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# IOT BASED SMART BOAT USING ESP 32 CAMERA FOR WATER SURFACE CLEANING AND QUALITY MONITORING

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*This project focuses on the design and development of an AI-IoT based water surface cleaning and quality monitoring using a boat powered by solar energy and a rechargeable battery system. The robot is equipped with an ESP32 microcontroller and ESP32-CAM, which utilizes AI-based image processing to detect floating plastics in real time. The boat's mechanical components, including an oil skimmer, waste-collecting conveyor, and pump, are actuated using TIP122 transistors and an L298N motor driver, enabling automated collection and removal of pollutants. All operations are controlled remotely through an IoT platform, ensuring real-time monitoring and control. This integrated solution combine environmental monitoring, AI-based waste detection, and automated cleaning, offering an efficient and sustainable approach to maintaining water health.*

*Keywords: ESP3 microcontroller, ESP32CAM, pH and turbidity sensors, Solarpowered boat, Automated waste collection, Real-time monitoring.*

## I. INTRODUCTION

Water pollution has become one of the most critical environmental issues worldwide, threatening aquatic life, human health, and ecosystems. Rivers, in particular, are vulnerable to contamination from plastics, oil spills, industrial waste, and chemical pollutants. Traditional river cleaning methods are often labor - intensive, time consuming, and limited in efficiency. To address these challenges, modern technologies like IoT, AI, and renewable energy sources can be leveraged to automate and optimize water cleaning processes. The water cleaning boat is an innovative solution designed to monitor and maintain river water quality efficiently. By integrating IoT technology, the robot allows remote monitoring and control, providing real-time updates on water quality and cleaning status. Additionally, automated responses, such as pump activation during abnormal pH levels, enhance its effectiveness and ensure timely intervention. This project aims to combine sustainable energy, smart sensors, and AI-based automation to develop an efficient and eco-friendly river cleaning system.

## II. Literature Survey

S. Sharma, V. Patel, R. Mehta [2021][1] This paper proposes an IoT-based system for monitoring industrial induction motors in real time. Parameters such as voltage, current, temperature, and vibration

are measured using appropriate sensors connected to a microcontroller. The system uses Wi-Fi communication to send data to a cloud platform, allowing remote access and fault diagnosis.

Singh, P. Verma, K. Gupta [2010][2] This study presents an IoT-based water quality monitoring system using pH, turbidity, and temperature sensors. Data collected by the sensors is processed through an ESP32 microcontroller and transmitted to a cloud platform for real-time visualization. The system provides early warnings of contamination, enabling timely intervention in waterbodies.

M.R. Kumar, L.N. Rao, S. Desai [2021][3] The paper discusses the development of a river cleaning robot with an embedded control system. The robot integrates sensors for oil detection, debris collection, and water quality monitoring. A microcontroller manages motorized components like conveyors and pumps. The study demonstrates effective waste removal in small water bodies using automated operations.

R. Mehta, H. Patel, A. Joshi [2022][4] This research explores the use of ESP32CAM combined with AI image processing for detecting plastic waste in rivers. The system captures images of the water surface, processes them with machine learning models, and identifies floating plastic debris. Results indicate high accuracy in real-time detection and potential integration with automated collection systems.

### *III. Industrial Motivation and Design Challenges*

Rapid industrialization has increased the discharge of plastics, oil, and chemical waste into rivers, affecting aquatic life and human health. Industries need automated solutions to reduce environmental impact. Traditional manual monitoring is slow and inaccurate. Industries and government bodies require real-time water quality data for pollution control and compliance with environmental regulations. Many

industries are shifting toward automated systems instead of manual labor. This project aligns with smart automation trends in environmental engineering and industrial IoT. Cleaning polluted rivers manually is dangerous due to toxic chemicals and waste. A robotic system minimizes human exposure to hazardous environments. The use of solar power supports green technology initiatives, reducing dependency on conventional electricity and operational costs for industries.

