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KEMENTERIAN PENDIDIKAN TINGGI



MAJLIS DEKAN/PENGARAH ASASI
UNIVERSITI AWAM MALAYSIA

Neptune's Needle

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ABSTRACT

Neptune's Needle is not merely an ordinary water monitoring device; it is a breakthrough innovation. Inspired by the sailfish's sleek design, it improves water-quality tracking, making it more efficient and rapid for scientists and environmental groups. The truth is, as water contamination and global warming increase rapidly, traditional monitoring methods cannot keep pace. Excessive manual sampling, countless hard-to-reach places, and the data consistently arrives late. The device fixes all those issues. It features a mobile robotic platform loaded with sensors for pH, turbidity, and temperature. This device navigates rivers, lakes, and coastal areas on its own, moving efficiently and constantly collecting data. It reaches places people are unable or advised not to go and sends live information immediately to anyone who needs it. That means faster decisions and better protection for our water. The device already makes monitoring easier, safer, and way more comprehensive. It eliminates time-consuming steps and drastically reduces costs. By delivering continuous, high-resolution data, it helps everyone stay ahead of aquatic pollution and react before problems get out of hand. In short, it's more than a clever creation, which is a crucial resource for research labs, environmental agencies, NGOs, and fish farms, providing reliable, up-to-the-minute information for smarter, sustainable water management.

Keywords: biomimicry, autonomy, sensing, sustainability, monitoring.

1. INTRODUCTION

Water pollution, climate change, and human impact are imposing a growing strain on water quality. That affects both the environment and our health. Traditional monitoring methods still depend on people taking samples by hand, which is time-consuming, labour-intensive, has limited reach, and occasionally endangers workers, particularly in challenging or hazardous locations. Obtaining precise, immediate data on water quality remains a big challenge for scientists and environmental groups. There is a necessity for a more intelligent, continuous method to track changes in water quality. Better sensors and autonomous technologies indeed open up new possibilities, but many current solutions are expensive, complicated, and difficult to transport.

That is where Neptune's Needle comes in. This new system combines biomimicry, autonomous navigation, and live water-quality sensing, completely influenced by how a

sailfish moves through water. It's built to gather data efficiently, without anyone having to step in. The objective is to assist researchers and NGOs in obtaining reliable, up-to-date information to monitor the environment and manage water resources more sustainably.

1.1 Scope of the Project

This project addresses the design of Neptune's Needle, an autonomous system that monitors basic water quality parameters, including pH, temperature, and turbidity. It is designed for rivers, lakes, and coastal areas. The device moves on its own, collects real-time data, and sends it straight to scientists or environmental groups who need to track water conditions. The main goals are to integrate sensors, make the system mobile, and boost data collection, especially in hard-to-reach or dangerous areas. For clarification, Neptune's Needle is focused on monitoring and data collection. Still, it is not equipped to handle water treatment or designed for extensive industrial operations, and it does not support long-term field testing.

1.2 Problem Statement

- Current water quality monitoring methods are time-consuming and rely on manual sampling, which limits data accuracy and coverage.
- It is difficult and sometimes unsafe for scientists and NGOs to access remote or polluted water areas.
- Water quality data is often limited due to the lack of continuous and real-time monitoring systems.

1.3 Objectives

- To design and develop an autonomous system capable of monitoring water quality in real time.
- To integrate sensors for measuring key parameters such as pH, temperature, and turbidity.
- To provide accurate and continuous data to support environmental monitoring by scientists and NGO

2. METHODOLOGY

The project is conducted in six stages: requirements, design, implementation, testing, deployment, and maintenance.

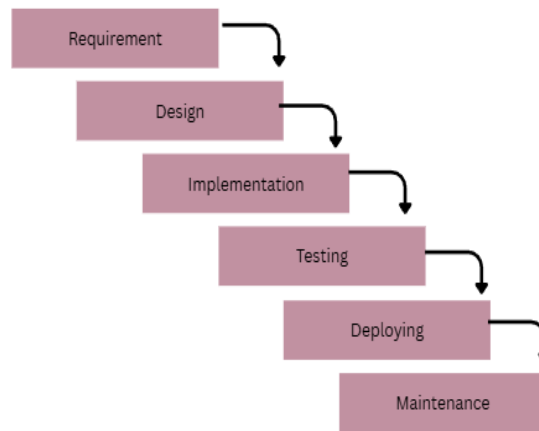


Figure 1. Neptune's Needle Methodology

a. Requirement Analysis

- Traditional water quality monitoring is slow, manual, and inconsistent. Difficult and dangerous for humans to access remote or hazardous water areas. A lack of real-time data leads to delays in decision-making.
- Develop an autonomous water monitoring biomimicry boat for rivers, lakes, and coastal areas. Provide real-time data collection and transmission with high accuracy of water parameters. Improve safety, efficiency, and speed of water quality analysis. Support smart water management and environmental protection.
- Budget (RM 423.02), harsh aquatic environments, and power supply limitations. Dependence on sensor accuracy and calibration.

b. System Design

- **Hardware Design:** ESP32 microcontroller, Turbidity sensor, Temperature Sensor, pH meter sensor, motor, radio receiver, and HC-06 Bluetooth Module.
- **Software Design:** Arduino IDE programming, Serial Bluetooth Terminal
- **Workflow Design:**

