point however will not only collect data from the sensors and send this data to the mother bot but will also help in the relaying of information towards the mother bot. This functioning changes dynamically as when there are new connections added or lost from the network.

CHAPTER 4

SOURCE CODE

Website - HTML SOURCE CODE

```
<!DOCTYPE html>

<html lang="en">

<head>

<meta charset="UTF-8">

<meta name="viewport" content="width=device-width, initial-scale=1.0">

<title>Coral</title>

<link rel="stylesheet" href="./main.css">

</head>

<body>

<header>

<nav>

<div class="logoside">

<p><a href="#home">Coral</a></p>

</div>

<ul class="linksside">

<li><a href="#About">About</a></li>

<li><a href="#GetIT">The Team</a></li>

</ul>
```

```
<div class="burger">

<div class="line1"></div>

<div class="line2"></div>

<div class="line3"></div>

</div>

</nav>

</header>

<main>

<div id="home" class="intro">

<div class="bg"></div>

<div class="data">

<h1 class="liveText">Live Water Body Stats</h1>

<div class="linearFlex" id="statsHolder">

<!--<div class="card">

<table>

<tr>

<td>Location</td>

<td class="right">Bellandur</td>

</tr>

<tr>

<td>pH</td>
```

```
<td class="right">7</td>

</tr>

<tr>

<td>Temp</td>

<td class="right">28 &#8451</td>

</tr>

<tr>

<td>Condition</td>

<td class="right">Healthy</td>

</tr>

</table>

</div> -->

</div>

<div class="linearFlex">

<a href="#statsExp" class="btn">What is this?</a>

<a href="https://twitter.com/share?ref_src=twsrc%5Etfw&text=I am aware,
are you? %23CleanLakes %23Coral" class="btn" target="_blank">Tweet
About This!</a>

</div>

</div>

</div>

<div id="About">
```

```
<div class="eighty">

<h2 class="priHeading center">About</h2>

<h2 class="secHeading">Why Coral?</h2>

<div class="linear">

<p class="genText">Like corals maintain restoration and balance in the
oceans, similarly, our device has been called Coral as it exists in water
bodies, without disturbing it’s surrounding environment and protects the lake
from being polluted or contaminated.

<br>

<br>

<!-- Coral uses existing technologies such as IoT and a mesh network to
collect data using sensors dispersed all across the lake, to trigger a response
depending on the contamination levels of the lake. All the devices work with
a hive mind, which means that the main data collection unit is a mother-bot
which houses an IoT module to send the collected data onto a private server. -
->

</p>

<imgsrc="./images/aquarium-1360326-640x480.jpg" alt=""
class="coralImg">

</div>

<h2 class="secHeading">What created Coral?</h2>

<div class="linear">

<p class="genText">

        Fresh water bodies which could help solve the issue of water
scarcity are polluted. Bangalore was once home to over 280 clean lakes,
```

sadly, now only 183 lakes remain most of which are very polluted.

Coral was born out of the idea that the society needed to be aware about the water bodies around them. It's the role of each one of us to take care of it.

<!-- The maintenance of the existing lakes and water bodies are managed extremely poorly, most of the industrial waste and human waste is let into these water bodies without any treatment, this results in the contamination of lakes which then become breeding grounds for mosquitoes and other bacteria which can be extremely dangerous for the people who live in close proximity of these water bodies.

 -->

<!-- Our devices will force the governing bodies to take action on the contaminations as it collects data regarding pollution levels in the lake beds and if the lake is unhealthy, the data is directly posted on social media which immediately forces the action to be taken and keeps the authorities accountable for their negligence, the data is monitored and studied in a way that allows for everyone to be a part of the process and initialize or raise awareness to this relevant issue and more importantly, acts on it. As a society, as much as it is our responsibility to bring awareness to a particular issue, it is equally important for us to initiate working on those issues rather than put the blame on authorities. This is us trying to break that chain. -->

<imgsrc="./images/ulsoor.jpg" alt="" class="coralImg">

<h2 class="secHeading" id="statsExp">How does it?</h2>

Coral uses existing technologies such as IoT and a Mesh Network to collect data using sensors in Scouts dispersed all across the water body.

These scouts have cost effective sensors installed which is displayed live here.

<imgsrc="./images/ulsoor.jpg" alt="" class="coralImg">

<h2 class="secHeading center">About Us</h2>

We’re a bunch of tech enthusiasts and tinkerminds. We try to solve problems that bring about a positive change in our own lives and society.

Working constantly on projects helps keep our curiosity alive and satisfy our undying love for learning new things. Moreover, it keeps our heart beating and blood flowing. We love making things.

<imgsrc="./images/team.png" alt="team image" class="teamimg eighty">

<a href="https://www.linkedin.com/in/jyothsna-suresh-381635198"

```
class="name">Jyothsna Suresh</a>&#8226 <a
href="https://www.linkedin.com/in/shakthivel-rajavelu-79636531/"
class="name">ShakthivelRajavelu</a>&#8226 <a
href="https://www.linkedin.com/in/saketvaibhav/" class="name">Saket
Vaibhav</a>&#8226 <a href="https://www.linkedin.com/in/nikhil-suresh-
b07b0b148/" class="name">Nikhil Suresh</a>

</p>

</div>

</div>

</main>

<script async src="./main.js"></script>

</body>

</html>
```

