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IOT BASED WATER POLLUTION MONITORING BOAT

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ABSTRACT :

The purpose of this project is to develop and implement an IoT-based Water Pollution Monitoring Boat designed to enhance the efficiency, accuracy, and coverage of water-quality assessment in natural water bodies. With increasing industrial discharge, agricultural runoff, and urban waste contamination, lakes, rivers, and ponds are facing severe environmental degradation, making continuous monitoring essential. To address these challenges, the proposed system employs an ESP32 microcontroller integrated with sensors such as pH and temperature sensors to continuously measure key water-quality parameters. The boat is equipped with GPS for location tracking and DC motors controlled through a motor driver to enable autonomous navigation across different regions of a water body.

Real-time sensor data and geographic coordinates are processed by the ESP32 and transmitted to the Blynk IoT platform, allowing users to remotely monitor water conditions through a smartphone application. This enables wide-area, real-time water analysis without requiring manual sampling. By combining IoT technology with an autonomous floating platform, the system provides a cost-effective, scalable, and reliable solution for tracking pollution levels, supporting environmental monitoring, and facilitating early detection of contamination. Ultimately, the project contributes to improved water-resource management and supports researchers and environmental authorities in maintaining ecological health.

Keywords: IoT-based Water Monitoring, Autonomous Water-Quality Boat, pH and Temperature Measurement, Real-time Environmental Monitoring, GPS-Based Tracking, Microcontroller-Based System, Pollution Detection, Multi-Sensor Monitoring.

INTRODUCTION

Water pollution has become a major global concern due to rapid industrialization, urban waste discharge, agricultural runoffs, and untreated sewage entering water bodies. Monitoring the quality of water in lakes, rivers, and reservoirs is essential to protect aquatic life, ensure safe drinking water sources, and maintain ecological balance. Traditional manual water testing methods are time-consuming, labor-intensive, and unable to provide real-time data, which limits timely decision-making.

To overcome these limitations, the project **"IoT-Based Water Pollution Monitoring Boat"** is proposed. This system uses a small autonomous or semi-autonomous boat equipped with multiple water-quality sensors to continuously monitor essential parameters such as pH, turbidity, temperature, dissolved oxygen, and conductivity. The collected data is sent to a cloud platform through IoT-based communication, enabling real-time tracking and analysis from any remote location. The boat can move across polluted or inaccessible water zones and gather accurate data without human intervention.

By integrating sensor technology, microcontroller-based processing, wireless communication, and mobile/cloud interfaces, this system provides a smart, efficient, and scalable solution to water pollution monitoring. The proposed IoT-enabled boat enhances environmental surveillance, supports early detection of contamination, and assists authorities and researchers in implementing effective water-quality management strategies.

PROBLEM STATEMENT

Traditional water-quality assessment methods depend largely on manual sampling, which is slow, labor-intensive, and unable to deliver continuous real-time data. As a result, pollution is often detected late, allowing contaminants to spread and harming aquatic ecosystems. Manual testing also makes it difficult to access deep, wide, or unsafe water areas, leading to incomplete and sometimes inaccurate measurements. In addition, the absence of automated monitoring, sensor-based detection, and reliable wireless communication limits the effectiveness of early warning systems. Therefore, an IoT-based water pollution monitoring boat is required to autonomously collect real-time water parameters, enhance data accuracy, and provide timely alerts for efficient and proactive water-quality management.

LITERATURE SURVEY

The evolution of IoT-based water pollution monitoring systems, as observed across recent research, shows a clear transformation from manual sampling techniques to autonomous, real-time water-quality assessment using sensor-equipped robotic platforms. Early developments by Sharma et al. (2019)

introduced basic floating monitoring units equipped with pH and turbidity sensors, demonstrating the feasibility of remote environmental sensing but lacking mobility and cloud integration. This foundation was strengthened by Rajesh Kumar et al. (2020), who implemented Arduino-controlled boats capable of collecting water parameters while navigating predefined paths; however, their systems still relied on short-range communication technologies such as Bluetooth. A major advancement occurred in 2021 when Priya Nair et al. integrated Wi-Fi modules like ESP8266 and cloud platforms such as ThingSpeak, enabling long-distance monitoring and centralized data visualization. Subsequent studies by Hritik Sen et al. (2022) emphasized the importance of multi-parameter sensing by adding dissolved oxygen and electrical conductivity measurement, significantly improving the system's environmental assessment capability.

