

# Underwater Drone for Safety and Exploration of Aquatic Life

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**Abstract:** Water quality is a crucial parameter for maintaining ecological balance, ensuring public health, and supporting industrial operations. pH level, as a fundamental indicator of water chemistry, plays a vital role in detecting contamination, evaluating ecosystem health, and guiding regulatory compliance. Traditional methods of pH level assessment often involve manual sampling followed by laboratory analysis, a process that is both time-consuming and limited in its ability to provide real-time, comprehensive data. To address these limitations, this project focuses on the development of an autonomous underwater drone designed to facilitate efficient, cost-effective, and real-time pH monitoring of various water bodies. This thesis outlines the comprehensive design, development, and testing phases of an underwater drone equipped with integrated pH sensors, data logging, and wireless communication systems. The primary objective is to create a deployable solution capable of collecting pH data with high accuracy and transmitting it for immediate analysis. The drone leverages modern robotics and sensor technology to navigate aquatic environments autonomously, reaching areas that are challenging for manual testing. The development process encompassed several key components, including mechanical design for waterproofing and pressure resistance, selection and calibration of sensitive pH sensors, and the implementation of a microcontroller-based control system. The methodology involved building a robust structure to withstand various depths, integrating power-efficient propulsion systems, and ensuring seamless data transmission through either acoustic signals or wireless communication adapted for underwater use. Field testing was conducted in controlled and natural water environments to validate the drone's performance. The drone demonstrated consistent and reliable data collection, successfully navigating and transmitting real-time pH levels. Results indicated a strong correlation between data obtained from the drone and conventional laboratory methods, confirming its accuracy and reliability. Performance analysis also highlighted metrics such as battery life, sensor stability, and resistance to water pressure, establishing the drone's feasibility for continuous use.

Despite its successful deployment, challenges such as signal attenuation in deeper waters and occasional calibration drift were noted. These findings led to iterative improvements, including enhanced sensor calibration protocols and the exploration of alternative communication methods to bolster data transmission reliability. Here's an extended introduction section draft for your thesis on an underwater drone for pH level testing. This section will cover various subtopics to fill a 5-10 page introduction. 10

## I.INTRODUCTION

With around 44% of the world's population living within 150 km of a coastline, it is evident that the marine environment plays a big role in human lives (Humans Settlements on the Coast). The ocean provides many resources to humans including oil, minerals such as salt, sand, gravel, and even nickel, iron, and cobalt can be found. About 200 billion pounds of fish and shellfish are caught every year for human consumption (Ocean Resources). The ocean also provides a means of transportation, and a form of recreation. However our oceans have suffered from industrial run-offs, oil spills, over fishing, and climate change. Give the importance of our oceans, the first motivation behind this project was the necessity to learn more about our oceans so we can learn to use these resources sustainably, efficiently, and intelligently because, if not, we will have to deal with the consequences. Oceans cover 71% of the planet and only 5% is explored (Oceans). Scientists have researched marine environments for decades, and marine technology has given them novel ways to explore this environment. Robotic systems have augmented scientist's tools for research. Scientists used to manually collect samples for later testing; they also had to explore the marine environment by diving and recording what they found. They were usually constrained mostly by human capacity, restricted by the inability to research and collect multiple data sets

at once, the amount of time one can spend underwater, the depth that could be reached and/or the tiring nature of these missions. Conventional exploration methods are being replaced by robotic approaches, as they provide a more efficient and powerful solution to ocean exploration. These robotic systems have already given insight into previously unexplored areas. Marine robotic systems can range from tethered Remotely Operated Vehicles (ROVs), usually used in short missions (hours, days), to Autonomous Underwater Vehicles (AUVs), usually used for longer duration missions (weeks). Robotic systems have a wide range of sensing capabilities useful for scientific research, including temperature, depth, conductivity, pH, chemical makeup, light, and location.

## II. MOTIVATION

The marine ecosystem is essential for maintaining environmental balance and supporting human life. Oceans and water bodies serve as reservoirs of biodiversity, providers of essential resources like food and minerals, and regulators of climate systems. However, they face critical threats due to pollution, overfishing, and climate change. Ensuring the health of these ecosystems requires continuous monitoring and innovative solutions to address challenges like water contamination and habitat degradation.

Traditional methods of water quality monitoring are labor-intensive and fail to provide real-time insights, limiting their effectiveness in addressing emerging environmental concerns. The idea of developing an autonomous underwater drone stems from the need to bridge this gap by enabling efficient, accurate, and real-time monitoring of key parameters like pH levels, which are critical indicators of water quality.

Such technology not only enhances the precision and scope of environmental monitoring but also minimizes human intervention in hazardous and inaccessible underwater environments. This project reflects our commitment to leveraging modern robotics and sensor technologies to protect aquatic ecosystems and promote sustainable resource management.