Website - CSS SOURCE CODE

```
*{

   margin: 0;

   padding: 0;

   box-sizing: border-box;

}

@import url('https://fonts.googleapis.com/css2?family=Jost&display=swap');

@import
url('https://fonts.googleapis.com/css2?family=Oxygen:wght@400;700&displ
ay=swap');

:root{
```

```
    --fontSmallText : 'Jost', sans-serif;
    --fontLargerText : 'Oxygen', sans-serif;
    --colorBGLighter : #111;
    --colorBGDarker :#000;
    --colorBGLighterHover : #333;
    --colorLighter : #DDD;
    --colorLighterLess : #AAA;
  scrollbar-color: rgb(0,0,0) var(--colorBGLighter);
  scrollbar-width: thin;
}

a{
    color: inherit;
    text-decoration: none;
}
body::-webkit-scrollbar {
    width: 0.5em;
}
body::-webkit-scrollbar-track {
    background-color: var(--colorBGLighter);
}
```

```
body::-webkit-scrollbar-thumb {
    background-color: black;
    outline: 1px solid rgb(0, 0, 0);
}
html{
    scroll-behavior: smooth;
}
/* Navigation */
nav{
    position: fixed;
    width: 100%;
    display: flex;
    justify-content: space-between;
    font-size: 1.05rem;
    font-family: var(--fontSmallText);
    color: var(--colorLighter);
    background-color: var(--colorBGLighter);
    opacity: 0.9;
}
.logoside{
    text-transform: uppercase;
```

```
    letter-spacing: 0.05rem;
    padding: 1rem;
    font-weight: bold;
    transition: background-color 0.5s ease-out;
}
.linksside{
    display: flex;
    list-style-type: none;
    transition: transform 0.5s ease-out;
}
.linksside li{
    padding: 1rem;
    transition: background-color 0.3s ease-out;
}
.logoside:hover, .linkssideli:hover{
    background-color: var(--colorBGLighterHover);
}
.burger{
    margin: 0.7rem;
    cursor: pointer;
    transition-duration: 0.5s;
```

```
    display: none;
}
.burger div{
    width: 20px;
    height: 2px;
    background-color: white;
    margin: 5px;
}
/* Main */


    /* Intro */
.bg{
    position: absolute;
    background-image: url(./images/bg.jpg);
    height: 100vh;
    width: 100%;
    background-size: cover;
    background-position: bottom;
    background-repeat: no-repeat;
    z-index: -1;
}
```

```
.data{
    display: flex;
    flex-direction: column;
    align-items: center;
    justify-content: space-around;
    height: 100vh;
}
.liveText{
    /* padding-top: 2em; */
    font-family: var(--fontLargerText);
    color: var(--colorLighter);
}
.linearFlex{
    display: flex;
    flex-wrap: wrap;
    justify-content: space-evenly;
}
.card{
    display: flex;
    flex-direction: column;
    /* justify-content: center; */
```

```
    width: 250px;
    height: 250px;
    background-color: #000000EE;
    /* margin: auto; */
    color: #AAA;
    /* padding: 1em; */
    font-size: 1.1em;
    /* border-radius: 5px; */
    border-radius: 50%;
    font-family: var(--fontSmallText);
    margin: 1em;
}
.card table{
    width: 80%;
    margin: auto;
    line-height: 1.5em;
}
.right{
    text-align: right;
    color: #EEE;
}
```

```
.btn{
    /* width: 10em; */
    color: white !important;
    padding: 1em !important;
    border: 1px solid white !important;
    background-color: #3333 !important;
    font-family: var(--fontSmallText) !important;
    border-radius: 1em !important;
    transition: background-color 0.5s ease-in !important;
    margin: 0 1em !important;
}
.btn:hover{
    background-color: #B0BAB9;
    color: black;
    opacity: 0.7;
}
    /* About */
#About{
    min-height: 100vh;
    padding: 1em 1em 3em 1em;
    background-color: var(--colorBGLighter);
```

```
}
.eighty{
    width: 80%;
    margin: auto;
}
.center{
    text-align: center;
}
.priHeading{
    font-size: 2em;
    font-family: var(--fontLargerText);
    /* color: var(--colorLighterLess); */
    color: white;
    font-weight: normal;
    padding: 2em 0 0em 0;
    text-transform: uppercase;
}


.secHeading{
    font-size: 2em;
    font-family: var(--fontLargerText);
```

```
    /* color: var(--colorLighterLess); */
    color: #B35D3E;
    font-weight: normal;
    padding: 2em 0 0.3em 0;
}
.linear{
    display: grid;
    grid-template-columns: 50% 50%;
    /* grid-gap: 2em; */
    justify-items: center ;
    align-items: center;
}

.genText{
    font-size: 1.2em;
    line-height: 1.5em;
    /* color: var(--colorLighter); */
    color: #B0BAB9;
    font-family: var(--fontSmallText);
    text-align: justify;
}
```

```
.coralImg{
    width: 300px;
    height: 300px;
    object-fit: cover;
    align-self: center;
}
    /* Get In Touch */
#GetIT{
    min-height: 100vh;
    padding: 1em 1em 3em 1em;
    background-color: var(--colorBGDarker);
}
.name{
    color: #237283;
    transition: background-color 0.5s ease;
}
.name:hover{
    background-color: #013444;
    text-decoration: none;
    color: white;
}
```

```
.teamimg{
    padding: 2em 0 0.5em 0;
    display: flex;
    width: 500px;
    align-items: center;
}
.caption{
    font-size: 1.2em;
    line-height: 1.5em;
    /* color: var(--colorLighter); */
    color: #B0BAB9;
    font-family: var(--fontSmallText);
}
@media screen and (max-width:768px)
{
body{
        font-size: 0.8em;
        overflow-x: hidden;
    }
.eighty{
        width: 100%;
```

```
    }
    /* Navigation */
nav{
        font-size: 1em;
    }
.linksside{
        position: absolute;
        right: 0;
        bottom: 0;
        top: 3.75em;
        height: 100vh;
        flex-direction: column;
        align-items: center;
        background-color: var(--colorBGLighter);
        justify-content: unset;
        transform: translateX(100%);
        opacity: 0;
    }
.linksside li{
        width: 100%;
        text-align: center;
```

```
        border-bottom: 1px solid #333;
        border-top: 1px solid #333;
    }
.burger{
        display: unset;
    }
.linear{
        grid-template-columns: 100%;
        grid-gap: 2em;
    }
}
/* Toggle Animations */
.nav-active{
    transform: translateX(0%);
    opacity: 0.95;
    width: 250px;
}
.burger-active{
    transform: rotate(90deg);
}
```

Website - JS SOURCE CODE

```
const burger = document.querySelector('.burger')

const nav = document.querySelector('.linksside')

const stats = document.getElementById('statsHolder')

burger.addEventListener('click', function(){

nav.classList.toggle('nav-active')

burger.classList.toggle('burger-active')

})

function readGist()

{

   const request = new XMLHttpRequest();

   var elementBot

request.open("GET",
"https://gist.githubusercontent.com/CrypticSocket/add6f0a7427b7d735b18f1
11acddbca9/raw/trial.txt", true);

request.onreadystatechange = () => {

if(request.readyState === XMLHttpRequest.DONE) {

        var status = request.status;

        if (status === 0 || (status >= 200 && status < 400)) {

            var data = JSON.parse(request.responseText)

data.forEach(nodeBot => {

elementBot = `<div class="card">
```

```
<table>

<tr>

<td>NodeName</td>

<td class="right">${nodeBot.NodeName}</td>

</tr>

<tr>

<td>pH</td>

<td class="right">${nodeBot.pH}</td>

</tr>

<tr>

<td>Temp</td>

<td class="right">${nodeBot.Temperature} &#8451</td>

</tr>

<tr>

<td>Condition</td>

<td class="right">${nodeBot.State}</td>

</tr>

</table>

</div>`

stats.innerHTML+=elementBot

            })
```

```
            // alert(stats.innerHTML)

            console.log("Successful")

          } else {

console.log("Failed. Check internet connection")

          }

        }

   };

request.send();

}

readGist();
```