Further refinement emerged in 2023 with the work of Liang Chen et al., who introduced GPS-enabled autonomous boats capable of mapping pollution hotspots across large water bodies, marking a shift toward geospatial intelligence. The field matured in 2024 as researchers such as Mohammed Rafi et al. incorporated solar-powered systems to increase operational duration and reduce reliance on external charging. Another major contribution came from Anusha Devi et al. (2024), who employed LoRa communication for long-range, low-power environmental monitoring in rural and remote water bodies. Most recently, in 2025, innovations focused on smart data processing and predictive analytics. For example, Vivek V. and colleagues (2025) integrated machine-learning algorithms for detecting abnormal pollution trends, while Tanmay Deshmukh et al. (2025) explored AI-based navigation for autonomous path optimization.

Despite these advancements, the literature highlights a consistent limitation: existing systems often excel in individual components—such as sensing, communication, navigation, or energy management—but rarely combine all these capabilities into a single, affordable, and fully integrated platform. There remains a notable gap for a cost-effective IoT-based water monitoring boat that simultaneously offers real-time multi-sensor data collection, autonomous mobility, long-range communication, and accurate geolocation tracking. Addressing this gap forms the core motivation of the present research.

EXISTING SYSTEM

Traditional water-quality monitoring relies on manual sampling and laboratory testing, which is time-consuming, labor-intensive, and provides only point-based data, delaying pollution detection. Stationary IoT-based systems with fixed sensors offer real-time monitoring but are limited to small areas and cannot cover entire water bodies. Semi-autonomous or manually controlled sensor boats improve coverage but face challenges like short communication range, low battery life, and lack of GPS tracking. Overall, existing systems are limited in mobility, coverage, and continuous real-time monitoring.

PROPOSED SYSTEM

The proposed system is an **IoT-based Water Pollution Monitoring Boat** designed to autonomously measure water-quality parameters such as pH and temperature while recording GPS locations. It uses an ESP32 microcontroller to process data from multiple sensors and control DC motors through a motor driver for automated navigation. The collected sensor readings and GPS coordinates are transmitted to the Blynk IoT cloud platform, enabling real-time monitoring through a mobile application. This system provides **wide-area, continuous, and real-time water monitoring**, addressing the limitations of manual sampling and stationary systems, and supports efficient water-quality management and pollution detection.

HARDWARE AND SOFTWARE IMPLEMENTATION

The implementation of the IoT-based water pollution monitoring boat includes an ESP32 microcontroller connected to key sensors such as a pH sensor (E201-C), temperature sensor (DS18B20), and a GPS module (NEO-6M) for real-time water quality and location tracking. The boat is powered using a Li-ion battery and uses an L298N motor driver to control the DC motors for navigation. All components are mounted on a custom PCB for stable operation. The software implementation involves programming the ESP32 using Arduino IDE to read sensor data, process values, and transmit them to the Blynk IoT platform via Wi-Fi. Blynk virtual pins are used to visualize live pH, temperature, and GPS coordinates, making the system fully automated and remotely accessible.

CIRCUIT DIAGRAM

The circuit diagram shows how all components of the water pollution monitoring boat are interconnected. The ESP32 acts as the main controller, receiving pH values through an analog pin and temperature data from the DS18B20 via a digital pin. The GPS module (NEO-6M) communicates with the ESP32 using TX and RX lines. For navigation, the ESP32 sends control signals to the L298N motor driver, which operates the two DC motors. A Li-ion battery powers the entire system, while a voltage regulator maintains stable voltage levels. All components are mounted on a PCB or breadboard for secure and organized wiring.

