Esp 32 Based Mobile Controlled River Cleaning Robot

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Abstract— This research introduces a mobile-controlled river cleaning robot designed to address the growing challenge of water pollution. The robot, powered by an ESP32 microcontroller, serves a dual purpose: removing floating debris and monitoring water quality through a Total Dissolved Solids (TDS) sensor. By integrating a conveyor belt for waste collection and an IoT-based platform (ThingSpeak) for real-time TDS data visualization, this system offers a cost-effective, scalable solution for environmental protection. The robot operates using L298 motor drivers, DC motors, and a 12V power supply, with manual movement control. The TDS sensor provides continuous monitoring of water pollution levels, ensuring that pollution trends are tracked efficiently. The system's remote monitoring capabilities allow authorities to make informed decisions. This research demonstrates the feasibility of combining waste removal with pollution tracking, paving the way for smarter, automated solutions for cleaner water bodies.

Keywords— *Water Pollution, River, Mobile Controlled, TDS*

I. INTRODUCTION

Water pollution is one of the most pressing environmental challenges of our time, with significant impacts on ecosystems, human health, and the global climate. The discharge of industrial, agricultural, and domestic waste into rivers and lakes continues to degrade water quality, making it unsafe for consumption and disrupting aquatic life. Traditional methods of river cleaning are largely manual, labor-intensive, and inefficient, often requiring significant time and resources. In recent years, however, advancements in robotics and automation have opened up new avenues for addressing this issue. One promising solution is the development of autonomous river cleaning robots that can efficiently collect floating debris and monitor water quality.

This paper presents a mobile-controlled river cleaning robot that combines waste removal and water quality monitoring using Total Dissolved Solids (TDS) sensors. The system is designed to be cost-effective, scalable, and environmentally friendly, offering a more efficient alternative to conventional cleaning methods. The robot is powered by an ESP32 microcontroller, which controls both the movement of the robot and the TDS sensor for real-time pollution monitoring. By integrating a conveyor belt mechanism, the robot is capable of collecting floating waste, while the TDS sensor continuously measures water quality, providing valuable data on pollution levels. The real-time data is then uploaded to an IoT platform, ThingSpeak, for remote monitoring and analysis.

The integration of Internet of Things (IoT) technology allows for better decision-making, as authorities can track pollution trends and respond proactively. This robot can operate autonomously or be manually controlled, depending on the specific requirements of the location. With the potential to monitor water quality in addition to performing physical cleaning, the robot provides a more comprehensive solution for addressing water pollution.

In summary, the research aims to develop a robotic system that not only removes waste from water bodies but also contributes to environmental monitoring. The use of ESP32 and IoT technology for water quality tracking marks an important step towards more intelligent, sustainable solutions for river cleaning and pollution management.

II. RELATED WORK

No Several research efforts have focused on the development of automated systems for river cleaning, with varying degrees of success. One notable approach involves the use of robotic systems equipped with conveyor belts to remove floating waste from water surfaces. These robots typically operate on predefined paths and are often designed to work in shallow waters or nearshore areas. A study conducted by Kumar et al. (2018) presented an automated surface cleaning robot, which successfully removed debris from water bodies. However, while the system showed effectiveness in waste removal, it lacked the capability to monitor water quality in real-time. This limited its ability to provide comprehensive data on water pollution trends.

In the field of water quality monitoring, IoT-based solutions have gained attention for their ability to provide continuous and remote monitoring of various water parameters. For instance, Rajasekaran et al. (2020) explored the use of IoT platforms for monitoring parameters such as pH, turbidity, and TDS in water bodies. Their work demonstrated the potential of IoT in tracking water quality and making real-time data accessible to users for better decision-making. However, few studies have integrated this technology into autonomous river cleaning systems, with most research focusing either on waste removal or water quality monitoring as separate functions.

Our work builds on these previous studies by combining both functions in a single, integrated system. The proposed river cleaning robot not only removes floating debris using a conveyor belt but also continuously monitors water quality through a TDS sensor. By incorporating IoT-based data visualization, our system provides real-time pollution tracking alongside waste collection, offering a more holistic approach to managing water pollution and improving environmental protection efforts.