Microcontroller - ESP32 SOURCE CODE

```
#include "painlessMesh.h"

#define   MESH_PREFIX     "HomeMesh"

#define   MESH_PASSWORD   "JSSN12345"

#define   MESH_PORT       5555

Scheduler     userScheduler; // to control your personal task

painlessMesh  mesh;

// Prototype

void receivedCallback( uint32_t from, String &msg );

// Send my ID every 10 seconds to inform others

Task logServerTask(10000, TASK_FOREVER, []() {
```

```
#if ARDUINOJSON_VERSION_MAJOR==6

DynamicJsonDocumentjsonBuffer(1024);

JsonObject msg = jsonBuffer.to<JsonObject>();

#else

DynamicJsonBufferjsonBuffer;

JsonObject& msg = jsonBuffer.createObject();

#endif

   msg["topic"] = "logServer";

   msg["nodeId"] = mesh.getNodeId();

   String str;

#if ARDUINOJSON_VERSION_MAJOR==6

serializeJson(msg, str);

#else

msg.printTo(str);

#endif

mesh.sendBroadcast(str);

   // log to serial

#if ARDUINOJSON_VERSION_MAJOR==6

serializeJson(msg, Serial);

#else

msg.printTo(Serial);
```

```
#endif

Serial.printf("\n");

});

void setup() {

Serial.begin(115200);

  //mesh.setDebugMsgTypes( ERROR | MESH_STATUS | CONNECTION |
SYNC | COMMUNICATION | GENERAL | MSG_TYPES | REMOTE |
DEBUG ); // all types on

  //mesh.setDebugMsgTypes( ERROR | CONNECTION | SYNC | S_TIME );
// set before init() so that you can see startup messages

mesh.setDebugMsgTypes( ERROR | CONNECTION | S_TIME );  // set
before init() so that you can see startup messages

mesh.init( MESH_PREFIX, MESH_PASSWORD, &userScheduler,
MESH_PORT, WIFI_AP_STA, 6 );

mesh.onReceive(&receivedCallback);

mesh.onNewConnection([](size_tnodeId) {

Serial.printf("New Connection %u\n", nodeId);

  });

mesh.onDroppedConnection([](size_tnodeId) {

Serial.printf("Dropped Connection %u\n", nodeId);

  });

  // Add the task to the your scheduler

userScheduler.addTask(logServerTask);
```

```
logServerTask.enable();

}

void loop() {

  // it will run the user scheduler as well

mesh.update();

}

void receivedCallback( uint32_t from, String &msg ) {

Serial.printf("logServer: Received from %u msg=%s\n", from, msg.c_str());

}
```

Microcontroller - NodeMCU SOURCE CODE

```
#include "painlessMesh.h"

#include <OneWire.h>

#include <DallasTemperature.h>

#define   MESH_PREFIX     "HomeMesh"

#define   MESH_PASSWORD   "JSSN12345"

#define   MESH_PORT       555

#define ONE_WIRE_BUS D4

Scheduler     userScheduler; // to control your personal task

painlessMesh  mesh;

// Prototype

void receivedCallback( uint32_t from, String &msg );
```

```
OneWireoneWire(ONE_WIRE_BUS);

DallasTemperature sensors(&oneWire);

size_tlogServerId = 0;

float Celcius=0;

float Fahrenheit=0;

// Send message to the logServer every 10 seconds

Task myLoggingTask(10000, TASK_FOREVER, []() {

  //To read the temperature

sensors.requestTemperatures();

Celcius=sensors.getTempCByIndex(0);

  Fahrenheit=sensors.toFahrenheit(Celcius);

  //Remove comment status if you need to test using the same node

 /* Serial.print("Boiling Water Temperature Test : ");

Serial.print(" C  ");

Serial.print(Celcius);

Serial.print(" F  ");

Serial.println(Fahrenheit);*/

#if ARDUINOJSON_VERSION_MAJOR==6

DynamicJsonDocumentjsonBuffer(1024);

JsonObject msg = jsonBuffer.to<JsonObject>();

#else
```

```
DynamicJsonBufferjsonBuffer;

JsonObject& msg = jsonBuffer.createObject();

#endif

   msg["topic"] = "Water Temperature:";

   msg["value"] = Celcius;



   String str;

#if ARDUINOJSON_VERSION_MAJOR==6

serializeJson(msg, str);

#else

msg.printTo(str);

#endif

   if (logServerId == 0) // If we don't know the logServer yet

mesh.sendBroadcast(str);

   else

mesh.sendSingle(logServerId, str);

   // log to serial

#if ARDUINOJSON_VERSION_MAJOR==6

serializeJson(msg, Serial);

#else

msg.printTo(Serial);
```

```
#endif

Serial.printf("\n");

});

void setup() {

Serial.begin(115200);

sensors.begin();

mesh.setDebugMsgTypes( ERROR | STARTUP | CONNECTION );  // set
before init() so that you can see startup messages

mesh.init( MESH_PREFIX, MESH_PASSWORD, &userScheduler,
MESH_PORT, WIFI_AP_STA, 6 );

mesh.onReceive(&receivedCallback);

  // Add the task to the your scheduler

userScheduler.addTask(myLoggingTask);

myLoggingTask.enable();

}

void loop() {

  // it will run the user scheduler as well

mesh.update();

}

void receivedCallback( uint32_t from, String &msg ) {

Serial.printf("logClient: Received from %u msg=%s\n", from, msg.c_str());

  // Saving logServer
```

```
#if ARDUINOJSON_VERSION_MAJOR==6

DynamicJsonDocumentjsonBuffer(1024 + msg.length());

DeserializationError error = deserializeJson(jsonBuffer, msg);

  if (error) {

Serial.printf("DeserializationError\n");

    return;

  }

JsonObject root = jsonBuffer.as<JsonObject>();

#else

DynamicJsonBufferjsonBuffer;

JsonObject& root = jsonBuffer.parseObject(msg);

#endif

  if (root.containsKey("topic")) {

      if (String("logServer").equals(root["topic"].as<String>())) {

          // check for on: true or false

logServerId = root["nodeId"];

Serial.printf("logServer detected!!!\n");

      }

Serial.printf("Handled from %u msg=%s\n", from, msg.c_str());

  }

}
```

CHAPTER 5

DESIGN PROCESS

Design is an integral part of this project, as it is a water based monitoring system, it relies on a foolproof design that allows the device to function without any hiccups. We have done extensive research and studied multiple papers to gather some insight as to how to go about designing our device.

Our design objectives were to make a Water Monitoring System that logs data and transmits it onto a live feed onto a server where anyone can keep a check on the condition of the water body that the device is deployed in.