Component Roles:

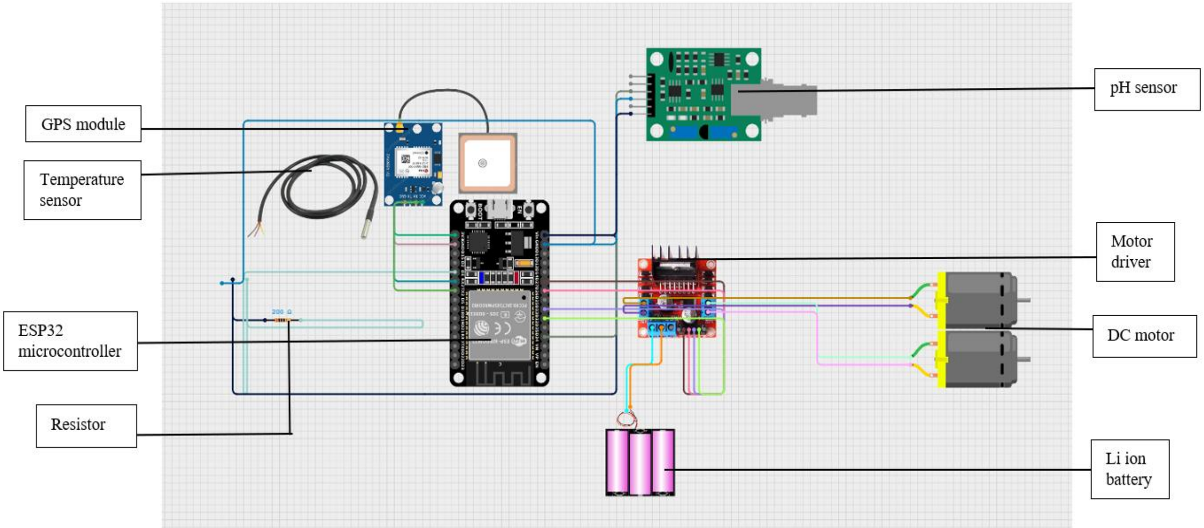
1. **Microcontroller (The Brain):**

ESP32 Microcontroller: Acts as the brain of the system. It reads data from sensors, processes it, controls the motors, and sends live data to the IoT platform using Wi-Fi.

2. **pH Sensor (E201-C):**

Measures the acidity or alkalinity of the water. Its output helps assess pollution levels in the water body.

3. **DS18B20 Temperature Sensor:**
   Provides accurate water temperature readings, which are important for understanding overall water quality.
4. **NEO-6M GPS Module:**
   Tracks the boat's live location by transmitting latitude and longitude, helping monitor where the data is collected.
5. **L298N Motor Driver:**
   Controls the direction and speed of the DC motors based on signals received from the ESP32.
6. **DC Motors:**
   Drive the boat forward, backward, and help with steering.
7. **Li-ion Battery:**
   Supplies power to the ESP32, sensors, and motors for long-duration operation.



Circuit diagram

Operational Scenarios

- **Real-Time Water Quality Monitoring**
  When the boat is placed in a water body, the pH and temperature sensors continuously measure the water's condition. The ESP32 processes this data and sends live readings to the Blynk app, allowing users to monitor pollution levels instantly.

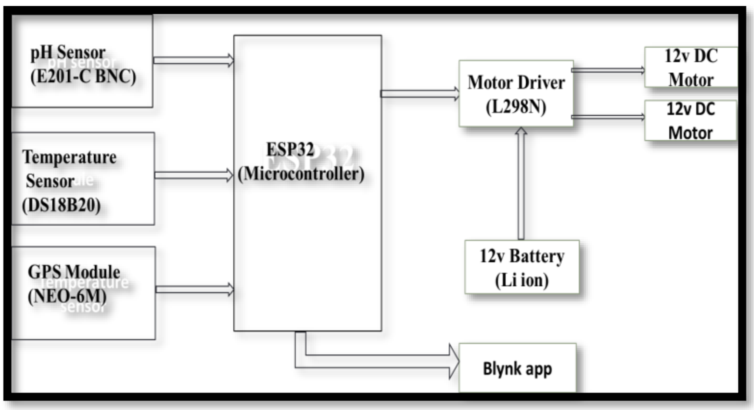
- **Automatic Location Tracking**
  As the boat moves, the GPS module updates its latitude and longitude. This helps users track the boat's path and identify the exact locations where pollution readings are taken.