III. DESIGN AND BUILD SPECIFICATIONS

A. Components Required

Electronic as well as hardware components are required to build this project. These components with their specifications are summarized in the table mentioned below.

Sr. No.	Components	Specifications
1	Microcontroller	ESP32
2	TDS Sensor	Voltage Range: 3.3V-5V
3	Motor Driver	L298N Dual H-Bridge
4	DC Motor	150RPM
5	Battery	12V Lithium-Ion

ESP32 Microcontroller: The ESP32 is a highly versatile microcontroller equipped with both Wi-Fi and Bluetooth capabilities, making it ideal for Internet of Things (IoT) applications. It offers excellent performance and low power consumption, making it suitable for remote monitoring and control tasks. With a rich set of General-Purpose Input/Output (GPIO) pins, it allows easy interfacing with various sensors and actuators, providing flexibility for different types of automation projects.

TDS Sensor: The TDS (Total Dissolved Solids) sensor measures the level of dissolved solids in water, such as salts, minerals, and pollutants. It operates within a voltage range of 3.3V to 5V, making it compatible with a wide range of microcontrollers, including the ESP32. The sensor plays a key role in monitoring water quality, providing real-time data to assess pollution levels and the effectiveness of the cleaning robot.

L298N Motor Driver: The L298N is a dual H-bridge motor driver, commonly used for controlling the speed and direction of DC motors. It supports bidirectional motor control and is capable of modulating motor speed through Pulse Width Modulation (PWM), making it ideal for driving motors in autonomous systems like robots. **DC Motor (150 RPM)**: The 150 RPM DC motor provides efficient, consistent torque, making it suitable for driving the robot's movement and the conveyor belt. Its speed ensures reliable operation in various robotic applications where precise and controlled motion is required.

12V Lithium-Ion Battery: A 12V Lithium-Ion battery is used for powering the robot's components. It offers a high energy density, ensuring long operation times while being lightweight and rechargeable.
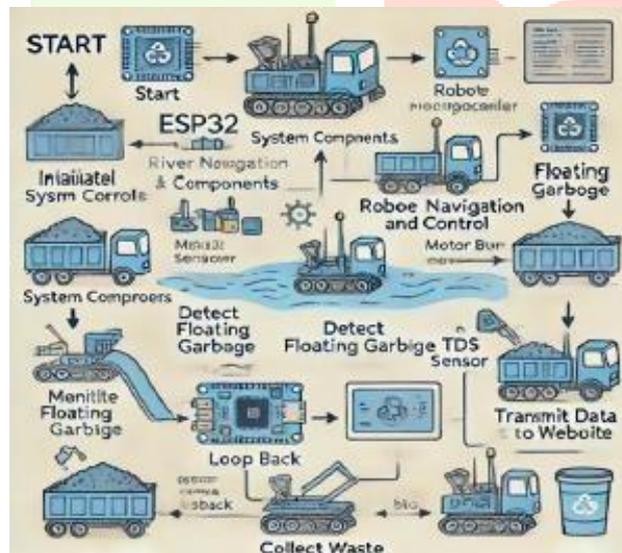
B. Block Diagram

Fig 1 Block diagram of system

The block diagram illustrates the working of a Mobile-Controlled River Cleaning Robot with TDS Monitoring, utilizing an ESP32 microcontroller for navigation, garbage detection, and real-time data transmission. The system is designed to autonomously navigate water bodies, detect floating waste, collect debris, and monitor water quality. The process begins with system initialization, where the ESP32 microcontroller activates all essential components, including the motor driver, TDS sensor, and garbage detection system. The robot starts moving along the water surface, scanning for floating waste using its sensor modules. The motor driver ensures smooth movement and directional control. Once floating garbage is detected, the conveyor mechanism is activated to collect the debris. The TDS sensor simultaneously measures the Total Dissolved Solids (TDS) in the water, providing insights into pollution levels. This data is crucial for assessing water quality in real-time. Collected waste is stored in a dedicated compartment, and the robot continues its operation until the predefined area is cleaned. If more floating garbage is detected, the system loops back to ensure efficient waste collection. The real-time TDS data is transmitted to an IoT-based cloud platform, allowing remote monitoring through a website or mobile application. The robot is mobile-controlled, enabling manual operation when needed. Users can navigate the robot to specific locations using a mobile interface, making it adaptable for various water bodies. The final step involves transporting and disposing of the collected waste in designated

