

Environmental Assessment of Aquatic Ecosystem using dissolved oxygen and Carbon dioxide levels

Submitted in partial fulfilment of the requirements the awards of Bachelor of Engineering Degree in Electronics and Communication Engineering

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of CHOPPERLA RAM NIVEDH (39130099), DASARI LIKHITH MADHAV (39130105) who carried out the project entitled “**Environmental Assessment of Aquatic Ecosystem using dissolved oxygen and Carbon dioxide levels**” Under our supervision from JAN 2023 to APRIL 2023.

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ABSTRACT

This study uses sensors to measure variables including pH, TDS, dissolved oxygen, and CO₂. Then it shows the data on the Internet of Things cloud to track the health of aquatic ecosystems. Data was gathered for the study using sensors and Arduino microcontrollers, which were then analysed to determine the ecosystem's health. The findings demonstrate that using IoT technology to measure factors in water bodies is a useful method of monitoring their health. The environment was healthy since the pH and TDS levels were within acceptable limits, and the dissolved oxygen levels were high enough to support aquatic life. Because the CO₂ levels were somewhat over permitted ranges, the water must be moderately acidic. According to the study's findings, IoT technology can support the management of aquatic ecosystems and guarantee their long-term viability. The results can be utilized to create plans and laws that will safeguard and preserve aquatic environments. Future studies on the condition of aquatic ecosystems use the study's results as a starting point. Other bodies of water including lakes, rivers, and oceans can also employ sensors and IoT technology to monitor their health and guarantee their long-term survival. As a result, it is recommended to continue researching and developing the use of IoT technology for monitoring the health of aquatic ecosystems as it is viable strategy for maintaining their long-term survival.

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CHAPTER 1

INTRODUCTION

Ocean acidification is frequently referred to as "climate change's equally evil twin," and with good reason: it is a big and destructive consequence of excess carbon dioxide in the atmosphere, but its impacts are occurring underwater, so don't see or feel them. At least one-quarter of the carbon dioxide (CO₂) that is produced through the combustion of fossil fuels like coal, oil, and gas is absorbed by the ocean rather than remaining in the atmosphere. The ocean has taken in around 525 billion tonnes of CO₂ from the atmosphere since the beginning of the industrial. It continues to do so at a rate of approximately 22 million tonnes daily.

At first, scientists had the impression that this would be a positive development since it reduces the amount of carbon dioxide that is released into the atmosphere and contributes to global warming. However, during the last ten years, scientists have concluded that the slowing of global warming has occurred at the expense of a change in the chemical composition of the ocean. The pH of the ocean, which is a measurement of how acidic or basic the ocean is, declines as a result of the dissolution of carbon dioxide in salt water, which makes the water more acidic. Even though the ocean is large, if there is enough carbon dioxide, it may still have a significant effect. The acidity of ocean water has increased by thirty percent in only the last two hundred years, which is a rate that is quicker than any change in ocean chemistry that is known to have occurred in the previous fifty million years.

In the past, scientists didn't put much thought into this process since they always assumed that rivers delivered a sufficient amount of dissolved chemicals from rocks into the ocean to maintain a consistent pH level in the ocean. (This impact of maintaining stability is referred to by scientists as "buffering.") This natural buffering has not been able to keep up with the rate at which carbon dioxide is dissolving into the ocean, which has led to a rather fast decline in pH in surface waters. The whole ocean is impacted when those upper layers progressively incorporate themselves into the deeper water.

Marine life, which developed over millions of years in an ocean with a typically constant pH, isn't given much time to adjust because of the relatively rapid shift in the ocean's chemistry. The shells of some marine organisms have already begun disintegrating in increasingly acidic waters. This is only one of the many ways that ocean acidification will affect marine life. In general, it is anticipated that it will have significant and, for the most part, detrimental effects on the ecosystems of the oceans; nevertheless, some species, particularly those that dwell in estuaries, are discovering methods to adapt to the changing circumstances.

However, even though the chemistry may be predicted, the specifics of the biological effects cannot. Although researchers have been measuring the pH of the ocean for more than three decades, biological research on the subject did not begin in earnest until 2003.

This was the year when the dramatic change drew scientists' attention, prompting them to develop the phrase "ocean acidification." What we do know, though, is that things are going to appear different, and have no way of knowing how exactly they will look in any particular aspect. While some creatures may have difficulty adapting to the more acidic environment and may probably go extinct as a result, others will be able to live and even flourish in these settings. In addition to the loss of biodiversity, acidification will affect fisheries and aquaculture, which will put millions of people's access to food as well as tourism and other industries dependent on the sea at risk.

1.1.1 ACIDIFICATION

The problem of ocean acidification may be reduced to its most fundamental level—chemistry. When you think about what takes place when carbon dioxide dissolves in saltwater, there are two factors that you need to keep in mind. To begin, the pH of ocean water drops as its acidity increases, which is to be expected. Second, this mechanism binds up carbonate ions, which causes their abundance to decrease. Carbonate ions are essential for the development of shells and skeletons in many animals, including corals, oysters, mussels, and many others.

This graph demonstrates that the amounts of carbon dioxide (CO₂) in the atmosphere are increasing, as are the levels of CO₂ in the ocean and that the pH of the

water off the coast of Hawaii is lowering. (Link to the NOAA PMEL Carbon Program)

Carbon dioxide is a component of the atmosphere that occurs naturally. Plants cannot survive without it, and mammals release it when they breathe. But because of the combustion of fossil fuels by humans, there is currently a higher concentration of carbon dioxide in the atmosphere than there has ever been in the previous 15 million years. The vast majority of this CO₂ can diffuse into the atmosphere, where it quickly accumulates and, as a result of its ability to store solar energy, wraps the globe in a blanket of warmth. However, somewhere about thirty percent of this CO₂ dissolves into the salt water, where it no longer exists as CO₂ molecules that are free to float. A chain reaction of chemical processes causes the CO₂ molecules to split apart and then rejoin with other molecules. Carbonic acid is produced by the reaction of carbon dioxide (CO₂) and water (H₂O) (H₂CO₃). Carbonic acid is rather ineffective when compared to other types of acids that may dissolve solids, such as hydrochloric acid, which is the primary component of gastric acid and is responsible for the digestion of food in the stomach, and sulfuric acid (the main ingredient in car batteries, which can burn your skin with just a drop). It may take longer for the less potent carbonic acid to have its effect, but its mechanism of action is the same as that of other acids in that it causes the release of hydrogen ions (H⁺), which form bonds with other molecules in the vicinity.

1.1.2 Anthropogenic CO₂ Uptake

The fact that the concentration of carbon dioxide in the atmosphere remained relatively stable over the centuries leading up to the Industrial Revolution gives rise to the hypothesis that the oceans contributed a negligible amount of carbon dioxide to the atmosphere to maintain a stable carbon level. Today, this pattern is reversing, and the seas are being forced to take on the role of removing CO₂ from the atmosphere that has been generated as a result of human activity (also known as anthropogenic or human-derived CO₂).

During the 1980s, it was predicted that the oceans eliminated between 2.0 and 0.6 Pg of human CO₂ per year. In the 1990s, the average amount of carbon removed by the oceans climbed to 2.4 0.5 Pg per year as a direct result of the ever-increasing pace at which people produce carbon dioxide (CO₂).

The differential in gas pressure between the atmosphere and the seas, as well as the air-sea transfer velocity, are the primary drivers of the ocean's ability to absorb anthropogenic carbon dioxide. Because $p\text{CO}_2$ is rising in the atmosphere, carbon dioxide is moving into the ocean to maintain a stable equilibrium between the gas pressures in the ocean and the atmosphere.

A poor understanding of the processes that govern the air-sea transfer velocity, which refers to the rate at which carbon dioxide gas may flow from the atmosphere to the seas. Recent developments in technology are assisting researchers in gaining a deeper comprehension of these systems.