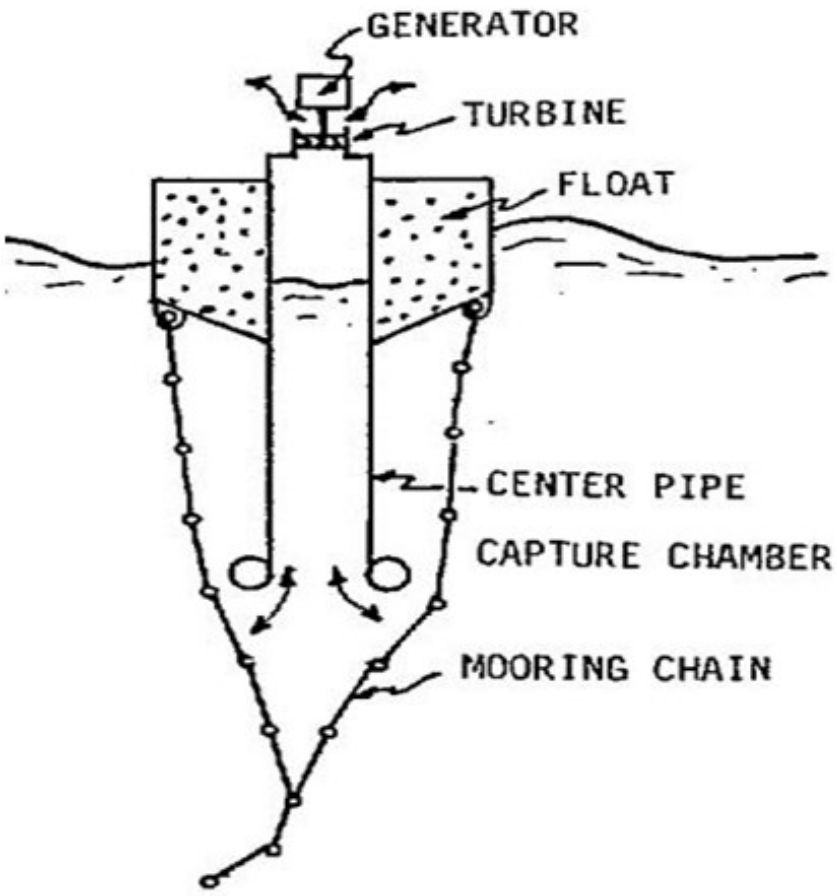

Figure 20. Center Duct Buoy Structure

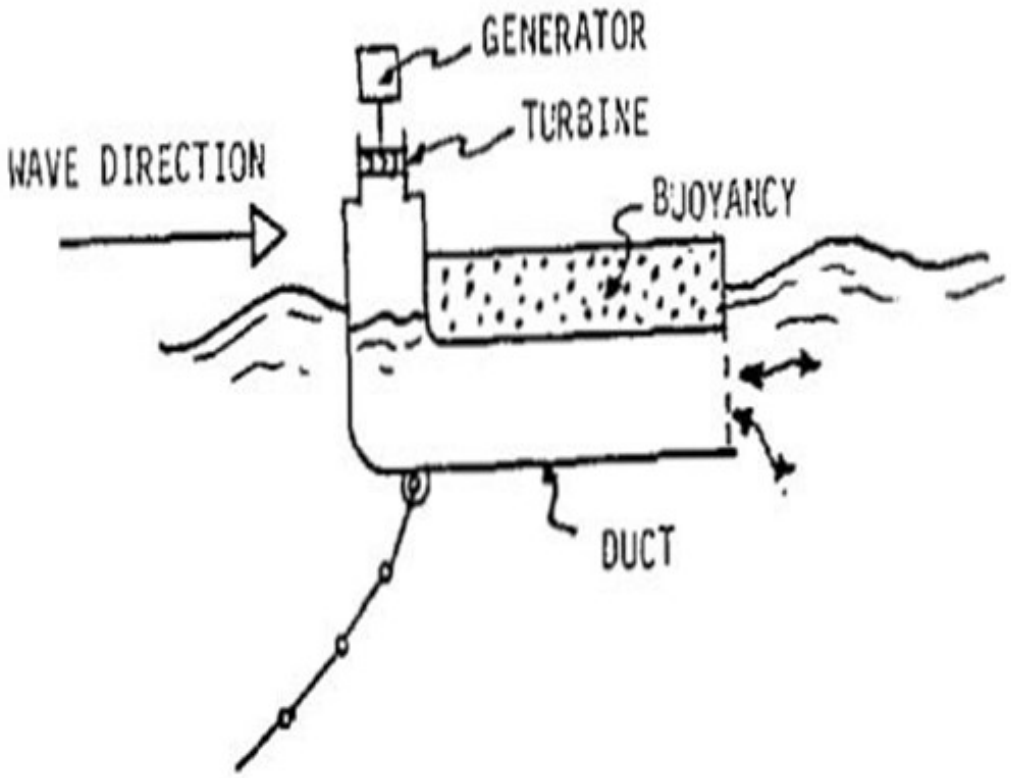

Figure 21. Backward Bent Duct Buoy

The first paper that we found has a group of researchers from Japan, that conducted a study on an American Naval Base and came up with two efficient ways to support the buoy structure.

The first one (shown in Fig 1) is The center pipe buoy which has good stability in waves, as any spar-type buoy does, but it does not have good stability in high currents. Another buoy shape (shown in Fig 2) that the research explored was The Backward Bent duct Buoy which is an air chamber bent backward from the direction of the oncoming wave. Frontward facing ducts were first studied with no plans to test a backward-facing duct.

Since there is no vertical center pipe the duct can be deployed in waters of any depth greater than the draft of the host buoy. The tests were conducted for the oncoming wave as they were conducted on Buoy structures that were required to generate energy from the movement of the turbines mounted atop the Buoy structure. Mooring chains can also be suspended along the length of the duct to keep the buoy stationary.

The backward bent duct buoy was observed to have the lowest drag of the two studied. Like drag observed in aerodynamics when we study structural integrity of planes, hydrodynamics play a crucial role in the structural integrity of water based structures as well, as they are subjected to a high level of tidal and wind pressure.

This study proved to be extremely insightful for us to use into our own project in the future, in case the weight distribution becomes a problem for us, we can always employ a backward bent duct if we explore a design that would make the weight distribution irregular. Our current design does not require us to use either of these designs as we employ a spherical design since we observed it to have a much more compact and cost effective design which fit our current usage requirements, however, in the future we do intend do explore more options that give us a better gauge of how best we can use materials and shape to our advantage for data logging.

Why Spherical Design?

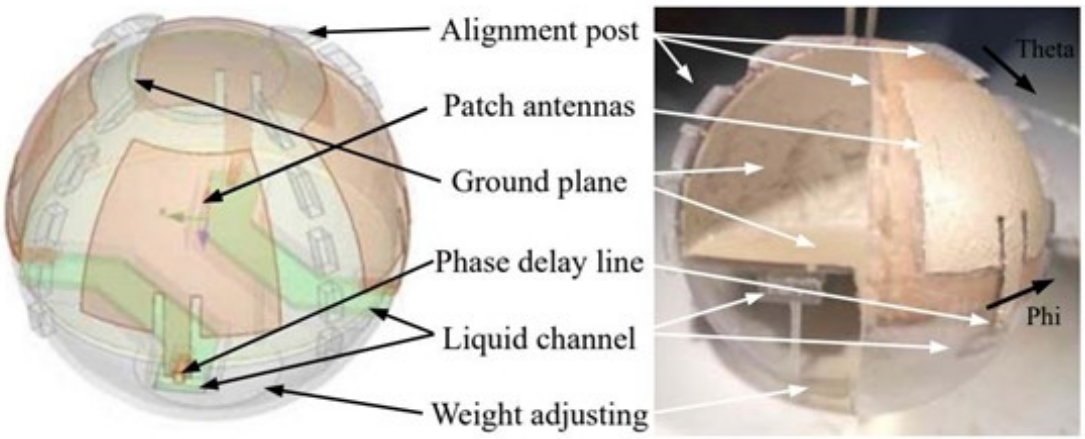

Figure 22. Spherical Buoy Structure with in built Antenna

We explored another paper by engineers from the Georgia Institute of Technology who have developed a 3D printed spherical antenna and sensors.