- **Remote Navigation Control**
  Through the Blynk app, users can control the boat's motors using virtual buttons or sliders. The ESP32 sends commands to the motor driver, allowing the boat to move forward, reverse, or turn.

- **Data Logging for Analysis**
  The system can operate for extended periods, continuously collecting sensor data. This information can be saved on the cloud, enabling later analysis of water quality trends.

- **Battery-Powered Field Operation**
  The boat operates on a rechargeable Li-ion battery, making it suitable for lakes, ponds, and rivers where direct power supply is not available.

BLOCK DAIGRAM



Block Diagram

The block diagram represents the overall architecture of the IoT-based water pollution monitoring boat. The system is centered around the ESP32 microcontroller, which acts as the main processing unit. Various sensors, including the pH sensor, temperature sensor, and ultrasonic sensor, are interfaced with the ESP32 to measure the water's pH level, temperature, and obstacle distance respectively. These sensors continuously send real-time data to the ESP32 for processing and analysis. The ESP32 also communicates with the motor driver (L298N), which controls the two 12V DC motors responsible for the movement of the boat. The motor driver receives low-power control signals from the ESP32 and uses power supplied by a 12V lithium-ion battery to drive the motors. In addition to processing sensor data and controlling the motors, the ESP32 transmits the collected water quality information to the Blynk IoT application via WiFi. The Blynk app displays live sensor readings and allows the user to remotely monitor and control the boat. Thus, the block diagram demonstrates how sensing, control, communication, and power modules work together to create a fully automated smart water monitoring system.