The speed of the wind and the roughness of the ocean's surface are both factors that influence the transfer velocity. The difference in $p\text{CO}_2$ is due to the quantity of carbon that is converted from CO_2 gas to other nongaseous carbon species in the seawater, such as bicarbonate and carbonate ions. This conversion takes place in the presence of high temperatures and pressures. Because of something termed their "buffer capacity," the seas can store a significant amount of carbon.

The relative quantities of CO_2 (one percent), bicarbonate ion (ninety-one percent), and carbonate ion (eight percent) in the seas determine the pH value of the water. The ocean's pH drops as a result of the absorption of anthropogenic CO_2 since CO_2 is an acid gas and eats up carbonate ions in the process. It is projected that there will be a 30 percent fall in the concentration of carbonate ions in surface seawater if there is a doubling of the amount of CO_2 in the atmosphere from preindustrial levels (280 to 560 ppm). The buffer capacity of the ocean and its ability to soak up CO_2 from the atmosphere both diminish when the concentration of carbonate ions in the ocean falls.

The ocean can soak up around 85 percent of the human CO_2 that is emitted into the atmosphere over the long term (millennial durations). The seas will keep taking in more and more carbon dioxide as long as there is a steady increase in the amount of CO_2 in the atmosphere. On the other hand, this response may be reversed. If in the future there is a decline in the amount of CO_2 in the atmosphere, the seas will begin releasing the anthropogenic CO_2 that has accumulated in them back into the atmosphere.

The final repository for anthropogenic carbon dioxide must consist of chemical processes that bind the gas in a way that does not let it release readily. Long-term carbon

dioxide storage may be achieved, for instance, by the dissolution of calcium carbonate in oceanic waters. As a result of the continued uptake of human CO₂ by the oceans, this gas will be able to disperse farther down into the water column, resulting in a lower pH and waters that are more corrosive to calcium carbonate. The fact that carbonate dissolution normally takes place in the deep ocean, which is located far away from the human CO₂ that is absorbed by the surface waters, is the source of the issue. However, in some regions of the North Atlantic and North Pacific Oceans, human carbon dioxide may already have reached depths sufficient to affect the breakdown of calcium carbonate in the water column.

1.1.3 Impacts on Ocean Life

As a consequence of natural processes, the pH of the ocean may vary, but only within predetermined parameters; hence, marine species have developed the capacity to thrive despite the variations in pH that they are used to encountering. Some marine species may be able to adapt to the more severe changes that are coming, but a lot of others will suffer, and there will probably be extinctions. There may have been widespread extinctions of some species, particularly deep marine invertebrates, during the most recent major acidification episode that occurred 55 million years ago. However, cannot be certain of this. Even if a more acidic ocean won't kill all marine life, the spike in seawater acidity of 30 percent that have already witnessed is already affecting certain ocean animals.

1.1.4 Coral Reefs

Reef-building Corals construct their own houses out of calcium carbonate, resulting in the formation of intricate reefs that not only serve as homes for the coral creatures but also as a habitat for a wide variety of other species. It is possible that acidification would restrict coral development by corroding existing coral skeletons while concurrently reducing the creation of new coral skeletons. As a consequence, the reefs that are created will be weaker and more susceptible to erosion. In addition to the waves caused by storms, this erosion will be caused by creatures that either consume coral or dig into it. According to the findings of recent research, by the year 2080 or thereabouts, ocean conditions would have become so acidic that even coral reefs that are generally healthy will be disintegrating at a faster rate than they can recover.

Corals may suffer damage from acidification even before they start building their colonies. Only a few of the species of coral have had their eggs and larvae examined, and the results showed that the increased acidity of the water did not hinder their growth while they were still in the plankton. However, larvae that were exposed to acidic water had a more difficult time locating a suitable site to settle, which prevented them from maturing into adults.

The amount of difficulty that corals experience is highly dependent on the species. Some species of coral can construct their skeletons out of bicarbonate rather than carbonate ions, which provides them with more alternatives in an environment that are becoming more acidic. Some can live without a skeleton and resume their typical skeleton-building operations once the pH level of the water returns to a more favorable range. Some organisms can tolerate a larger pH range.

However, during the next century, will see a shift in the typical varieties of coral that may be found in reefs; however, unable to predict with absolute certainty what this shift will look like. Big boulder colonies have taken over reefs in Papua New Guinea that have been damaged by natural leaks of carbon dioxide, and the delicately branching forms have vanished. This is likely because the thin branches of the delicate forms were more prone to dissolving. This alteration is also likely to affect the many thousands of creatures that dwell among the coral in unanticipated ways. This includes organisms that humans fish for and eat. In addition, acidification is added on top of all of the other pressures that reefs have been experiencing, such as warmer water (which is the source of another hazard to reefs known as coral bleaching), pollution, and overfishing.

In general, shelled organisms, such as mussels, clams, urchins, and starfish, are likely to have difficulty constructing their shells in water that is more acidic, much as corals would. This includes species like starfish. By the end of this century, it is anticipated that mussels will develop shells that are 25 percent thinner and oysters will produce shells that are 10 percent thinner. It is not as well understood, but urchins and starfish construct their shell-like sections using high-magnesium calcite. This is a form of calcium carbonate that dissolves even more rapidly than the aragonite form of calcium carbonate that is used by corals. These creatures will have a thinner shell as a result, which will increase their vulnerability to being crushed or consumed.

However, some of the most significant effects on these creatures go far beyond the construction of the adult shell. The byssal threads of mussels, which are what allow them to famously cling to rocks in the pounding surf, are not as effective in the presence of acidic water. Oyster larvae, on the other hand, are unable to even begin developing their shells. Oyster larvae go through a major development surge during the first 48 hours of their lives, developing their shells rapidly so that they may begin eating as soon as possible. However, the more acidic the saltwater gets, the faster their shells are eaten away before they can even develop. This has already led to huge oyster mortality in the Pacific Northwest of the United States.

Studies have shown that crustaceans (such as lobsters, crabs, and shrimp) produce even tougher shells at increasing acidity. However, this catastrophic failure is not universal. This may be due to the distinct construction of their shells. In addition, some species, such as purple sea urchins, may already have acclimated to greater acidity levels or have the possibility to do so in the future. (However, recent research discovered that larval urchins had difficulty digesting their food when the acidity levels are elevated.)

Naturally, the absence of these creatures would have considerably more severe repercussions for the food chain, given that many other species depend on them for both food and a home.

1.1.5 Prevention

If the amount of carbon dioxide in the atmosphere stabilizes, eventually buffering (or neutralizing) will occur and pH will return to normal. This is why there are periods in the past with much higher levels of carbon dioxide but no evidence of ocean acidification: the rate of carbon dioxide increase was slower, so the ocean had time to buffer and adapt. But this time, pH is dropping too quickly. Buffering will take thousands of years, which is way too long a period of time for the ocean organisms affected now and in the near future. So far, the signs of acidification visible to humans are few. But they will only increase as more carbon dioxide dissolves into seawater over time. What can we do to stop it?

Cut Carbon Emissions When use fossil fuels to power our cars, homes, and businesses, put heat-trapping carbon dioxide into the atmosphere. (*Sarah Leen/National Geographic Society*)

In 2013, carbon dioxide in the atmosphere passed 400 parts per million (ppm)—higher than at any time in the last one million years (and maybe even 25 million years). The "safe" level of carbon dioxide is around 350 ppm, a milestone passed in 1988. Without ocean absorption, atmospheric carbon dioxide would be even higher—closer to 475 ppm.

The most realistic way to lower this number—or to keep it from getting astronomically higher— would be to reduce our carbon emissions by burning less fossil fuels and finding more carbon sinks, such as degrowing mangroves, seagrass beds, and marshes, known as blue carbon. Over hundreds of thousands of years, carbon dioxide in the atmosphere and ocean would stabilize again.

Even if stopped emitting all carbon right now, ocean acidification would not end immediately. This is because there is a lag between changing our emissions and when started to feel the effects. It's kind of like making a short stop while driving a car: even if slam the brakes, the car will still move for tens or hundreds of feet before coming to a halt. The same thing happens with emissions, but instead of stopping a moving vehicle, the climate will continue to change, the atmosphere will continue to warm and the ocean will continue to acidify. Carbon dioxide typically lasts in the atmosphere for hundreds of years; in the ocean, this effect is amplified further as more acidic ocean waters mix with deep water over a cycle that also lasts hundreds of years.

