Multipurpose, Energy and Cost Efficient River Surface Cleaning Boat

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***Abstract*—Aquatic ecosystems are huge, valuable and very complex systems. Floating debris can entangle and trap aquatic animals causing physical harm. It may also cause plastic and chemical pollution in the river. Large number of suspended loads may cause a variety of difficulties to aquatic life by preventing light penetration into submerged plant life. Evidently, solutions need to be found for the removal of such debris from aquatic environments. Hence, in this paper a river surface cleaning boat is designed. The water cleaning boat project focuses on protecting aquatic animals present in the water bodies with no suspended solids, to minimize aquatic pollution and also taking as another objective minimizing labour and human involvement. The project comes with a method for river cleaning via a treadmill system. This water boat initiative goes as far as arguing that Science, Technology, and Community can be fused together to a sustainable environment to aquatic life.**

***Index Terms*—Aquatic Ecosystem, Eco-friendly Technology, Lithium-Ion Battery, Minimizing Human Intervention, Remote-controlled Boat, River Surface Cleaning, Waste Collection.**

Abbreviation: River Surface Cleaning Boat (RSCB)

I. INTRODUCTION

Water covers about 71% of the Earth's surface, playing a vital role in supporting lives of Earth. Since the earliest times, rivers and lakes have provided resources that sustain communities, and even today, they are crucial to our development in many ways. However, as industrialization has expanded, the damage has been overlooked which caused various impact to the natural resources. Wastewater systems carry materials that are often non-biodegradable, posing serious risks to the environment by contributing to climate change and flooding. It's essential to take responsibility for conserving these resources to ensure sustainable development. Years of uncontrolled waste disposal have led to significant water pollution. The time has come for everyone to start cleaning up the water bodies that are so vital to human beings and animals. Traditionally, cleaning rivers and lakes involves manually removing trash, plastic, and other debris from the water's surface. However, this method requires a lot of human labour, making it risky, costly, and time-consuming. This has created a need for a more efficient, eco-friendly solution that requires minimal human involvement. A water-cleaning boat designed for river surface cleaning offers one such solution. This system can gather waste from water bodies like lakes, rivers, and ponds with less manual intervention. The boat's design includes a cleaning mechanism powered by a conveyor belt system. As the belt moves backward, it collects surface debris into a bin. The boat itself is navigated by a person using a remote-control application, allowing it to navigate the boat on the surface water with ease and remove waste efficiently.

In modern automation and control systems, precise motor selection and control are critical for optimizing power efficiency and achieving specific operational goals. This project focuses on developing a remote-controlled motorized system to drive a boat and a conveyor belt, integrating DC motors, an ESP32 microcontroller, and motor drivers with a 22V battery. By calculating torque, speed, and power requirements, the project ensures that each motor operates within its optimal range, providing reliable propulsion and controlled conveyance while maximizing battery life. The ESP32 microcontroller facilitates wireless control, enabling flexible and responsive motor management. Additionally, careful consideration of load distribution further enhances system stability and efficiency, ensuring smooth operation for prolonged use. This project not only demonstrates the integration of mechanical, electrical, and control components but also showcases how intelligent motor selection and management can improve operational effectiveness in applications.

Contamination of water reservoirs has become a critical issue affecting public health, agriculture, and ecosystems worldwide. Pollutants, including industrial waste, agricultural runoff, and microplastics, threaten water quality and biodiversity. Monitoring and cleaning these reservoirs are challenging due to their size, inaccessibility, and the last amount of data required to assess water health effectively. Conventional methods often involve high costs, human labour, and environmental disruption, underscoring the need for more efficient solutions. This project is motivated to address these challenges through a remote-controlled system that can navigate boat on water reservoirs to clean the surface and monitor the quality of water and collect data efficiently. By designing a boat equipped with DC motors and an ESP32 microcontroller for wireless control, the project aims to create an energy-efficient solution that minimizes environmental impact and reduces operational costs. This system can contribute significantly to river surface cleaning management by providing a flexible, scalable tool for real-time water quality monitoring and potential cleanup applications.