This innovation fits perfectly well with the design of our device as it is both compact and cost-effective. The spherical design as shown in the figure is to be immersed into water, so in most cases, the sphere would be approximately 40% submerged under water. One of the main reasons we inclined towards a spherical design for our device was that it aids in signal communication a lot better through the antenna if the buoy is shaped like a sphere, as the omnidirectional gain is a lot better, which means a wider range of transmission can be obtained for a spherical design.Omnidirectional waves for communication are the best option for us as our devices are scattered in close proximity to each other and aids in better signal handling.

Another feature that we can use with spherical design equipped antenna is the diversity it provides in terms of space or direction while using Multiple In Multiple out mode or MIMO, which is used widely in communication arrays as it provides high speed wireless communication link to support a wide range of applications without the expansion of the available bandwidth or increase of transmitted power. MIMO is used in our project in our project in the form of Mesh Networks as a multichannel mode of transmitting and

receiving data in a much more dynamic manner.

In many water reservoirs and lakes abroad, shade balls are used to slow down evaporation and reduce the exposure of UV rays from reacting with the chemicals present in the water, these shade balls can simultaneously be used as water monitoring devices as they can be spread across the entire area of the water body, which is one of the reasons we chose a spherical design for our project.

Figure 23. Shade Balls dispersed across Water Body

Some of the newer developments have improved the way we can go about designing our Water Quality Monitoring System with a spherical design, with a cost effective model and without damaging the environment any more.

Industrial Buoys that are usually deployed in oceans to monitor incoming wind pressure , or weather monitoring of the oceans, use a Hexene copolymer based Linear Low Density Polyethylene Resin (LLDPE) which is specifically designed for rotational molding applications. LLDPE has a higher tensile strength and exhibits a greater impact and puncture resistance compared to some other plastics. Other alternatives that are available in the market that prove to be the best option include mixtures of polymers and other compounds done through Injection Molding according to industry standards.

Proposed Design

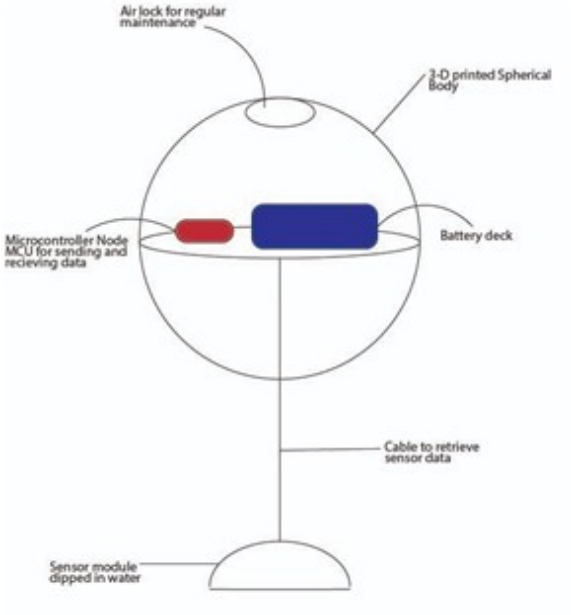

Figure 24. Rough 2D Diagram of Coral

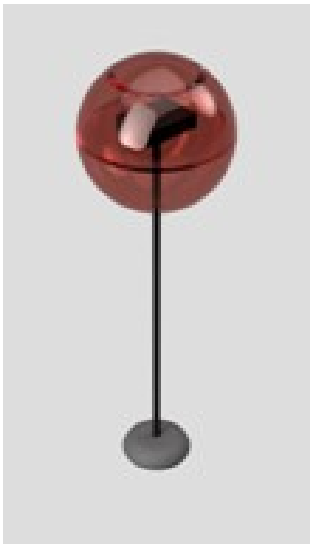

Figure 25. 3D Rendered Model of Coral

This is the proposed model of our device, here we have shown the journey from a rough sketch blueprint to a 3D model visualization to arrive at a design we can go ahead with, and one that we think suits best for the device we are building. As we discussed, in the previous topic, carefully studied design considerations were made while arriving at a structure that we have presented.

As you can see in the figures, the battery deck leaves ample space for the rest of the components and leaves enough room for antenna and insulation as well, our sensor chamber that is suspended right below our drive acts as a housing for all our sensors, while being exposed to an adequate amount of water for accurate testing and data acquisition, while simultaneously also acting as an anchor to reduce the movement of our device.

One of the main structural advantages of our WQMS (Water Quality Management Systems) has been the minimal maintenance our device needs once it is deployed into a water body. The buoys are coloured with brighter shades to be easily identifiable, so the colours are ingrained in such a way that the pigmentation penetrates throughout the surface of the plastic so that it would not lose it's colour that easily.

Eco-Friendly Design

Having extensively studied the use of plastics and it's harms, we have chosen not to be a part of the problem and take a step in the right direction by recycling the plastic we can use to build the device. As a future prospect, we can collect the plastic waste collected from the lakebed and shred them by segregating the different kinds of plastics we can melt using industrial injection molding techniques.

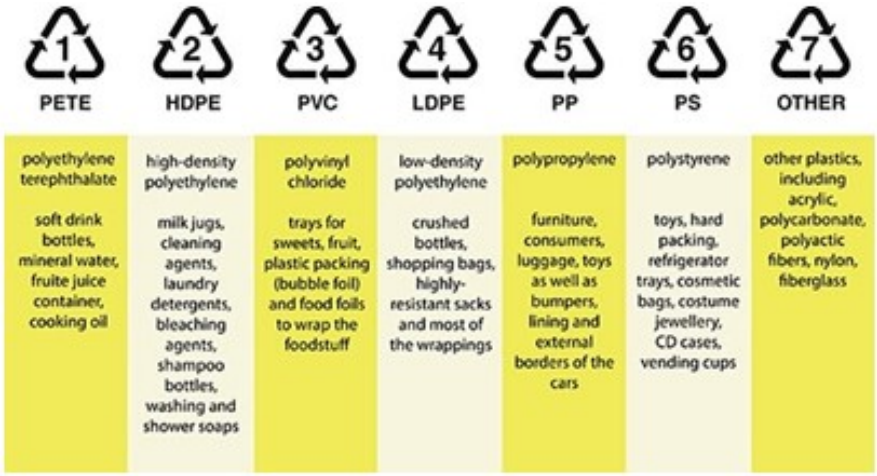

Figure 26. Different Grades of Industrial Plastics

Using different grades of plastics to identify which works best in the

conditions our device is going to be subjected to, LLDPE are a kind of lowdensity polyethylene that can easily be recycled by melting at a high temperature and have good UV resistance. Using a mix of polyethylenes and polymers will provide a good structural integrity to the device even after recycling of the material being used to build the project.