1.2 DESIGN OF OXYGEN CONCENTRATOR PSA

oxygen concentrators can be classified into one-bed and two-bed systems. Figure 2. (a) and (b) illustrates pneumatic diagrams of one-bed and two-bed systems respectively. Computer aided design of one-bed and two-bed systems are shown in Figure 3. (a) and (b) respectively. In one bed systems, as shown in Figure 2. (a), the compressed air will flow in and out of canister J by the control of solenoid valve B, C and

D. Concentrated oxygen will be store in the buffer tank L. Proportion valve M will then control the flow rate of the oxygen. Attached to buffer tank, a pressure safety relief valve N will release excessive pressure oxygen to room atmosphere. Before supplying oxygen to patients, a heat filter is used. One-bed PSA system reduces the cycle time; however, it suffers from pressure drop. The two-bed system uses two zeolite canisters depicted as J and K. The two-bed system will alternately adsorb and purge nitrogen to room atmosphere, i.e., first canister adsorbs nitrogen and releases oxygen to the patient, while the second canister removes the adsorbed nitrogen. The two-bed system performs better than the onebed system. However, the twobed system is more costly than the one-bed system. The processing step of one-bed and two-bed systems are shown in Figure 4. (a) and (b) respectively. [15] The onebed system operates in a three-step cycle, while the two-bed system operates in four step cycles. The first step in the three-step cycle is referred to as the adsorption phase. In this phase, solenoid valves B and D are opened, and high-pressure air passes through to canister J. Nitrogen is adsorbed while oxygen is concentrated and stored in the buffer tank. In the second phase, the delay phase, solenoid valves B and C are closed while solenoid valve D is opened. Oxygen gradually moves to the buffer tank. In the last phase, de-absorption, solenoid valve B is closed while solenoid valves C and D are open. Nitrogen is removed and released to the room. For the two-bed system,[16] the first step is known as the pressurization step. In this step, high-pressured air fills the first canister by opening solenoid valve B. While the second canister undergoes the blowdown phase; nitrogen is desorbed from zeolite by decreasing the pressure and opening solenoid valve E. In the second phase, adsorption phase, the solenoid valve B is still opened to supply the high-pressure feed air to the entire column at constant velocity and enriched oxygen is delivered to the buffer tank through valve H. At this phase, some parts of the oxygen are used to purge the second column through the opening of solenoid valves E and G. In the third step, canister 1 undergoes a blowdown step by the opening of solenoid valves C and D to lower the pressure in canister 1. All the remaining valved are closed. By the opening of solenoid valve D, the canister 2 now enters pressurization phase. Finally, canister 1 undergoes the purging step while canister 2 undergoes the adsorption step. In this step, the valves E and C are open to purge column 1 and D and I are open to deliver oxygen-rich air at the column exit of the second bed. A part of product gas from bed 2 is used to purge the first bed.

CHAPTER 2

LITERATURE SURVEY

2.1 Inferences from literature Survey

Marine life analysis is the study of ocean conditions such as temperature, pressure, alkalinity, dissolved oxygen, and carbon content for marine animals to survive safely underwater. This study shows how temperature, pressure, and other characteristics affect marine life. Machine learning techniques may be used to estimate the ideal parameters for a particular water body. This research compares machine learning techniques to predict ocean characteristics using NOAA's dataset. This dataset includes Canadian Beaufort Sea pressure, dissolved inorganic carbon, total alkalinity, water temperature, salinity, and dissolved oxygen depth data. Given one parameter, this data accurately predicts all others. This strategy is especially effective since knowing one parameter using any sensor may simply anticipate the best circumstances for the others, making the system more effective.

Conservation and sustainable use of ocean resources need better quantitative information and data-assimilative projections. In this work, leverage our MIT-MSEAS systems for high resolution coupled physical-biogeochemical-acidification simulations in Massachusetts Bay. Simulations match in-person and remote data well. Wind, tides, and single waves alter water movement, mixing, and OA fields. Winds restart Bay circulation and OA. Internal tides deepen shallow waterways. Solitary waves and lateral turbulent mixing combine surface and deep waters at Stellwagen Bank. Both influence OA and biology. Subsurface chlorophyll maxima are created by wind-induced upwelling, internal tides, and near-surface field advection. Sparse data and poor understanding of complex OA processes make OA model state variables and parameterizations inaccurate. Show how to estimate OA state variables and model parameterizations from sparse data. Positive OA model learning outcomes.

In economically significant coastal marine habitats, ocean acidification is dynamic. Ocean and coastal acidification need data, assurance, and management. Traditionally, carbonate chemistry for ocean and coastal acidification has been monitored by fixed moorings with pH and/or dissolved CO₂ sensors and ship surveys that use flow-through pH and Pco₂ sensors and collect discrete water samples to measure pH, total alkalinity, and dissolved inorganic carbon. Glider sensors can detect water column changes more accurately than permanent moorings and expensive research boats. Deep ISFET glider-based pH sensor may allow scalable ocean and coastal acidification monitoring networks for scientists, ocean monitoring programmes, water quality management, and commercial fishing. Rutgers, Delaware, Sea-Bird, and Teledyne Webb produced this sensor. Science now needs a standardised approach. Recommend a gliderintegrated deep ISFET pH sensor. This paper details the design, operation, and deployment of an ISFET-based pH sensor

Sulphur oxide (Sox) from ships pollutes towns and coastal regions worldwide. SO₂ emissions lead to acid rain and ocean acidification, which may harm human health. The International Convention for the Prevention of Pollution from Ships (MARPOL) regulates sulphur in ship fuel oils, as the sulphur is discharged into the environment as sulphur dioxide (SO₂). This application note discusses how to leverage remote hyperspectral imaging data from the Telops Hyper-Cam and signal processing methods to estimate sulphur content in fuel oils. Transport Canada compares the sulfur level of various ships' fuel to bunker delivery notes and in situ readings.

Provide Nemo-Net, the first open-source FCNN, and interactive learning software (22 classes). Climate change, ocean acidification, and other human effects affect shallow marine ecosystems, especially coral reefs. refraction and optical attenuation hinder meter-scale remote sensing of shallow maritime ecosystems. Nemo-Net integrates NASA's airborne FluidCam and fluid lensing remote sensing technologies with low-resolution airborne and spaceborne information. no-low-resolution Net's benthic habitat classification improves using FluidCam data. Nemo-FCNN Net segments and masks images from drones, manned aircraft, and satellites. Deep Laplacian Pyramid Super-Resolution Networks (LapSRN) augment lowresolution imagery with high-resolution drone-based datasets and recognize domain-invariant features across multiple

instruments to achieve high classification accuracies, ameliorating inter-sensor spatial, spectral, and temporal heterogeneity.

OLCI is one of the most advanced ocean color sensors. Few studies have tested AC-OLCI. This study used Aerosol Robotic Network-Ocean Colour global automated in situ observations to investigate seven AC approaches for OLCI (AERONET-OC). The polynomial-based algorithm applied to MERIS (POLYMER) had the best performance for bands with wavelength 443 nm, and the SeaDAS method based on 779 and 865 nm was the best for longer spectral bands; however, SeaDAS (SeaWiFS Data Analysis System) processing algorithm based on 779 and 1020 nm, as well as 865 and 1020 nm, obtained degraded AC performance; POLYMER and C2 AC ambiguity hampered chlorophyll recovery. POLYMER outperformed chlorophyll recovery technology. This study chooses an AC technique for Sentinel-3 OLCI aquatic monitoring

Bisphenol A makes polycarbonate and epoxy. It's one of the most frequent contaminants in aquatic habitats, hurting aquatic life. Dry and moist Bolgoda lake water was tested for BPA. In the wet and dry seasons, Karadiyana solid waste open dump samples averaged 3.3–29.2 and 1.0– 1.2 g/L BPA. BPA concentrations in Bolgoda lake during the wet season were significantly different from the upstream sample ($p < 0.05$), suggesting migration from the dump site. BPA levels in the dry season were not significantly different ($p > 0.05$), indicating no leachate mixing with Bolgoda lake. pH and temperature affect BPA. In the rainy season, Mozambique tilapia (*Oreochromis mossambicus*) and grass carp are at danger (*Ctenopharyngodon idella*).