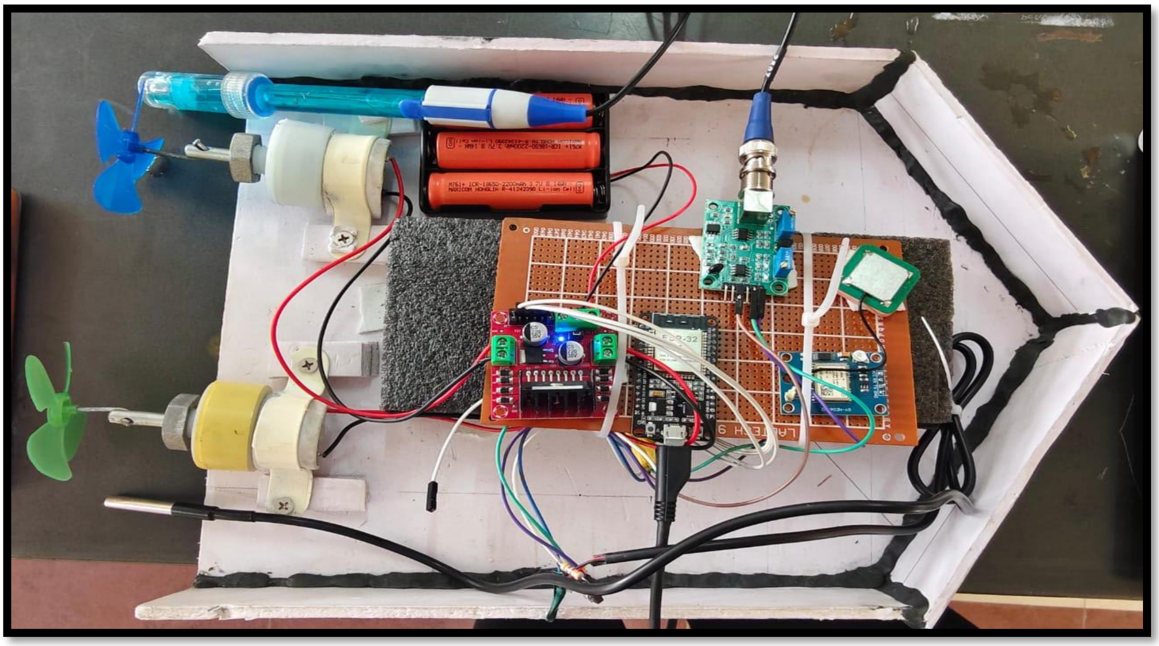
RESULTS

The IoT-based water pollution detection boat was tested in different water conditions, and it successfully collected and transmitted real-time data for pH, temperature and location. During testing, the pH sensor provided accurate readings across multiple points, showing higher pH levels in clean water areas and lower levels in regions with chemical contamination. The sensor responded quickly to changes when the boat moved from clean to polluted zones, confirming its proper calibration and sensitivity. The DS18B20 temperature sensor consistently measured water temperature with high precision. The readings remained stable even when the boat experienced slight vibrations or movement, proving the sensor's reliability in real-time monitoring.

The GPS module continuously transmitted the boat's location to the IoT dashboard, enabling the user to track the boat's path and match pollution levels with specific locations on the map. The propulsion system, driven by 12V DC motors and an L298N motor driver, performed efficiently and alloted smooth navigation even in mildly flowing water. The IoT communication through the ESP32 was stable and showed no major data delays.

Overall, the results confirmed that the system successfully worked as a fully functional pollution monitoring platform, capable of collecting accurate sensor data, moving autonomously/with remote control, and displaying complete water parameters to the user.