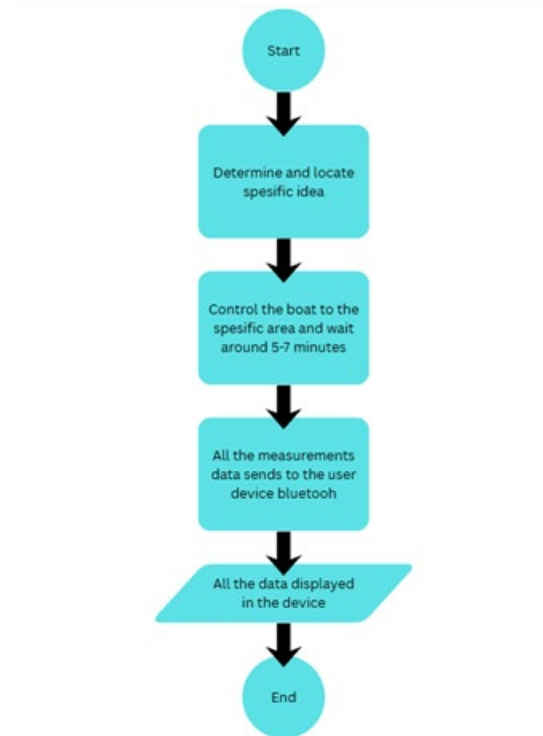


Figure 2. Neptune's Needle Flowchart

c. Implementation

Assemble hardware components and wire connections:

- Integrate pH, Turbidity, and Waterproof DS18B20 Temperature sensors.
- Implement a 4.7k Ω pull-up resistor circuit for digital temperature data transmission.
- Configure Bluetooth (HC-05/06) for wireless data logging.

Develop firmware in Arduino IDE for:

- **Multi-Sensor Data Acquisition:** Sampling analog signals from pH and turbidity modules and digital signals from the OneWire bus.
- **Data Filtering:** Implementing a 10-sample averaging buffer for stable turbidity voltage readings.
- **Serial Communication:** Configuring HardwareSerial (Serial2) to transmit real-time data strings to a mobile interface.
- **ESP32 DEVKIT V1 Platform:** Optimizing code for 32-bit dual-core processing.

Mobile Interface Configuration:

Pairing with Serial Bluetooth Terminal for real-time monitoring and data visualization on mobile devices.

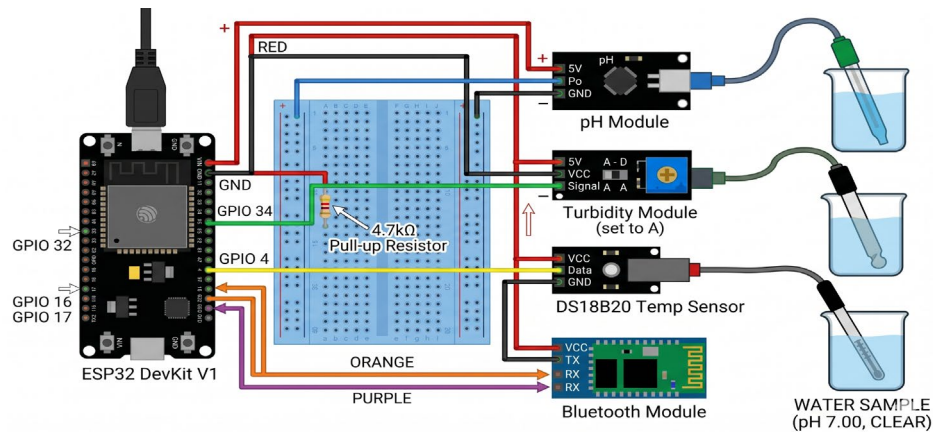


Figure 3. Hardware Assembling

Integration & Testing

Test system in real-time aquatic conditions:

- Monitor sensor stability and response times when submerged in various water samples.
- Verify the physical integrity of waterproof seals on the temperature probe.

Validate:

- **Sensor Calibration:** Compare analog voltage readings against known pH and turbidity benchmarks.
- **Data Accuracy:** Ensure the 4.7Ω resistor provides a stable digital temperature signal without "No Sensor" drops.
- **Bluetooth Connectivity:** Confirm reliable data transmission to the mobile app within a 10-meter range.

Simulate Environmental Variations:

- Introduce varying levels of sediment to confirm the turbidity sensor's analog sensitivity.
- Monitor the thermal response curve of the DS18B20 probe to verify rapid temperature detection.

Deployment

- Field Deployment in Targeted Aquatic Environments
- Stakeholder Onboarding and System Integration
- Real-Time Monitoring and Alert Configuration



Figure 4. Final Product

Maintenance

- Monitor system performance and logs.
- Replace faulty hardware components if needed.
- Plan enhancements: Dissolved oxygen sensor addition,

3. RESULTS AND DISCUSSION

3.1 Finding

The design of Neptune's Needle draws direct inspiration from the natural hydrodynamics of the manatee and the sailfish, blending fluid efficiency with stability. While it is out there, its suite of smart sensors constantly tracks critical metrics like pH, turbidity, and temperature, feeding that info back instantly through a real-time IoT and cloud system. Because it is built for entirely uncrewed operations, the entire process is handled via remote monitoring, effectively removing the need for a human presence on the water while keeping data flowing 24/7.

4. CONCLUSION

In conclusion, Neptune's Needle offers smart, autonomous boats for water-quality monitoring, measuring pH, turbidity, and temperature in real time. This system reduces manual labour, enhances safety, and speeds up data collection for both research and industrial use. By leveraging continuous operations and IoT technology, the project is set to become a vital tool for more efficient water resource sustainability.

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