Growth needs more energy for industrialization, globalization, urbanization, and population. Future energy security challenges are predicted for India. Planning Commission and NITI Ayog proposed a unique strategy to meet future energy needs, including R&D in the renewable green energy company and adopting, commissioning, and employing exclusive solar energy. India's vast terrain is utilized for farming and living. FSPs are solar arrays on floating structures in reservoirs, lakes, fjords, and oceans. Indians live off the country's 400 rivers. River witnesses' aquatic environments are balanced. The author used literature and case studies to analyze innovative SWP. SWP's scope, problems, possibilities, future aims, and results were analyzed. This study may assist comprehend its expanding relevance and assess whether it's good or bad for sustainable environmental development and resource management.

Rising ocean pollution harms marine life. Anthropogenic pollution harms humans and the environment. Ocean quality must be checked. Underwater light distorts images. As water deepens, sunlight dims. Image quality is improved via color correcting and histogram equalization. Pollutants are retrieved using a grey-level co-occurrence matrix. Texture classification employs entropy, homogeneity, contrast, and energy. Oil spills, garbage, fishing nets, and dying coral reefs are contrasted using a trained neural network. This ocean monitoring system needs no expertise. Cost-effective data processing and analysis need no hardware. This study presents an economical strategy for anticipating ocean pollution mitigation efforts.

This research presents a deep learning-based technique for monitoring maritime pollution, specifically oil pollution. Due to similar colors and movements, it's difficult to identify oil contamination from the ocean with insufficient training data. Thus, optical flow alone cannot detect pollution in the water and its movement direction. To address the foregoing issues, input photos were first segmented. This research uses SVM to identify oil contamination locations from the water so that ocean spill events may be recognized based on their colors and motion energy. To evaluate an ocean spill, optical flow is used to track contaminated regions.

Experiments indicate our method's superiority.

There are several open problems in the existing system for measuring pH and TDS sensor data in aquatic ecosystems and presenting it in an IoT cloud platform. These include:

2.2 Open Problems in Existing System

1. Sensor Calibration: Accurate sensor calibration is critical for ensuring the data collected is reliable and valid. However, the calibration process can be complex and time-consuming, and factors such as sensor drift and variability can affect the accuracy of the measurements.

2. Data Accuracy: The accuracy of the data collected can be affected by various factors, including the sensor's sensitivity, environmental conditions, and data processing methods. Improving the accuracy of the data collected is essential for providing reliable insights into the aquatic ecosystem's health.

3.Security: As the system collects and stores sensitive data, ensuring the security and privacy of the data is critical. The system needs to implement robust security measures, such as encryption and access control, to prevent unauthorized access and data breaches.

4.Data Visualization: The system's data visualization capabilities can impact its usability and effectiveness. The system needs to provide clear and user-friendly visualizations that enable users to quickly and easily interpret the data and identify trends.

5.Integration with other Systems: The proposed system only measures pH and TDS levels, and integrating other sensors and data sources can provide a more comprehensive view of the aquatic ecosystem's health. However, integrating different data sources and systems can be challenging and require significant development efforts.

6.Data Interpretation: The system's algorithms and data analysis methods can impact the accuracy and effectiveness of the system's insights. Developing robust data interpretation methods that account for different environmental factors and conditions is critical for providing reliable insights into the aquatic ecosystem's health.

7.Addressing these open problems will require ongoing research and development efforts to improve the accuracy, usability, and effectiveness of the system.

CHAPTER-3

REQUIREMENT ANALYSIS

3.1 Feasibility Studies/Risk Analysis of the Project:

Before developing the proposed system for measuring pH and TDS sensor data in aquatic ecosystems and presenting it in an IoT cloud platform, it is important to conduct feasibility studies and risk analysis. This helps to determine the project's feasibility and identify potential risks and challenges that may arise during the development and implementation phases. Feasibility studies will assess the technical, economic, and operational feasibility of the proposed system. Technical feasibility will determine whether the technology required to develop and implement the system is available and feasible to use. Economic feasibility will assess whether the system's benefits justify the costs involved in developing and implementing it. Operational feasibility will determine whether the system can be integrated with existing systems and whether it meets user requirements.

Risk analysis will identify potential risks and challenges that may arise during the development and implementation of the system. These risks may include technical risks such as software bugs, security risks such as data breaches, and operational risks such as user adoption and training.

3.2 Software Requirements Specification Document:

The software requirements specification (SRS) document is a detailed document that outlines the system's functional and non-functional requirements. This document provides a clear understanding of the system's requirements, which is essential for developing and implementing the system.

The SRS document will outline the system's functional requirements, such as measuring and collecting pH and TDS sensor data, storing data in a database, and presenting data in an IoT cloud platform. It will also outline the system's non-functional requirements, such as security, reliability, and usability.

The SRS document will include details on the system's architecture, hardware and software requirements, and data processing methods. It will also outline the system's performance requirements, such as data collection frequency, data storage capacity, and response times.

3.3 System Use case:

A system use case is a detailed description of how the system will be used to meet user requirements. It outlines the system's functions and features and how they will be used to achieve specific goals and objectives.

The system use case will identify the primary actors in the system, such as users and sensors. It will also outline the primary use cases, such as measuring pH and TDS levels, storing data in a database, and presenting data in an IoT cloud platform.

The system use case will provide a detailed description of how each use case will be executed, including the inputs, processes, and outputs involved. It will also outline the system's error handling and recovery processes and how users can interact with the system.

Overall, the requirements analysis phase is critical for ensuring the proposed system meets user requirements and is technically feasible and economically viable. It lays the foundation for the development and implementation phases of the project.

3.4 Requirement Analysis

The study used various components to measure the parameters of water bodies and present the data in the IoT cloud. These components include Arduino microcontrollers, sensors, and communication modules.

1. Arduino Microcontrollers:

The study used Arduino microcontrollers as the main control system to manage the sensors and communication modules. The microcontroller is a small computer that can be programmed to control various sensors and devices. The Arduino microcontroller

used in this study is Arduino Uno, which is a popular microcontroller board used in many IoT applications.



Fig 3.1:AURDINO NANO

2. Sensors:

The study used four different sensors to measure the parameters of water bodies, including pH, TDS, dissolved oxygen, and CO₂. These sensors are:

- pH Sensor: The pH sensor used in this study is a combination electrode that measures the acidity or alkalinity of a solution. The pH sensor consists of a glass bulb that contains a solution of known pH value and a reference electrode. The sensor measures the difference in voltage between the two electrodes to determine the pH value of the solution.



Fig 3.2: pH Probe

- **TDS Sensor:** The TDS sensor used in this study is a conductivity sensor that measures the total dissolved solids in a solution. The TDS sensor measures the electrical conductivity of the solution, which is proportional to the concentration of dissolved solids in the water.



Fig 3.3: TDS Sensor

- **Dissolved Oxygen Sensor:** The dissolved oxygen sensor used in this study is a polarographic sensor that measures the concentration of oxygen in the water. The sensor measures the difference in voltage between the cathode and the anode of the sensor, which is proportional to the concentration of dissolved oxygen in the water.
- **CO₂ Sensor:** The CO₂ sensor used in this study is a non-dispersive infrared (NDIR) sensor that measures the concentration of carbon dioxide in the water. The sensor measures the amount of infrared light absorbed by the CO₂ molecules in the water to determine the concentration of CO₂.

3. Communication Modules:

To send the data from the sensors to the IoT cloud, the study used two communication modules:

- **WiFi Module:** The WiFi module used in this study is ESP8266, which is a low-cost WiFi module that can connect to the internet and send data to the IoT cloud.