Fig 1:Top view of project



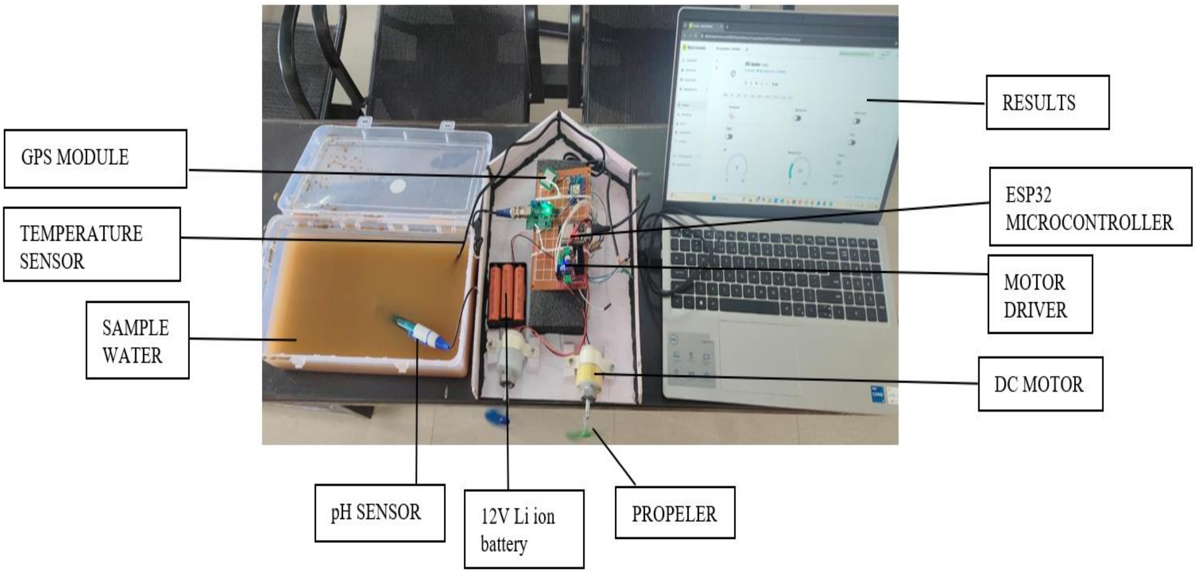


Fig.2 Hardware setup of IOT based water pollution monitoring boat

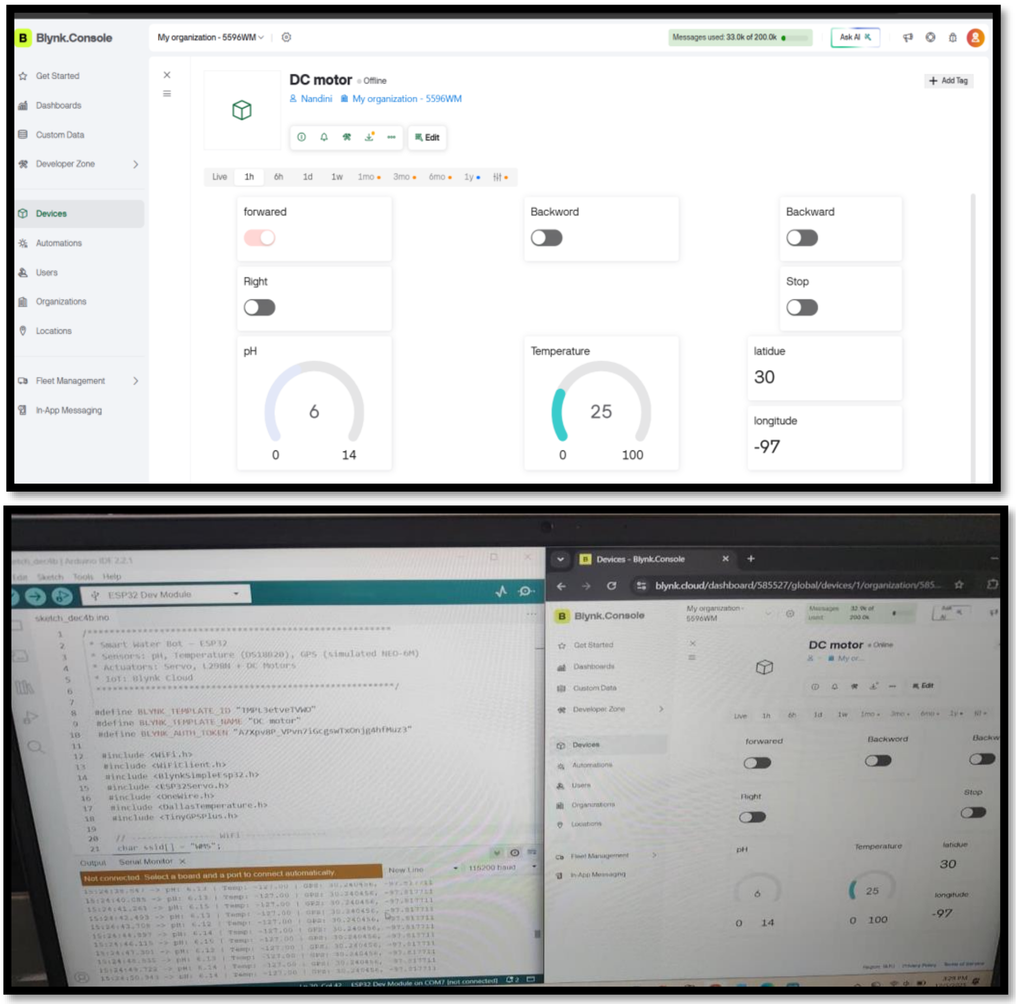


Fig 3:Results Shown in Blynk and serial monitor

CONCLUSION

The IoT-Based Smart Water Pollution Monitoring Boat provides an innovative and efficient solution for monitoring water quality. With integrated sensors, GPS, servo-driven steering, and IoT connectivity through the Blynk app, the system enables real-time data monitoring and remote navigation. The project successfully combines mobility, IoT, and environmental sensing to support pollution detection and water resource management. It meets all objectives and demonstrates its effectiveness as a modern monitoring tool.

FUTURE SCOPE

- Add more sensors for detecting heavy metals and chemicals.
- Enable autonomous navigation using AI.
- Real-time data analysis with alerts for pollution spikes.

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