Insulation

Insulation of the device needs to be considered as it is submerged in water, and can be subjected to some amount of moisture. The electronic components need to be properly insulated from the water that surrounds the device.

We are using industry grade silicone threads to insulate the device from the electrical components.

Commonly known as plumbing tape, the silicone thread is a good alternative to other expensive insulation materials that we have looked for in the market.

Silicone putty guns can also be used but the prevalent issue with a Silicone putty gun is that it cannot be removed and used again and again.

Figure 27. Plastic discarded in Lakes

The use of recycled plastics to solve the dooming spill on water bodies is a good solution to solve the spillage of waste material on lakes and other man made water bodies.

Mooring

A buoy-based system must be moored to ensure that it remains stationary. The buoy is usually moored via a stainless steel mooring line, bottom chain and anchor. It is recommended to moor the buoy in the deepest part of the waterway to ensure the most inclusive measurements. This allows for multiple measurement depths and will best reflect the characteristics of the water body as a whole.

For our device, we have managed to use a single point mooring system in which our sensor chamber acts as an anchor for the device to remain stationary without being subjected to much movement being caused by winds or other external factors.

Figure 28. Single Point Mooring Visual

Single-point moorings are not common, but they require the least amount of mooring equipment. This setup can be deployed in very calm waters with minimal instruments. A single-point mooring should only be used when all sensors and equipment are housed within an instrument cage or deployment pipe. Hanging sensors risk getting damaged or entangled with the anchor line. A cage or pipe protects the instruments from entanglement, subsurface debris, and currents without affecting sensor readings.

In a single-point configuration, a mooring line connects the buoy directly to a bottom chain and anchor. The sensors are typically housed within a central

deployment pipe or attached to a rigid instrument cage. The anchor, bottom chain, and mooring line are assembled and attached to the buoy prior to deploying the system.

Mooring is an important factor for us to consider while designing the device as any water body involves displacement of anything that is on the water surface, through winds that create a low tide or other factors involving aquatic life. Mooring of a Buoy or in our case, the device which is the water quality monitoring system needs to remain stationary and cannot involve any tilt which would shift the antenna and disrupt signal transmission, making data logging a challenge after deployment of the device on the water body.

Building Of The Prototype

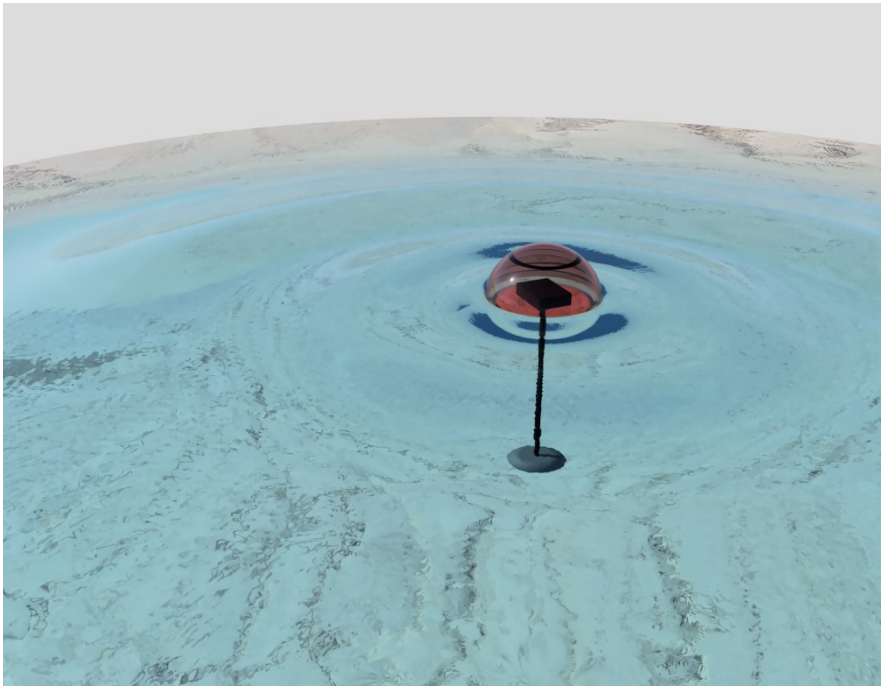

Figure 29. Proposed Model Of Coral in Water Body

Figure 30. Front View of Coral

The building of the prototype from the insight we gathered and to put it to test in the real conditions is the eventual next step in this project. The building of the working prototype would help us gauge the real possibility of this working out in the longer run and seeing this solve a very important problem for the water bodies of the city.

Injection Moulding

For the build of the prototype, we are going to use the industrial method of injection moulding as it provides a very accurate and strong structural build for our design of the project, injection moulding would help us get perfectly measured spheres with accurate threading marks that would help us properly arrange the device with allowing us to build the device with all the electrical components and insulation, with necessary adjustments made to arrange for weight distribution.

Industry grade injection moulding devices have very expensive moulds, so to cut the costs we are going to get pre made spherical shapes to help us initially with the designs as they cannot be manufactured in bulk with the current cost restrictions that we are facing in the market for the sourcing of the materials and equipment.

Figure 31. Injection Moulding Press

We hope to come up with a permanent cyclical solution to acquire raw materials for building our device by sourcing the plastic obtained from cleaning of the lakes and recycle them to be able to use for our designs without having to worry about spending money on raw materials and hopefully a much more environment friendly alternative.

3D Printing

3D Printing of the device exterior is also something that we considered in early stages of the project as it was cost effective compared to other industrial options we considered.

The filament we were looking for was the widely used PLA, which is a recyclable thermoplastic polymer. Easily resourced and inexpensive, which made it an ideal alternative to other options we had in mind. But upon testing and printing of the material we realised that the layering of the 3 axis printing did not allow us to get a solid structure, the spherical shape turned out to be a lot more fragile and brittle in build.

Another filament we explored was a polyamide filament which is a Nylon material, although this proved to have a more robust structural integrity and refined layering, which included a higher resistance to moisture in its build. However, sourcing of a Nylon filament is an expensive option and hence, it is not feasible.