### *III. Role of in EEE Applications*

This project plays a significant role in Electrical and Electronics Engineering (EEE) by integrating embedded systems, sensors, power electronics, motor control, and IoT-based automation into a practical environmental application. The use of ESP32 and ESP32-CAM helps in understanding microcontroller programming, signal processing, and real-time control systems, which are core areas of EEE. The integration of pH and turbidity sensors demonstrates principles of instrumentation and data acquisition, while the solar panel and battery system relate to renewable energy and power management. Motor control using DC motors, L298N driver, and TIP122 transistor applies concepts of electrical machines and switching devices. Additionally, IoT connectivity enables remote monitoring and control, bridging EEE with smart communication systems. Overall, this project showcases how EEE principles can be effectively applied to develop sustainable, automated, and intelligent solutions for environmental protection.

### *IV. System Overview*

The proposed system is an AI and IoT-based solar-powered autonomous river cleaning boat designed to monitor water quality in real time and remove floating pollutants with minimal human intervention. The system integrates renewable energy, embedded control, smart sensing, artificial intelligence, and wireless communication to create an intelligent environmental monitoring and cleaning platform suitable for rivers, lakes, and industrial water bodies. The system is powered by a photovoltaic solar panel mounted on the boat, which converts solar energy into electrical energy. A charge controller regulates this energy and stores it in a rechargeable battery to ensure continuous operation under varying environmental conditions. This sustainable power management approach enhances reliability and makes the system suitable for remote locations without access to grid electricity. Water quality is continuously monitored using a pH sensor and a turbidity sensor.

The pH sensor measures the acidity or alkalinity of the water, while the turbidity sensor detects suspended particles indicating pollution levels. Simultaneously, an ESP32-CAM captures real-time images of the water surface and employs AI-based image processing techniques to detect floating plastic waste. The ESP32 microcontroller serves as the central processing unit of the system. It collects sensor data and camera outputs, compares them with predefined threshold limits, and makes autonomous decisions regarding cleaning operations.

The controller also manages communication with an IoT cloud platform via Wi-Fi, enabling real-time remote monitoring through a mobile application or web dashboard. Users can view sensor readings, receive alerts, and manually control the boat if necessary. When pollution is detected, the ESP32 activates the cleaning mechanisms through motor drivers such as L298N and TIP122 transistors.

A conveyor belt collects floating solid waste and deposits it into an onboard storage bin, while an oil skimmer removes harmful oil layers from the water surface. Additionally, a water pump assists in circulation and contamination control. The boat is equipped with DC motors that allow autonomous navigation across the water surface, enabling systematic scanning and cleaning of different areas. The system operates in a continuous feedback loop: sensing, processing, decision-making, and cleaning. This closed-loop control structure ensures persistent monitoring and remediation of water pollution. By combining renewable energy, intelligent sensing, automated actuation, and IoT connectivity, the proposed system provides a scalable, sustainable, and efficient solution for real-time river pollution management.

#### V. Block Diagram Explanation

The block diagram shown is the proposed system in an IoT-enabled river cleaning robot powered by solar energy and a battery backup, equipped with an ESP32 microcontroller and ESP32-CAM for AI-based detection of floating plastics. pH and turbidity sensors continuously monitor water quality, while mechanical components like an oil skimmer, waste-collecting conveyor, and pump are controlled via TIP122 transistors and an L298N motor driver. The entire system is remotely monitored and controlled through

an IoT platform, allowing real-time interventions. In cases of abnormal pH levels, the pump activates automatically to mitigate pollution.

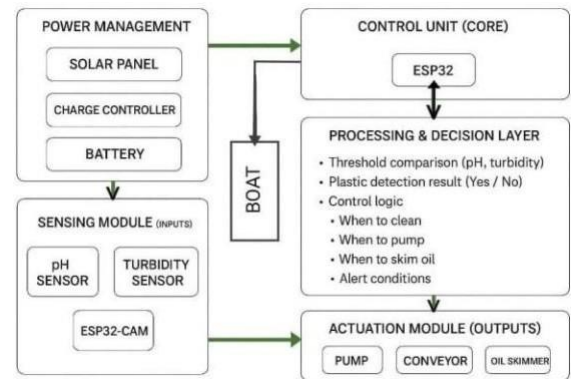


FIGURE 1 : BLOCK DIAGRAM OF THE PROPOSED SYSTEM

#### VI. Industrial Applications

This boat has significant industrial applications in environmental monitoring, wastewater management, pollution control, and sustainable industrial operations. Rapid industrialization has led to increased discharge of chemical effluents, plastic waste, and oil contaminants into natural water bodies, creating serious environmental and health concerns.