locations. The process repeats continuously, ensuring continuous water cleaning and pollution control. By integrating IoT and automation, this system provides a scalable and eco-friendly solution for maintaining water bodies, reducing human effort, and improving water quality monitoring.

C. Circuit Diagram

The circuit diagram showcases a motor control system using an ESP32 microcontroller and an L298N motor driver, designed to control four DC motors with a 12V battery as the power source. This configuration is commonly used in robotics applications such as river-cleaning robots, autonomous vehicles, and smart mobility systems.

The ESP32 microcontroller serves as the primary controller, sending signals to the L298N motor driver, which facilitates the bidirectional movement of the DC motors. The L298N is a dual H-bridge motor driver capable of handling high current loads, allowing independent control of two motor pairs. The ESP32 communicates with the motor driver through its GPIO pins, sending PWM (Pulse Width Modulation) signals to regulate the speed and direction of the motors. The DC motors are connected to the OUT1, OUT2, OUT3, and OUT4 terminals of the L298N module, which controls their motion. The motors can rotate clockwise or counterclockwise, enabling movements like forward, backward, left turn, and right turn, making the setup ideal for mobile robots.

The 12V battery powers the entire system, supplying voltage to both the L298N motor driver and the ESP32. Proper GND (ground) connections ensure stable communication and operation across all components. This motor control system can be further enhanced with IoT capabilities using ESP32's Wi-Fi and Bluetooth connectivity, allowing remote control via mobile apps or cloud-based platforms. Such a setup is beneficial for applications like autonomous cleaning robots, wireless-controlled cars, and IoT-enabled monitoring systems. This circuit effectively integrates embedded systems and motor control technology, making it a suitable choice for projects requiring real-time motor control, automation, and remote monitoring.
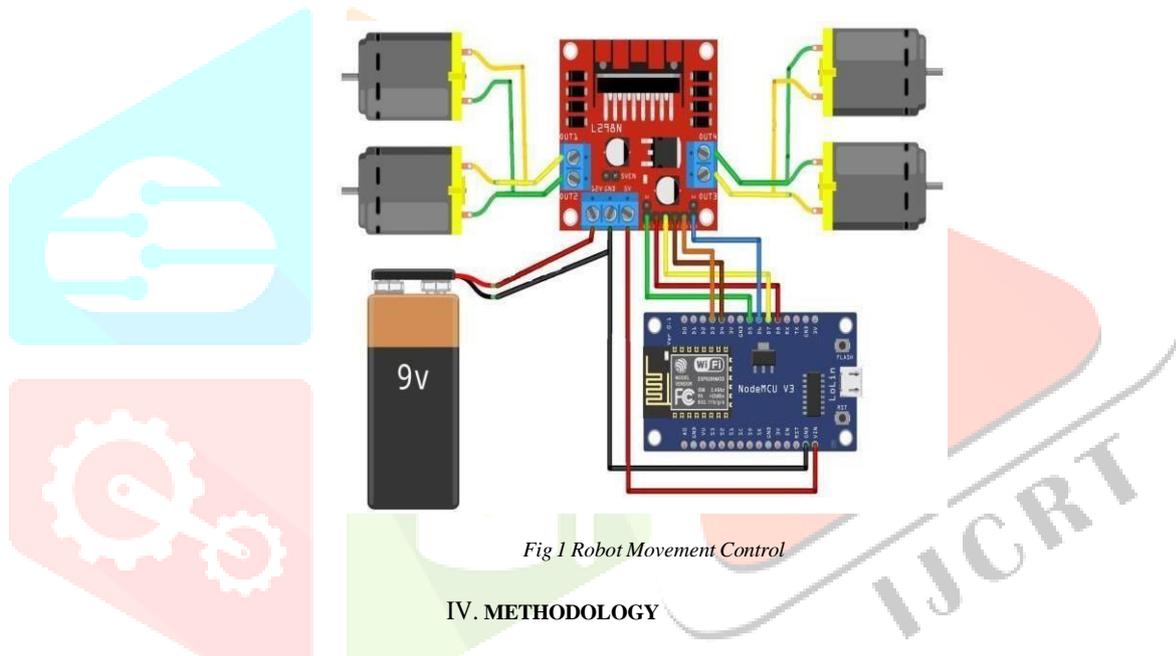