River surface cleaning boats play a vital role in maintaining the health and cleanliness of rivers and waterways. Here are some of the key roles of river surface cleaning boats:

1. Debris removal: River surface cleaning boats are equipped to remove floating debris, such as plastic bottles, bags, and other trash, from the river surface.
2. Oil spill cleanup: These boats can be used to contain and clean up oil spills, preventing damage to aquatic ecosystems.
3. Algae and weed control: River surface cleaning boats can be equipped with machinery to remove excess algae and weeds, which can harm aquatic life.
4. Water quality monitoring: Some river surface cleaning boats are equipped with water quality monitoring equipment, allowing them to track changes in water quality and identify potential pollution sources.
5. Education and awareness: River surface cleaning boats can serve as a visible reminder of the importance of keeping our waterways clean and can help raise awareness about the impact of pollution on aquatic ecosystems.
6. Supporting aquatic life: By removing debris and pollutants, river surface cleaning boats help create a balanced environment for aquatic plants and animals to thrive.
7. Promoting sustainable water management: By keeping rivers and waterways clean, river surface cleaning boats promote sustainable water management practices and help protect these vital resources for future generations.

Overall, river surface cleaning boats play a critical role in maintaining the ecological health and cleanliness of our waterways, and their work has a positive impact on both the environment and local communities.

1.1) PROBLEM STATEMENT

This project aims to design and implement a remote-controlled, motor-driven system to drive a river surface cleaning boat to collect the debris from river water surface.

1.2) OBJECTIVE OF THE PROPOSED WORK

1. To design and implement a boat capable of navigation within water reservoirs, ensuring stability and precision in movement to reach designated areas.
2. To achieve extended operation without frequent recharging or battery replacement.
3. To enable wireless control, providing flexibility for remote operation over Wi-Fi.
4. To develop a cost-effective, scalable, and energy-efficient river cleaning system that ensures robust performance across various water environments while minimizing ecological impact.

II LITERATURE SURVEY

2.1) INTRODUCTION

Literature survey is the process in which a complete and comprehensive review is conducted encompassing the published work from other alternative sources of information. Further, the results of this process are documented. This entire process comes in aid of the researcher to address the important and relevant aspects of the research that had not been addressed prior to the conduction of this research. Therefore, it can be understood that the conduction of literature survey is necessary for the process of gathering secondary data for the research which might prove to be extremely helpful in the research and also designing the architecture of the project.

2.2) RESEARCH PAPERS FOR RSCB

In [1], The author presented an automated water-cleaning boat designed to remove floating debris from rivers and lakes using a conveyor belt mechanism. Controlled via a mobile app with an ESP32 camera, the boat navigates remotely, reducing human intervention and labour. Results showed that the boat efficiently collected waste, achieved an 88.81% improvement in cleaning time compared to traditional methods. Advantages include reduced manual labour, efficient cleaning, and remote operation, while disadvantages may involve limited waste storage capacity and dependency on battery power for operation.

In [2], The author presented a solar-powered water-cleaning bot that removes floating trash and a shore-based system that detects and reports littering. The bot is controlled through image processing and machine learning, with a virtual fence feature for proactive monitoring. Results show the system effectively reduces human intervention, promotes eco-friendliness, and offers both preventive and reactive waste management. Advantages include sustainable operation, cost-effectiveness, and reduced labour, while disadvantages involve limitations in garbage collection capacity and the need for multiple bots for larger water bodies.

In [3], The author presented an innovative river cleaning system, called “The DAAG (Design and construction of advanced air tube guider) mechanism,” designed to remove floating solid waste from freshwater sources like rivers. Key components include water wheels, a conveyer system, a trash rack, and an air-tube piping guider mechanism, it helps collect dispersed waste in one location, reducing power consumption and enhancing efficiency. The system operates with DC gear motors and remote control, allowing it to navigate efficiently and gather waste for disposal. Observations indicate that the system significantly improves waste collection efficiency, providing a technological solution to river pollution and contributing to water conservation efforts.

In [4], The author presented on developing an innovative propulsion mechanism for a cleaning boat designed to operate in non-structural environments, such as irregular terrains and shallow water. The proposed mechanism combines rubber tires, paddles, and tracked feet to enhance maneuverability and adaptability in both aquatic and land conditions. The design enables the boat to traverse obstacles, stairs, slopes, and ditches with greater stability and minimal turning radius, addressing limitations of traditional cleaning machinery. Through trajectory analysis and optimization, the study determines the maximum stair height the boat can climb, showcasing the system’s potential for environmental clean-up in complex, unstructured settings.

In [5], The author presented the design of a river cleaning machine aimed at addressing water pollution in national rivers burdened by sewage, debris, and pollutants. The proposed machine uses a waterwheel-driven conveyor belt to collect floating waste, minimizing human intervention and reducing operational risks and costs associated with manual cleaning. It is fully mechanical, eliminating the need for complex electronics and ensuring durability and ease of maintenance. The machine offers advantages such as low initial costs, environmental friendliness, and suitability for various water bodies. Future improvements could include advanced sorting capabilities, solar power integration, and enhanced motor systems for greater efficiency.