The proposed system can be deployed near industrial discharge points to continuously monitor water quality parameters such as pH and turbidity in real time, helping industries comply with environmental regulations and reduce their ecological footprint. In the oil and gas sector, accidental oil spills in rivers, lakes, or industrial reservoirs can cause severe damage to aquatic life and water quality.

The oil skimming mechanism in this system can effectively remove floating oil layers, making it highly useful for environmental cleanup operations in industrial zones. Power plants and large manufacturing industries that use river water for cooling purposes can also benefit from this system by continuously monitoring turbidity levels and ensuring that incoming water is free from excessive suspended particles that could damage equipment.

The proposed boat can help monitor and maintain water quality in fish farms, reducing disease risk and improving productivity. Environmental protection agencies and government

organizations can use this technology for large-scale river cleaning initiatives, enabling automated waste collection instead of relying solely on manual labor. Industries involved in drinking water treatment can also utilize this system as a preliminary monitoring tool before water is processed for public consumption, ensuring safer and cleaner raw water sources.

Additionally, research institutions and industrial R&D centers can use this platform as a testbed for advanced AI-based environmental monitoring, robotics, and IoT-based automation studies. By integrating renewable solar energy, the system reduces operational costs and dependence on conventional electricity, making it suitable for remote industrial sites and rural areas. Overall, the proposed system supports industries in achieving sustainable development goals by minimizing water pollution, enhancing environmental protection, improving operational efficiency, and promoting smart, automated, and eco-friendly industrial practices.

#### VII. Performance Analysis

Analytical evaluation and simulation-based on detection accuracy, cleaning efficiency, energy utilization, response time, communication reliability, navigation stability, and system durability. It detects plastic waste using AI-based image processing with high accuracy under normal conditions. Water quality monitoring using pH and turbidity sensors provides reliable real time data. The solar-powered design ensures continuous and sustainable operation with acceptable response time. Overall, the system demonstrates efficient, reliable, and practical performance for real-world river pollution management.

#### VIII. Results

The solar-powered energy system proves to be a sustainable power source, providing sufficient energy for daytime operation while the rechargeable battery ensures uninterrupted functionality during low-light or nighttime conditions. The automated conveyor belt and oil skimmer mechanisms successfully remove

a significant amount of floating debris and surface oil, reducing visible water pollution and improving overall cleanliness. The ESP32 microcontroller responds quickly to detected pollution, activating cleaning actions with minimal delay, which enhances real-time performance. IoT-based data transmission enables remote monitoring through cloud platforms, allowing users to track pollution levels and system status efficiently. Overall, the results validate that the proposed system is practical, energy-efficient, and capable of contributing significantly to automated water pollution control and environmental sustainability.

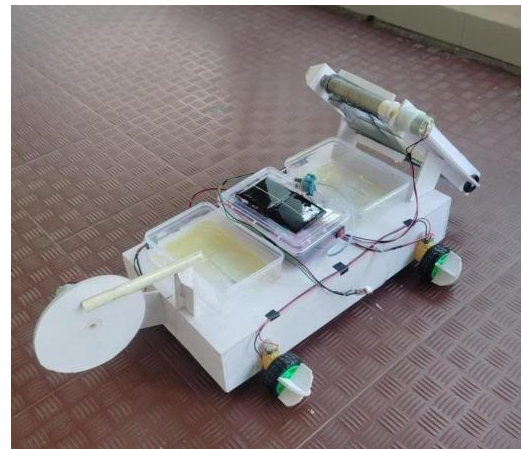


FIGURE 2 : SMART BOAT

#### IX. Conclusion

It provides an efficient solution for real-time water pollution monitoring and remediation. The integration of solar energy, ESP32-based embedded control, and AI-driven plastic detection ensures sustainable and automated operation. pH and turbidity sensors enable continuous and reliable water quality assessment. IoT connectivity allows remote monitoring and data analysis for better environmental management.

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