Flowchart

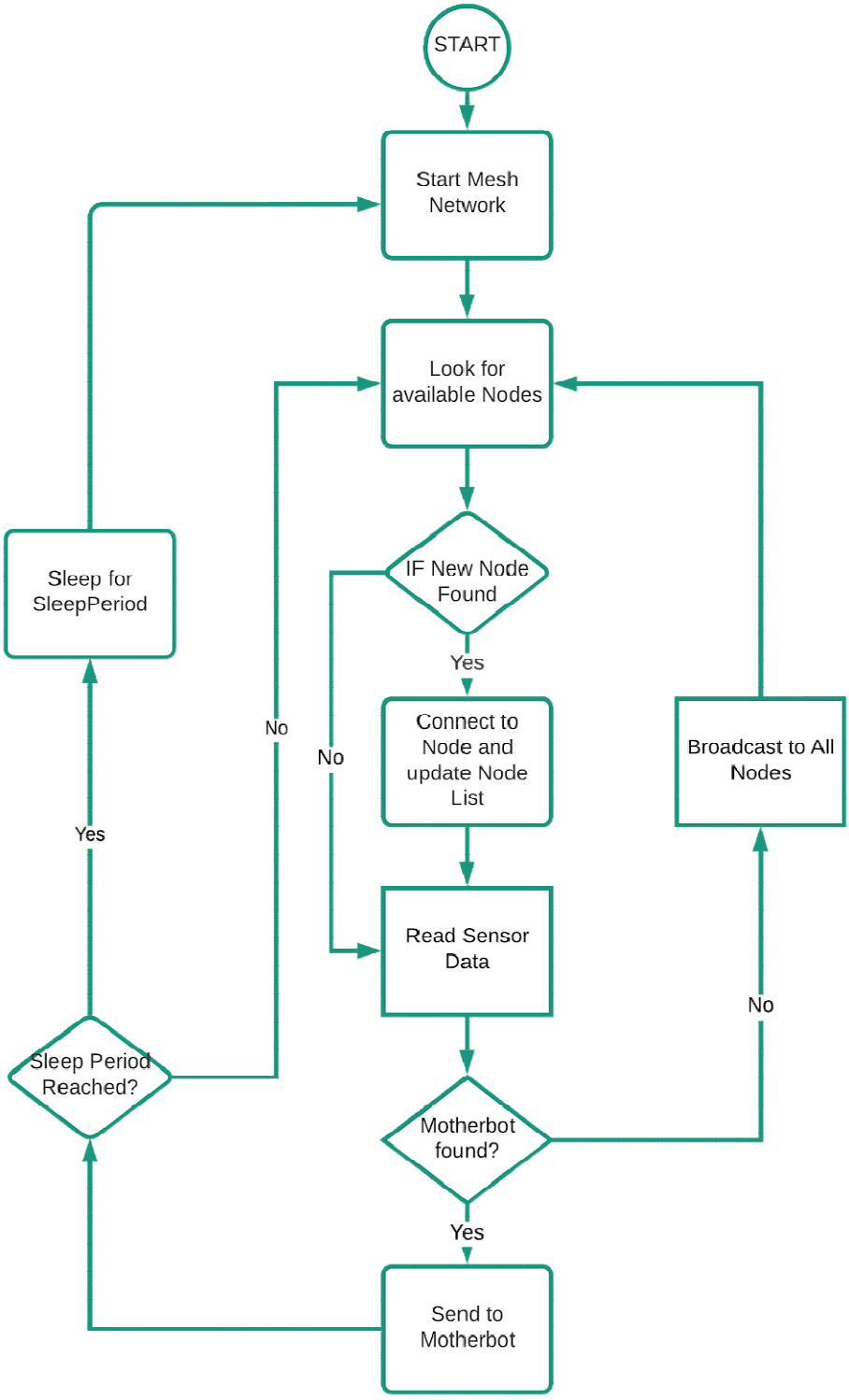

Figure 32. Flowchart showing Data Logging to MotherBot

The scouts are the main data acquisition points in our network. Once the nodes start, they first create the mesh network and start looking for all available nodes on the same network. If a new node is found, they will add them to their node list, if no new nodes are found they will continue. The nodes will then collect the data from the individual sensors and convert it to JSON format, now if the mother bot node id is known, they will send the message only to the mother bot, through the mesh network, if the mother bot is not known, the message will be broadcast to all the nodes on the mesh network. Once this is done the scouts will go into sleep mode for the designated sleep duration. This series of tasks is performed indefinitely.

The mother bot acts as the collection node for all the information as well as the interface node to the internet. Once the mother bot is started up, it will start the mesh network and the GSM module and establish a connection to the server. Now the mother bot starts looking for other nodes on the network, if found it will connect to the node and add it to the node list. If no new node is found it will continue. The mother bot now broadcasts its own identity to all the other nodes on the network, this is done so that all the bots can recognize it and send the information to the mother bot. Once the information is received the file is compiled with all the individual sensor data from each scout and at the end of the post period, a message is uploaded to the server. Once this is done, the mother bot will then go into sleep mode for the set duration. This series of tasks is performed indefinitely.