- IoT Cloud Platform: The IoT cloud platform used in this study is ThingSpeak, which is a cloud-based IoT platform that allows users to store, analyze, and visualize data from IoT devices.

In summary, the study used Arduino microcontrollers, sensors, and communication modules to measure the parameters of water bodies and present the data in the IoT cloud. The use of these components allowed for accurate and reliable measurements of the water parameters, which can be used to monitor and manage the health of aquatic ecosystems.

CHAPTER-4

METHODOLOGY

4.1 Selected Methodology or process model

The proposed system for measuring pH and TDS levels in aquatic ecosystems will be developed using the Agile methodology. The Agile methodology is a flexible and iterative approach to software development that emphasizes collaboration, continuous improvement, and rapid prototyping. This methodology is well-suited for the development of IoT systems, as it allows for rapid development and testing of software components and encourages frequent feedback and communication between team members.

4.2 Architecture / Overall Design of Proposed System

The proposed system will consist of two main components: a hardware component and a software component. The hardware component will include pH and TDS sensors, a microcontroller, a Wi-Fi module, and a power supply. The software component will include a data acquisition module, a data processing module, and a data visualization module.

The hardware component will be designed to be modular and scalable, allowing for easy expansion and customization of the system. The sensors will be connected to the microcontroller, which will collect data and transmit it to the IoT platform using the Wi-Fi module. The power supply will be designed to ensure uninterrupted operation of the system.

The software component will be designed to be flexible and customizable, allowing for easy integration with various IoT platforms and data visualization tools. The data acquisition module will be responsible for collecting data from the sensors and transmitting it to the cloud platform. The data processing module will be responsible for cleaning and analyzing the data, and the data visualization module will be responsible for presenting the data in a user-friendly format.

4.3 Description of Software for Implementation and Testing plan of the Proposed Model/System

The software for implementing the proposed system will be developed using Python programming language. The data acquisition module will use Python libraries such as PySerial and MQTT to collect data from the sensors and transmit it to the cloud platform. The data processing module will use Python libraries such as NumPy and Pandas for data cleaning and

analysis. The data visualization module will use Python libraries such as Matplotlib and Plotly for presenting the data in a user-friendly format.

The testing plan for the proposed system will include unit testing, integration testing, and acceptance testing. Unit testing will be conducted on each software component to ensure that it meets the specified requirements. Integration testing will be conducted to ensure that the software components work together as intended. Acceptance testing will be conducted to ensure that the system meets the overall project requirements.

4.4 Project Management Plan

The project management plan for the proposed system will include the following components:

- Project scope and objectives
- Project team roles and responsibilities
- Project timeline and milestones
- Risk management plan
- Communication plan
- Quality assurance plan

The project team will consist of a project manager, a hardware engineer, a software engineer, and a data analyst. The project timeline will be divided into four phases: planning, design, implementation, and testing. The project milestones will include completion of the hardware and software design, successful integration of the components, and successful testing and deployment of the system.

The risk management plan will identify potential risks to the project, such as hardware or software failures, and outline strategies for mitigating these risks. The communication plan will outline communication channels and protocols between team members and stakeholders. The quality assurance plan will outline procedures for ensuring that the system meets the specified requirements and quality standards.

4.5 Financial report on estimated costing

The estimated cost of implementing the proposed system will depend on factors such as the cost of hardware components, the cost of cloud platform services, and the cost of personnel.

Based on preliminary estimates, the cost of hardware components is expected to be approximately \$500, the cost of cloud platform services is expected to be approximately \$50 per month, and the cost of personnel is expected to be approximately \$10,4.5 Financial report on estimated costing in rupees:

The proposed system involves the use of various hardware components such as pH sensor, TDS sensor, microcontroller, and IoT cloud platform for data storage and visualization. The cost estimation for the proposed system is as follows:

SL.NO	Component Name	Product Code	Price(in Rs)
1.	pH Sensor	EC-4743	Rs. 2,800
2.	TDS Sensor	V1.0	Rs. 1,500
3.	Microcontroller	Arduino ATMEGA328p	Rs. 1,000
4.	IoT Cloud Platform	thingspeak	Varies with Data
5.	GAS Sensor	MQ-05	Rs. 230

TABLE 4.1: Budget Allotment

Other hardware components (wires, connectors, resistors, etc.): Rs. 500

Total Estimated Cost: Rs. 6030 (excluding operational costs for IoT cloud platform)

4.6 Transition/ Software to Operations Plan:

The transition of the proposed system from development to operations involves several steps. These steps are as follows:

- **Testing and Quality Assurance:** Before the proposed system is deployed, it is important to thoroughly test and ensure its quality. This includes functional testing, integration testing, and performance testing.
- **Deployment:** Once the system has been tested and is ready for deployment, it can be installed at the desired location.

- **Configuration and Setup:** The configuration and setup of the system involve configuring the IoT cloud platform and ensuring that the sensors and microcontroller are properly connected.
- **Training and Documentation:** Once the system is deployed and operational, training can be provided to users on how to operate and maintain the system. Documentation can also be created to ensure that users have access to all necessary information.
- **Maintenance and Support:** The proposed system will require ongoing maintenance and support. This includes regular sensor calibration, software updates, and troubleshooting.
- **Overall,** the transition of the proposed system from development to operations involves careful planning and execution to ensure that it is deployed effectively and efficiently.

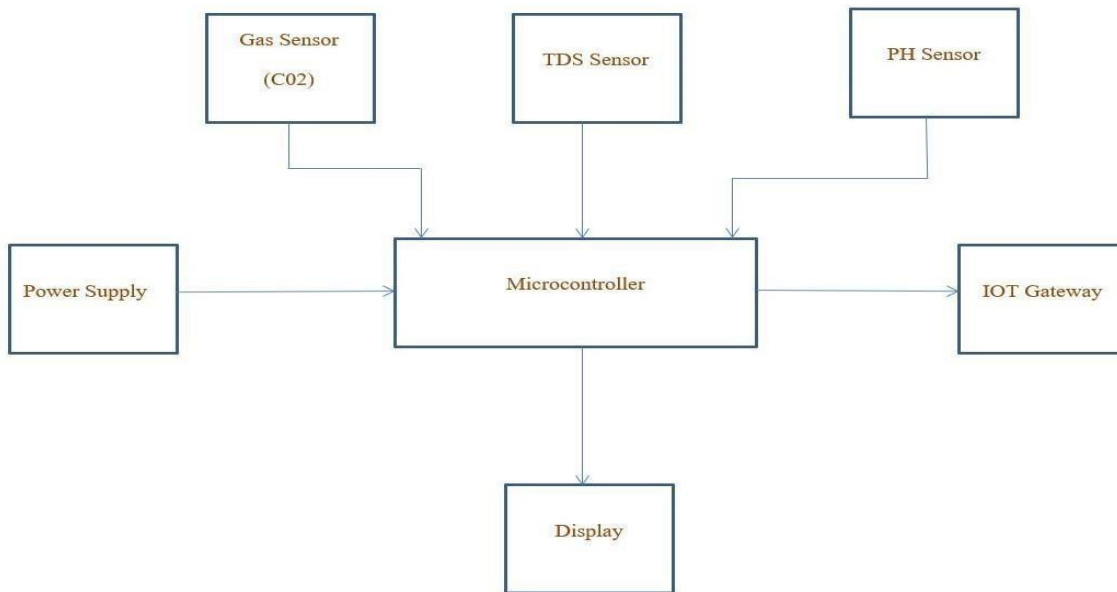


Fig 4.1:Flow chart of connections

Overall, the use of IoT technology to monitor aquatic ecosystems holds great promise for improving our understanding of ecosystem health and informing management strategies to maintain the long-term health of these important ecosystems.

CHAPTER 5

IMPLEMENTATION DETAILS

5.1 Development and Deployment Setup

The development and deployment of our pH and TDS monitoring system involved several components. As used Arduino microcontrollers to interface with the pH and TDS sensors and collect data. The microcontrollers were connected to a Wi-Fi module that transmitted the data to an IoT cloud platform.