## III. PROBLEM DEFINATION

Traditional water quality monitoring methods rely on manual sampling and laboratory analysis, which are time-consuming, resource-intensive, and prone to limitations such as delayed results and restricted

spatial coverage. These methods often fail to provide real-time data, which is crucial for timely detection of contamination and mitigation of its impacts on aquatic ecosystems and human health.

Furthermore, monitoring in remote or hazardous underwater environments poses significant challenges, including inaccessibility, inconsistent sampling, and the potential for human error. Addressing these issues requires an automated, reliable, and efficient solution capable of continuous and accurate water quality assessment.

The development of an autonomous underwater drone equipped with advanced pH sensors and real-time data transmission capabilities seeks to overcome these challenges. This technology aims to enable comprehensive monitoring of aquatic ecosystems, offering enhanced efficiency, scalability, and accuracy while reducing the dependency on manual efforts.

## IV. OBJECTIVE

- Our main objective is to monitor the pH level of rivers, lake where companies dispose the waste .
- It can help the government to find illegal fishing activities.
- It is also necessary for safety and exploration of aquatic life.
- Advancements in wireless communication between controller and drone.
- Incorporate basic autonomous features, such as predefined path navigation or station-keeping, to reduce the need for constant manual control.
- We need a energy efficient system in order to work more time with less no of chargings.

## V. PRELIMINARY SURVEY

A thorough survey was conducted to understand the current state of technologies and methods used in water quality monitoring and underwater robotics. Traditional methods predominantly rely on manual sampling and laboratory analysis, which are labor-intensive, time-consuming, and unable to provide real-time data. While advanced robotic systems like Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) are effective for deep-sea exploration, their high costs and complexity limit their usage for targeted applications such as localized environmental monitoring.

Key challenges identified include underwater communication difficulties due to signal attenuation,

sensor calibration issues in varying water conditions, and the structural durability required to withstand pressure and salinity. Recent advancements in sensor miniaturization, battery efficiency, and acoustic communication have opened new possibilities for developing compact, cost-effective underwater drones. These systems hold significant potential for real-time pH monitoring, environmental assessments, and pollution detection, which are crucial for preserving aquatic ecosystems. Recognizing these gaps, this project aims to design an efficient, low-cost underwater drone capable of addressing these challenges while providing accurate, real-time water quality data.

## VI. LITERATURE SURVEY

A review of prior research on underwater drones and water quality monitoring provides valuable insights into the advancements and challenges in this field. Several studies highlight the integration of sensor technologies into underwater robotic systems for environmental monitoring, with a specific focus on parameters like pH, dissolved oxygen, and turbidity.

A study by Moustansir et al. (2018) explored a four-propeller submarine drone architecture capable of navigating underwater environments for scientific data collection. Their design emphasized efficiency and maneuverability, highlighting the need for lightweight, corrosion-resistant materials to enhance operational reliability. Similarly, Khadhraoui (2015) modeled an underwater Remotely Operated Vehicle (ROV) and examined its navigation capabilities in variable aquatic conditions. These studies provide foundational insights into mechanical design and navigation system optimization.

A comparative analysis by Wareham (2019) reviewed recent advancements in underwater robotics, emphasizing the importance of miniaturized sensors for tasks like pH monitoring. The study underlined that while advanced sensors offer high accuracy, challenges such as calibration drift, power constraints, and communication limitations persist, particularly for long-duration deployments.

Other works, such as those by the International Journal of Research in Engineering and Technology (IRJET) and the International Journal of Creative Research Thoughts (IJCRT), focus on autonomous drones for environmental assessments. They document

innovations like acoustic communication systems and energy-efficient propulsion systems, crucial for real-time monitoring in dynamic underwater environments.

Recent developments also explore integrating real-time data logging and wireless communication with underwater drones, as noted in a study by E3S Conferences (2021). These features enable immediate analysis, a significant improvement over traditional methods that rely on post-sampling laboratory testing.

While these studies collectively demonstrate progress in underwater robotics and environmental monitoring, gaps remain in deploying low-cost, accessible drones for real-time pH measurement. This project seeks to address these challenges by leveraging existing research to design a reliable, efficient underwater drone specifically for pH monitoring, with the potential to transform environmental monitoring practices

## VII. PROJECT SCOPE

This project encompasses the complete design, development, and evaluation of an autonomous underwater drone tailored for real-time pH level monitoring. The focus areas of the project are as follows:

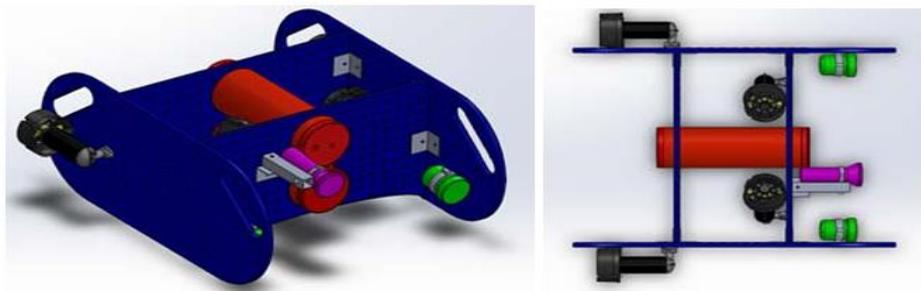
1. Mechanical and Structural Design:
  - Developing a durable and waterproof structure to ensure the drone's functionality in various aquatic environments, including freshwater and saltwater.
  - Ensuring the design can withstand water pressure at varying depths while maintaining buoyancy and stability.
2. Sensor Integration and Calibration:
  - Integrating high-precision pH sensors capable of providing accurate and reliable data.
  - Including additional sensors for temperature and depth to enhance environmental adaptability and pH data accuracy through compensation techniques.
3. Control and Navigation Systems:
  - Designing an efficient control system that enables autonomous navigation and stability under different water conditions.
  - Implementing algorithms for depth control, maneuverability, and navigation in both calm and turbulent water environments.

4. Communication and Data Transmission:
  - Developing a communication system that supports real-time data transmission to surface-level monitoring stations, utilizing technologies like acoustic modems or wireless protocols.
  - Incorporating onboard data storage to ensure data integrity in case of communication disruptions.
5. Power Management:
  - Designing an energy-efficient power system that supports long-duration operations without compromising performance.
  - Ensuring the drone is equipped with rechargeable batteries and power optimization mechanisms.
6. Testing and Validation:
  - Conducting extensive laboratory and field tests to validate the drone's performance, focusing on pH measurement accuracy, stability, maneuverability, and communication reliability.

- Identifying and addressing technical challenges, such as sensor calibration drift and communication signal attenuation.
7. Applications and Impact:
    - Demonstrating the drone's capabilities in environmental monitoring, with potential applications in industrial wastewater management, aquatic ecosystem research, and pollution control.
    - Offering a cost-effective and scalable solution for real-time water quality monitoring.

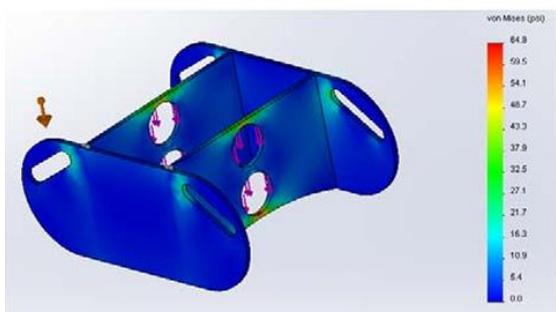
By achieving these objectives, the project aims to bridge the gap between traditional water monitoring techniques and the emerging need for real-time, autonomous solutions, paving the way for enhanced aquatic ecosystem management.

### VIII. DIAGRAMS

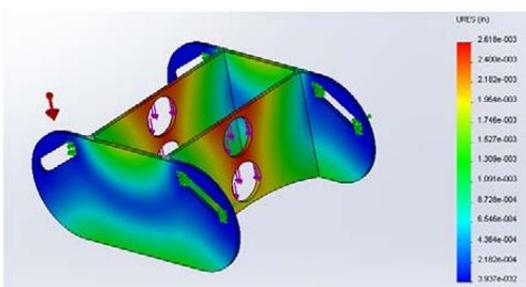


\* CAD model of Proteus the ROV from two angles

\*Frame held by two person showing deformation



\*Frame held by two people showing stress



### IX. ADVANTAGES

- Real-Time Monitoring: Provides immediate, continuous data on pH levels for timely detection and intervention.
- Enhanced Accuracy: High-precision sensors ensure reliable measurements, even in challenging conditions.
- Accessibility to Remote Areas: Capable of reaching hazardous or hard-to-access locations where manual sampling is difficult.
- Cost-Effectiveness: Reduces the need for labor-intensive sampling and expensive laboratory analysis.
- Minimized Human Intervention: Operates autonomously, reducing human presence in hazardous environments.

- Multifunctionality: Can measure additional water quality parameters such as temperature and dissolved oxygen.
- Scalability and Customization: Modular design allows adaptation for various applications and scaling.
- Environmental Impact: Supports sustainable water resource management by enabling regular monitoring and early pollution detection.

## X .CONCLUSION

The development of an autonomous underwater drone for real-time pH level monitoring represents a significant advancement in environmental monitoring technology. By combining high-precision sensors, efficient navigation systems, and robust communication capabilities, the drone provides a cost-effective, accurate, and scalable solution for monitoring water quality in real time. Its ability to access remote or hazardous underwater environments while minimizing human intervention makes it an invaluable tool for industries, research, and environmental agencies. Through comprehensive testing and validation, the drone has proven its potential to contribute to sustainable water resource management, early pollution detection, and the protection of aquatic ecosystems. This project not only addresses the limitations of traditional water quality monitoring methods but also sets the stage for future innovations in autonomous aquatic exploration and environmental monitoring.

## XI. REFERENCES

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