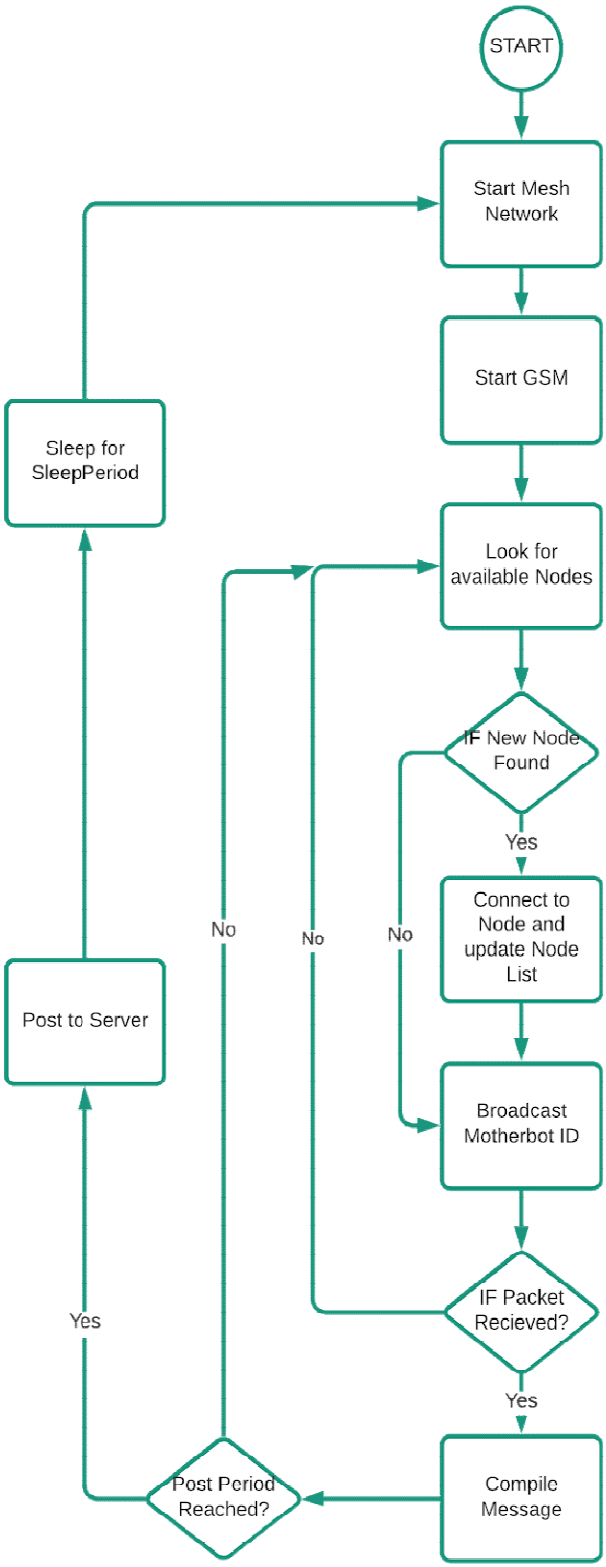

Figure 33. Flowchart showing Data Broadcast to Server

CHAPTER 6

RESULTS AND DISCUSSIONS

The website is now live at https://crypticsocket.github.io/Coral/. It shows data for the last tests done with the bots. The website is ready to accept data from any number of scouts. As the number of scouts increases the number of blocks in the home page will populate displaying data from each of the scouts. When the number of scouts increases, an average data from each water body will be posted here so that it isn't very crowded and confusing.

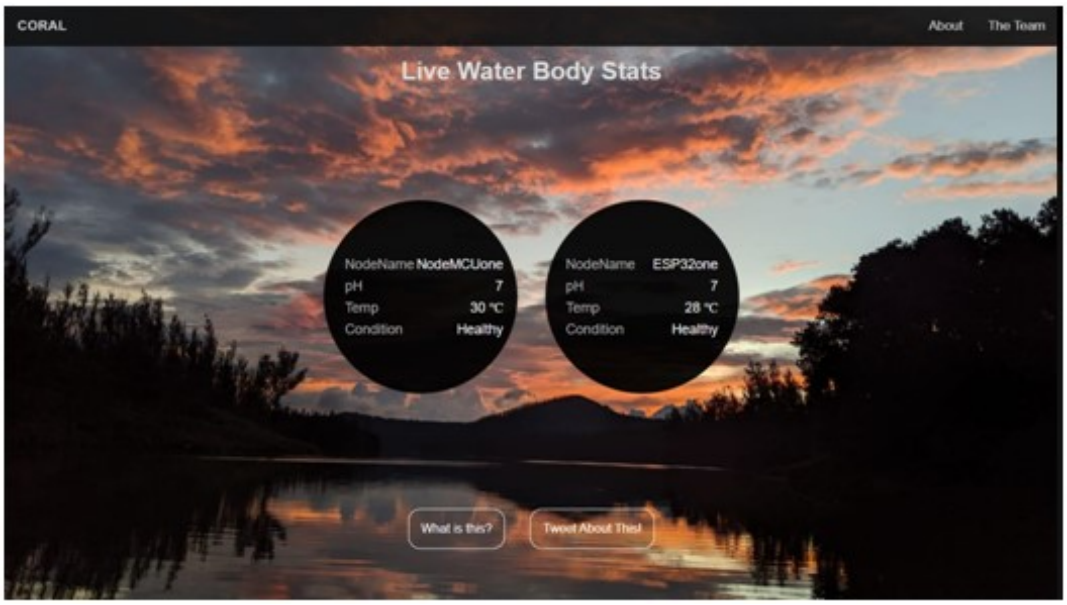

Figure 34. Website Home Page Screengrab

The website also has an option to tweet which gives a link back to the website. In this way, people wanting to help us in creating awareness can do so.

Data is being stored at our Github Gist. The figure below shows the last posted data from the bots. This is the data that is being used by the website to populate the blocks. The server will serve to be sufficient for a while before we might need something better. The amount of data that can be stored here will not be much of a problem but rather the request rates might be.

```
[
  {
    "NodeName":"NodeMCUone",
    "pH":"7",
    "Temperature":"30",
    "State":"Healthy"
  },
  {
    "NodeName":"ESP32one",
    "pH":"7",
    "Temperature":"28",
    "State":"Healthy"
  }
]
```

Figure 35. Lake Condition Code Snippet

Discussion

In the past, our government has invested crores of Rupees in cleaning of the different water bodies, like lakes and rivers. The Ganga river would be one of the greatest examples. But recently, during the global lockdown for COVID-19, it was noticed that all the rivers and lakes had become clean again. The water hadn't been seen that clean in many years, even after spending all the money. Hence this tells us that it isn't cleaning of the water bodies, but to monitor how much wastes are dumped into it that is important.

Figure 36. News Coverage On River Condition after Lockdown

There are rules for all industries to install filters before dispersing off their waste into the water bodies but a lot of industries skip this step in order to save some money. If the authorities became more strict about this, the water bodies would remain clean and that, Coral can help with.

Right now is the right time as all the water bodies are clean. There cannot be a better moment to start afresh and maintain the gift that Mother Nature has given to us. We've done a lot of damage to our planet and now it is high time that we realise our mistakes and make a step towards a better Earth. It's time for us to preserve our water bodies for the generations to come.

To this problem, Coral is our answer.

CHAPTER 7

CONCLUSIONS AND FUTURE DIRECTIONS

The product that we have developed has a lot of scope. There are several advantages of Coral that we've noticed, such as :-

- Cost effective hardware
- Minimalistic Software
- Flexible Design
- Social Media Integration
- Efficient Power Management
- Eco Friendly

Based on the advantages, and it's flexibility, Coral can also be seen having a wide range of applications, such as :-

- Water body monitoring (Lakes, Ponds, Ocean etc)
- Water tank monitoring
- Swimming pool monitoring
- Monitor pools of other chemicals

Although we have tried our best to make Coral have as much as needed to monitor water bodies, there's always scope for improvement and hence, we think the following are additions we can make to Coral to make it better and more self sufficient.

- More sensors

- Solar Powered
- Better Server Capabilities
- Machine Learning Detections
- Better Social Media Integration
- Displaying Geographic Location
- Implementing LoRa
- Movement of bots
- BOD and COD Monitoring
- Waste Plastic Recycled Design

And although cleaning wasn't our main intention with Coral, we could also, in the future, try to implement cleaning.

In conclusion, we would like to state that Coral was born out of helplessness, the initiative to save our lakes and other water bodies have to be taken. Adequate measures have to be taken to ensure that the water entering our lakes are treated and do not affect life around it. We have a solution that works.

As a society, as much as it is our responsibility to bring awareness to a particular issue, it is equally important for us to initiate working on those issues rather than put the blame on authorities.

It's high time and we are trying to *break the chain*

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