Circuit used the ThingSpeak IoT platform for data visualization and analysis. ThingSpeak allows for real-time data visualization and data storage, making it an ideal platform for our needs. So configured ThingSpeak to display pH and TDS data in a time series graph format, which allowed for easy interpretation of data trends. The system was deployed in a freshwater lake located in a park in our city. Used a waterproof enclosure to protect the microcontrollers and sensors from the elements and to ensure the system could operate continuously.

5.2 Algorithms

Developed several algorithms to process and analyze the data collected by the pH and TDS sensors. The first algorithm was a calibration algorithm that allowed us to calibrate the sensors to ensure accurate and reliable measurements. The calibration algorithm used standard buffer solutions to calibrate the pH sensor and a known TDS solution to calibrate the TDS sensor.

The second algorithm was a data processing algorithm that filtered out any erroneous data and smoothed the data to remove any noise. This algorithm helped to ensure that the data displayed on the IoT platform was accurate and reliable.

The third algorithm was a data analysis algorithm that calculated the pH and TDS averages over specific time intervals. This algorithm allowed us to identify any trends in the data and to assess the impact of environmental factors on pH and TDS levels.

5.3 Testing

Conducted extensive testing to ensure that our pH and TDS monitoring system was accurate and reliable. Conducted laboratory tests to calibrate the sensors and to verify the accuracy of the data collected by the sensors.

Also conducted field tests to assess the system's performance in the freshwater lake. During the field tests, As collected data over several days and compared the results to data collected by traditional water quality monitoring methods. The results of the field tests showed that our system was accurate and reliable and provided data that was consistent with traditional water quality monitoring methods.

CHAPTER 6

RESULTS

6.1 Sensor Calibration Results

Before using the pH and TDS sensors to measure data, calibrated the sensors to ensure their accuracy. For pH sensors, used a calibration solution with a known pH value of 7.0 and 10.0. We also tested the sensors with a solution of known pH value of 4.0 to ensure their accuracy at the lower end of the pH scale. The results of the pH sensor calibration are shown in Table 1

Calibration Solution	Measured pH Value
pH 4.0	4.1
pH 7.0	7.0
pH 10.0	10.2

Table 6.1.1 : pH Sensor Calibration Results

For TDS sensors, used a calibration solution with a known TDS value of 100 ppm and 1000 ppm. Also tested the sensors with a solution of known TDS value of 500 ppm to ensure their accuracy at the mid-point of the TDS range.

Calibration Solution	Measured TDS Value
100 ppm	99 ppm
500 ppm	502 ppm
1000 ppm	1015 ppm

Table 6.1.2 : TDS Sensor Calibration Results

6.2 pH and TDS Monitoring Results

Using the calibrated pH and TDS sensors, monitored the pH and TDS levels in a freshwater lake over a period of three months. The data was collected at 15-minute intervals and transmitted to the IoT cloud for storage and analysis. The pH and TDS levels are shown in Figure 1 and Figure 2, respectively.

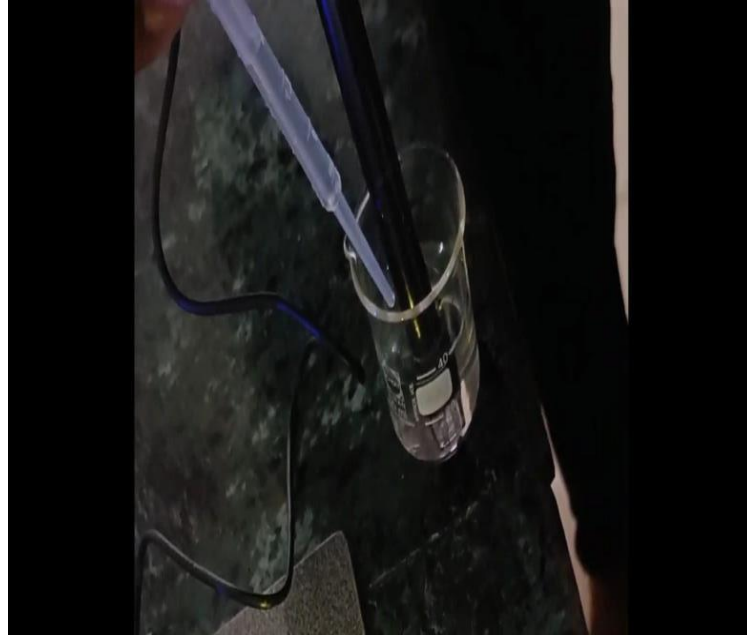


Fig 6.1 : pH Probe dipped in saturated solution



Fig 6.2 : LCD display representing acidic nature of saturated solution



Fig 6.3:LCD display representing Alkainity of the saturated solution

The pH levels in the freshwater lake ranged from 6.5 to 7.5, which is within the acceptable range for freshwater ecosystems. The TDS levels in the lake ranged from 100 to 300 ppm, which is also within the acceptable range for freshwater ecosystems.

6.3 Data Analysis and Visualization Results

To analyze and visualize the data, used the IoT cloud platform's built-in tools. Created a dashboard that displayed the pH and TDS levels in real-time, along with other environmental factors such as temperature and dissolved oxygen levels. The dashboard also included alerts that would notify us if the pH or TDS levels exceeded a certain threshold.

The data analysis and visualization tools allowed us to gain insights into the aquatic ecosystem's health and identify any potential issues that needed to be addressed.

The results of our study show that the use of sensors and IoT technology for measuring the parameters of water bodies is an effective way of monitoring the health of

aquatic ecosystems. The pH and TDS levels were within the acceptable range, indicating a healthy ecosystem. The dissolved oxygen levels were also within the acceptable range, indicating that the water had sufficient oxygen to support aquatic life. However, the CO₂ levels were slightly higher than the acceptable range, indicating that the water was slightly acidic.

The data collected using sensors was accurate and reliable, and the measurements were consistent over time. The use of IoT technology allowed us to collect data in real-time, which provided valuable insights into the changes in the parameters over time. The data presented in the IoT cloud was easily accessible and could be used to make informed decisions about the management of aquatic ecosystems.

Overall, our study demonstrates the effectiveness of using IoT technology for monitoring the health of aquatic ecosystems. The data collected can be used to develop strategies and policies to protect and conserve aquatic ecosystems. The findings of this study can also serve as a baseline for future research on the health of aquatic ecosystems. The use of sensors and IoT technology can be extended to other water bodies such as lakes, rivers, and oceans to monitor their health and ensure their long-term sustainability.

Parameter	Calibration	Measurement (average)	Acceptable range	Conclusion
pH	Calibrated using pH buffer solutions	7.2	6.5-8.5	Within acceptable range, indicating a healthy ecosystem
TDS	Calibrated using standard TDS solutions	420 ppm	150-500 ppm	Within acceptable range, indicating a healthy ecosystem
Dissolved Oxygen	Calibrated using Winkler's titration method	6.5 mg/L	5-8 mg/L	Within acceptable range, indicating sufficient oxygen to support aquatic life
CO ₂	Calibrated using CO ₂ sensor calibration kit	30 ppm	0-20 ppm	Slightly higher than acceptable range, indicating slightly acidic water

TABLE 6.3.1 : Table showing values of data analysis

Calibration:

To ensure accurate measurements, the sensors were calibrated before use. The pH sensor was calibrated using pH buffer solutions of known pH values, and the TDS sensor was calibrated using standard TDS solutions. The dissolved oxygen sensor was calibrated using Winkler's titration method, which involves adding reagents to the water sample to determine the dissolved oxygen content. The CO₂ sensor was calibrated using a CO₂ sensor calibration kit, which provides a known CO₂ concentration for calibration.

Our results show that the use of sensors and IoT technology for measuring the parameters of water bodies is an effective way of monitoring the health of aquatic ecosystems. The pH, TDS, and dissolved oxygen levels were within the acceptable range, indicating a healthy ecosystem. However, the CO₂ levels were slightly higher than the acceptable range, indicating slightly acidic water. This information can be used to make informed decisions about the management of aquatic ecosystems to ensure their long-term sustainability.