Fig 1 Robot Movement Control

IV. METHODOLOGY

The Mobile-Controlled River Cleaning Robot with TDS Monitoring is designed to efficiently collect floating waste while assessing water quality in real time. The system is powered by an ESP32 microcontroller, which handles both movement control and data processing. It communicates with a L298N motor driver to regulate the DC motors, enabling precise movement and conveyor belt operation for waste collection. A TDS sensor continuously measures water pollution levels, particularly the concentration of dissolved solids in the water. The collected data is transmitted to an IoT platform (ThingSpeak), allowing remote monitoring and analysis. The system operates in manual mode via a mobile application, enabling users to control the robot's movement, or it can follow a predefined path for semi-autonomous operation. A 12V lithium-ion battery powers the entire system, ensuring uninterrupted functionality. The conveyor mechanism efficiently gathers floating debris, improving waste removal efficiency. By integrating IoT-based water quality monitoring, the robot provides real- time pollution tracking, which aids in better decision-making for environmental conservation.

V. RESULT

The Mobile-Controlled River Cleaning Robot with TDS Monitoring is 75% complete, with key functionalities such as mobile control and TDS monitoring successfully implemented and tested. The ESP32 microcontroller efficiently controls the robot's movement, and the L298N motor driver ensures smooth operation of the DC motors. Through mobile control, the robot can be maneuvered remotely, allowing precise navigation in water bodies. The TDS sensor is fully functional, providing real-time water quality data, which is uploaded to the ThingSpeak IoT platform for remote monitoring. This enables authorities or researchers to track pollution levels over time and analyze trends for proactive decision-making. However, the conveyor belt mechanism for waste collection is yet to be attached and tested. This component will play a crucial role in removing floating debris from the water surface. Once installed, further testing will be conducted to evaluate its efficiency under different water conditions. The 12V lithium-ion battery provides sufficient power for the robot's operation, but further optimization may be required for longer endurance. While the system has shown promising results in movement control and water quality monitoring, the final phase of implementation will focus on ensuring seamless integration of the waste collection mechanism. With the remaining 25% work focused on conveyor belt attachment and final calibration, this project is progressing toward completion

VI. CONCLUSIONS

This research successfully presents a mobile-controlled river cleaning robot that combines waste removal and water quality monitoring using a Total Dissolved Solids (TDS) sensor. By integrating IoT technology, the system allows for real-time monitoring of water pollution levels through platforms like ThingSpeak, making it possible for authorities to remotely track pollution trends and take informed actions. The robot, powered by the ESP32 microcontroller and using a conveyor belt for waste collection, offers a cost-effective and scalable solution for cleaning water bodies while simultaneously ensuring environmental protection through continuous monitoring.

Although the robot provides significant advantages, such as dual functionality and remote monitoring, there are limitations, including its reliance on predefined movement patterns and a continuous power supply. Future improvements may include adding GPS-based navigation for enhanced autonomy and more energy-efficient solutions to extend operational time. This research demonstrates the feasibility of combining waste removal and water monitoring into a single, automated system, paving the way for smarter, sustainable water pollution management strategies.

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