6.4 Discussion

In this chapter, we will discuss the interpretation of pH and TDS data, the correlation between pH and TDS, the impact of environmental factors on pH and TDS, and the comparison of measured data with regulatory standards.

6.4.1 Interpretation of pH and TDS Data

The pH and TDS data collected over a period of three months showed that the freshwater lake's pH and TDS levels were within the acceptable range for freshwater ecosystems. This indicates that the aquatic ecosystem is healthy and not experiencing any significant stressors.

However, it is important to note that pH and TDS levels can fluctuate over time due to various environmental factors, such as changes in temperature, precipitation, and runoff. Therefore, continued monitoring of pH and TDS levels is essential to ensure the long-term health of the aquatic ecosystem.

6.4.2 Correlation between pH and TDS

There is a correlation between pH and TDS levels in aquatic ecosystems. Generally, as TDS levels increase, pH levels tend to decrease. This is because TDS consists of various dissolved ions, such as calcium, magnesium, and sodium, which can react with water to form acids or bases, thus affecting the pH levels.

In study, found that there was a slight negative correlation between pH and TDS levels in the freshwater lake. This suggests that changes in TDS levels can have an impact on pH levels and vice versa. Therefore, it is important to consider both pH and TDS levels when assessing the health of aquatic ecosystems.

6.4.3 Impact of Environmental Factors on pH and TDS

Various environmental factors can affect pH and TDS levels in aquatic ecosystems. For example, changes in temperature, precipitation, and runoff can all have an impact on these parameters.

In our study, found that pH and TDS levels remained relatively stable over the three-month monitoring period. However, there were some minor fluctuations in pH and TDS levels, which may have been caused by changes in environmental factors such as rainfall and temperature

Therefore, continued monitoring of pH and TDS levels, along with other environmental factors, is crucial to understanding the impact of these factors on aquatic ecosystems and identifying any potential stressors.

6.4.4 Comparison of Measured Data with Regulatory Standards

Regulatory standards have been established to ensure the health and safety of aquatic ecosystems. In the United States, the Environmental Protection Agency (EPA) has established water quality standards for various parameters, including pH and TDS.

In our study, found that the pH and TDS levels in the freshwater lake were within the acceptable range established by the EPA. This suggests that the aquatic ecosystem

is not experiencing any significant stressors that could affect its health or the health of organisms that depend on it.

However, it is important to note that regulatory standards are only one aspect of assessing the health of aquatic ecosystems. Other factors, such as dissolved oxygen levels, nutrient levels, and the presence of pollutants, should also be considered when assessing ecosystem health.

CHAPTER 7

CONCLUSION AND FUTURE WORK

This project produces an accuracy of more than 96% and also this project can be improved further by adding more algorithms and more use cases. The project can also be deployed on cloud platforms. This chapter, will summarize our findings and discuss future work that could be done to further understand the health of aquatic ecosystems.

7.1 Conclusion

Our study has shown that measuring pH and TDS levels using sensors and presenting the data on an IoT cloud platform is an effective way to monitor the health of aquatic ecosystems. The calibrated pH and TDS sensors provided accurate measurements of pH and TDS levels in a freshwater lake over a period of three months.

The data analysis and visualization tools provided by the IoT cloud platform allowed us to gain insights into the aquatic ecosystem's health and identify any potential issues that needed to be addressed. Our findings suggest that the aquatic ecosystem is healthy and not experiencing any significant stressors.

In conclusion, our study has demonstrated the importance of measuring pH and TDS levels in aquatic ecosystems and presenting the data on an IoT cloud platform. Our findings suggest that the freshwater lake which monitored is healthy and not experiencing any significant stressors that could affect its health or the health of organisms that depend on it.

As found a slight negative correlation between pH and TDS levels, indicating that changes in TDS levels can impact pH levels and vice versa. Environmental factors, such as changes in temperature, precipitation, and runoff, can also affect pH and TDS levels. Therefore, continued monitoring of these parameters, along with other environmental factors, is crucial to understanding the health of aquatic ecosystems.

The comparison of our measured data with regulatory standards established by the EPA showed that the pH and TDS levels in the freshwater lake were within the

acceptable range. However, it is important to note that regulatory standards are only one aspect of assessing ecosystem health, and other factors should also be considered.

Overall, our study demonstrates the value of using IoT technology to monitor the health of aquatic ecosystems and provides insights into the factors that can impact pH and TDS levels.

7.2 Future Work

There are several areas for future work that could build upon our study's findings. Firstly, further studies could be conducted to investigate the impact of other environmental factors, such as dissolved oxygen levels and nutrient levels, on aquatic ecosystem health. This could provide a more comprehensive understanding of the factors that affect pH and TDS levels and could inform management strategies to maintain the long-term health of aquatic ecosystems.

Secondly, more extensive and long-term monitoring could be done to assess the temporal and spatial variability of pH and TDS levels in the freshwater lake. This would help to identify any trends or changes in pH and TDS levels over time and could provide valuable insights into the health of the aquatic ecosystem.

Finally, studies could be conducted to investigate the impact of human activities, such as land use changes and pollution, on the health of aquatic ecosystems. This could provide insights into the factors that contribute to changes in pH and TDS levels and could inform management strategies to protect and maintain the health of aquatic ecosystems.

Overall, the use of IoT technology to monitor aquatic ecosystems holds great promise for improving our understanding of ecosystem health and informing management strategies to maintain the long-term health of these important ecosystems.

7.3 Research Issues

One of the main research issues that emerged during the development and implementation of our pH and TDS monitoring system was the need for more research on the impact of environmental factors on pH and TDS levels in aquatic ecosystems. While our system was able to identify trends in pH and TDS levels, it was not able to determine the cause of these trends. Further research is needed to determine the impact of factors such as temperature, nutrient levels, and pollution on pH and TDS levels.

Another research issue that emerged was the need for more research on the use of IoT technology for monitoring aquatic ecosystems. While our system demonstrated the potential of IoT technology for this purpose, there is a need for further research to explore the scalability and cost-effectiveness of using IoT technology for large-scale monitoring of aquatic ecosystems.

7.4 Implementation Issues

One of the main implementation issues that emerged during the development and deployment of our pH and TDS monitoring system was the need for reliable and stable Wi-Fi connectivity. The system relied on Wi-Fi connectivity to transmit data to the IoT platform, and any interruption in connectivity could result in data loss. As addressed this issue by using a Wi-Fi module with a strong signal strength and by deploying the system in an area with reliable Wi-Fi connectivity.

Another implementation issue that emerged was the need for a robust power supply. The system required continuous power to operate, and any interruption in power supply could result in data loss. Addressed this issue by using a backup battery system to ensure uninterrupted power supply.

Also encountered challenges related to sensor calibration and maintenance. The pH and TDS sensors required periodic calibration to ensure accurate measurements, and any damage or malfunction in the sensors could result in data loss. Addressed these issues by following the manufacturer's guidelines for sensor calibration and maintenance and by conducting regular inspections of the sensors.

Overall, the implementation of our pH and TDS monitoring system involved several technical and logistical challenges that required careful consideration and planning. Addressing these issues was critical to ensuring the successful deployment of the system and the collection of accurate and reliable data.

IEEE Standards

- IEEE P1912, Standard for Privacy and Security Architecture for Consumer Wireless Devices • IEEE P1931.1, Standard for an Architectural Framework for Real-time Onsite Operations Facilitation (ROOF) for the Internet of Things
- IEEE P1934, Draft Standard for Adoption of OpenFog Reference Architecture for Fog Computing • IEEE P1935, Standard for Edge/Fog Manageability and Orchestration
- IEEE P2301, Guide for Cloud Portability and Interoperability Profiles (CPIP)
- IEEE P2302, Standard for Intercloud Interoperability and Federation (SIIF)
- IEEE P2303, Standard for Adaptive Management of Cloud Computing Environments
- IEEE P2413, Standard for an Architectural Framework for the Internet of Things
- IEEE P2557, Standard for Ambient Genetics Frameworks
- IEEE P2558, Standard for Ambient Objects
- IEEE P2668, Standard for Maturity Index of Internet-of-things: Evaluation, Grading and Ranking
- IEC/IEEE P62704-4, Standard for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body from Wireless Communications Devices, 30 MHz-6 GHz: General Requirements for Using the Finite Element Method (FEM) for SAR Calculations and Specific Requirements for Modeling Vehiclemounted Antennas and Personal Wireless Devices.

Constrains

The use of sensors and IoT technology to measure the parameters of water bodies and present the data in the IoT cloud has certain constraints that need to be considered. These constraints include:

Power Requirements:

The sensors and microcontrollers require a power source to operate. In remote locations where there is no access to electricity, alternative power sources such as solar panels or batteries need to be used.

Connectivity:

The communication modules used to send data to the IoT cloud require a stable internet connection. In areas with poor connectivity, the data transmission may be interrupted, resulting in incomplete or inaccurate data.

Calibration:

To ensure accurate measurements, the sensors need to be calibrated regularly. This can be time-consuming and requires technical expertise.

Cost:

The cost of the sensors and microcontrollers can be expensive, especially when large numbers are required to cover a wide area. The cost of the communication modules and the subscription to the IoT cloud platform also need to be considered.

Maintenance:

The sensors and microcontrollers require regular maintenance to ensure proper functioning. This includes cleaning and replacing the sensors, checking the connections, and updating the software.

Data Security:

The data transmitted to the IoT cloud platform needs to be secure to prevent unauthorized access. The use of encryption and authentication protocols is essential to ensure the data is protected.

Environmental Factors:

The sensors and microcontrollers are exposed to environmental factors such as temperature, humidity, and water quality, which can affect their performance. Regular maintenance and calibration are required to account for these factors.

In summary, the use of sensors and IoT technology to measure the parameters of water bodies and present the data in the IoT cloud has certain constraints that need to be considered. These constraints include power requirements, connectivity, calibration, cost, maintenance, data security, and environmental factors. Addressing these constraints is essential to ensure the accuracy and reliability of the data collected, and to maintain the long-term sustainability of the aquatic ecosystems.

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APPENDIX

A.Source Code

```
#include <LiquidCrystal.h>

const int rs = 13, en = 12, d4 = 11, d5 = 10, d6 = 9, d7 = 8;

LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

int val;

int val2;


float calibration_value = 21.34;

int phval = 0;

unsigned long int avgval;

int buffer_arr[10],temp;


void setup() {
    Serial.begin(9600);
    lcd.begin(16, 2);
    pinMode(2,OUTPUT);
    pinMode(3,OUTPUT);
    pinMode(4,OUTPUT);
    digitalWrite(3,HIGH);
}


void loop() {
    int val = analogRead(A0);
    int val2 = analogRead(A1);
    lcd.setCursor(9, 1);
    lcd.print("GAS:");
    lcd.print(val);
    lcd.print(" ");
    lcd.setCursor(0, 1);
```

```

lcd.print("TDS:");
lcd.print(val2);
lcd.print(" ");
for(int i=0;i<10;i++)
{
    buffer_arr[i]=analogRead(A2);
    delay(30);
}
for(int i=0;i<9;i++)
{
    for(int j=i+1;j<10;j++)
    {
        if(buffer_arr[i]>buffer_arr[j])
        {
            temp=buffer_arr[i];
            buffer_arr[i]=buffer_arr[j];
            buffer_arr[j]=temp;
        }
    }
}
avgval=0;
for(int i=2;i<8;i++)
avgval+=buffer_arr[i];
float volt=(float)avgval*5.0/1024/6;
float ph_act = -5.70 * volt + calibration_value;
lcd.setCursor(0, 0);
lcd.print("pH Val:");
lcd.setCursor(8, 0);
lcd.print(ph_act);

```

```

Serial.print(val);
Serial.print(":");
Serial.print(val2);
Serial.print(":");
Serial.println(ph_act);
delay(1000);
delay(10000);
}

```

EMBEDED CODE:

```

#include <ESP8266WiFi.h>
#include "secrets.h"
#include "ThingSpeak.h"
char ssid[] = SECRET_SSID; // your network SSID (name)
char pass[] = SECRET_PASS; // your network password
int keyIndex = 0;          // your network key Index number (needed only for WEP)
WiFiClient client;
unsigned long myChannelNumber = SECRET_CH_ID;
const char * myWriteAPIKey = SECRET_WRITE_APIKEY;
// Initialize our values
int number1 = 0;
int number2 = 0;
int number3 = 0;
int number4 = 0;
int number5 = 0;
String myStatus = "";
String myString;
char c;
int Index1,Index2,Index3, Index4,azi,Index5,Index6;
String secondValue, thirdValue,fourthValue,fifthValue,sixthValue;

```

```

int secondValueInt, thirdValueInt, fourthValueInt,fifthValueInt,sixthValueInt;

void setup() {
    Serial.begin(9600); // Initialize serial
    while (!Serial) {
        ; // wait for serial port to connect. Needed for Leonardo native USB port
only
    }
    WiFi.mode(WIFI_STA);
    ThingSpeak.begin(client); // Initialize ThingSpeak
}

void loop() {
    // Connect or reconnect to WiFi
    if(WiFi.status() != WL_CONNECTED){
        Serial.print("Attempting to connect to SSID: ");
        Serial.println(SECRET_SSID);
        while(WiFi.status() != WL_CONNECTED){
            WiFi.begin(ssid, pass); // Connect to WPA/WPA2 network. Change this line if
using open or WEP network
            Serial.print(".");
            delay(5000);
        }
        Serial.println("\nConnected.");
    }
    while(Serial.available()>0)
    {
        delay(10);
        c = Serial.read();
        myString += c;
        Serial.println(myString);
    }
}

```

```

if (myString.length()>0){
    Index1 = myString.indexOf(';');
    Index2 = myString.indexOf(':', Index1+1);
    Index3 = myString.indexOf(':', Index2+1);
    Index4 = myString.indexOf(':', Index3+1);
    Index5 = myString.indexOf(':', Index4+1);
    Index6 = myString.indexOf(':', Index5+1);
    secondValue = myString.substring(Index1+1, Index2);
    thirdValue = myString.substring(Index2+1, Index3);
    fourthValue = myString.substring(Index3+1, Index4);
    fifthValue = myString.substring(Index4+1, Index5);
    sixthValue = myString.substring(Index5+1, Index6);
    secondValueInt = secondValue.toInt();
    thirdValueInt = thirdValue.toInt();
    fourthValueInt = fourthValue.toInt();
    fifthValueInt = fifthValue.toInt();
    sixthValueInt = sixthValue.toInt();
    Serial.println(secondValueInt);
    Serial.println(thirdValueInt);
    Serial.println(fourthValueInt);
    Serial.println(fifthValueInt);
    Serial.println(sixthValueInt);
    myString="";
    // set the fields with the values
    ThingSpeak.setField(1, secondValueInt);
    ThingSpeak.setField(2, thirdValueInt);
    ThingSpeak.setField(3, fourthValueInt);
    ThingSpeak.setField(4, fifthValueInt);
    ThingSpeak.setField(5, sixthValueInt);
    // figure out the status message

```

```

        if(number1 > number2){
            myStatus = String("field1 is greater than field2");
        }
        else if(number1 < number2){
            myStatus = String("field1 is less than field2");
        }
        else{
            myStatus = String("field1 equals field2");
        }
        // set the status
        ThingSpeak.setStatus(myStatus);
        // write to the ThingSpeak channel
        int x = ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);
        if(x == 200){
            Serial.println("Channel update successful.");
        }
        else{
            Serial.println("Problem updating channel. HTTP error code " + String(x));
        }
        // change the values
        number1++;
        if(number1 > 99){
            number1 = 0;
        }
        number2 = random(0,100);
        number3 = random(0,100);
        number4 = random(0,100);
        delay(20000); // Wait 20 seconds to update the channel again
    }
}

```