In [6], The author presented the design and fabrication of a remote-controlled river cleaning machine aimed at reducing water pollution. It uses automated technology to collect floating waste, primarily plastics, from water surfaces and deposit it into a bin. The system includes a conveyor mechanism powered by DC motors, a propeller for movement, and sensors to detect waste levels in the collection bin. This approach is intended to be more efficient, cost-effective, and eco-friendly than traditional cleaning methods, helping to protect aquatic life and improve water quality while reducing human intervention.

III. BLOCK DIAGRAM OF RSCB

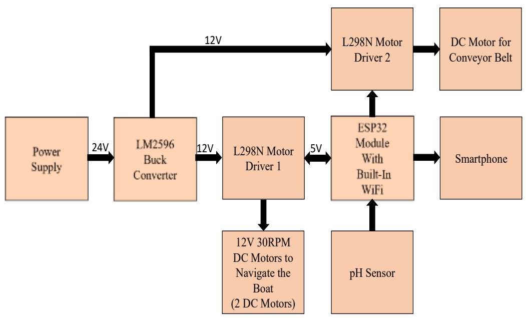

Fig.1: Block Diagram of RSCB

Fig. 1 provides an overview of the components and connections in the river surface cleaning boat project which is explained below in detail.

A) ESP32 Devkit V1 development board:
The central microcontroller for the system, the ESP32 manages motor control, sensor data processing, and communication. It receives inputs from the smartphone and sends signals to the motor driver. The Wi-Fi capability of the ESP32 allows it to connect to a smartphone or other devices for remote monitoring and control. In [7], the detailed specifications of the ESP32, including our ESP32 Devkit V1, are described. Fig. 2 presents the image of the ESP32 development board, while Table 1 provides its detailed specifications.

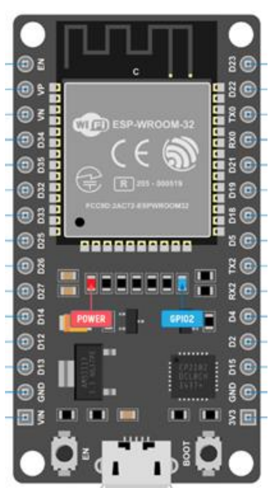

Fig.2: ESP32 devkit V1 module

Table 1:Specification of ESP32 devkit V1 development board

Parameter	Description
Number of cores	2 (Dual core)
Wi-Fi	2.4 GHz (IEEE 802.11 b/g/n standard
Bluetooth	BLE (Bluetooth low energy) and legacy bluetooth
Architecture	32 bits
Clock frequency	Upto 240 MHz
RAM	512 KB
Pins	30, 36, or 38 (depending on the model)
Peripherals	Capacitive touch, ADC, DAC, 12C, UART, CAN 2.0, SPI, I2S, RMII, PWM and more

B) L298N Motor driver
This dual H-Bridge motor driver controls DC motors, which are responsible for propelling and steering the boat. Also, it is used to drive the conveyor motor which is responsible for collecting debris from the surface of the water. The L298N receives power from the battery and control signals from the ESP32. The L298N motor driver controls the speed and direction of DC motors with a current capacity of up to 2 amps. This module is responsible for the movement control of propeller motors, allowing forward and reverse motion, essential for navigating. In [8], the detailed specifications of the L298N motor driver are described. Fig. 3 displays the image of the L298N motor driver module. Table 2 provides the detailed specifications of the L298N motor driver module as per the requirements of our project. In this Project, two motor drivers are used for successful operation.

Fig. 3: L298N motor driver module

Table 2: Specifications of L298N Motor Driver

Item type:	L298N motor driver
Current rating (A)	2
Voltage rating (V)	5 to 35
Driver IC	Double H-bridge L298N
Max. supply voltage (V)	46
Operating voltage (VDC)	5 ~ 35
Max. operating current (A)	2
Logical voltage (V)	5
Driver current (A)	0 – 6 mA

C) Lithium-ion battery:

The main power source for the boat, providing energy to all other components, including the motor drivers (2xL298N) and the ESP32. The battery voltage is regulated as needed for different components. The 4500mAh, 6S-configured battery ensures a consistent 22.2V output, delivering stable and extended operational power.. The 3C discharge rate supports moderate power draws, while the 6S2P arrangement helps in distributing load efficiently, contributing to extended battery life. It's well-suited for seeking a reliable, high-capacity battery for River Surface Cleaning Boat. Fig. 4 displays the image of the lithium-ion battery pack, while Table 3 provides the detailed specifications of the lithium-ion battery as per the requirements of project.

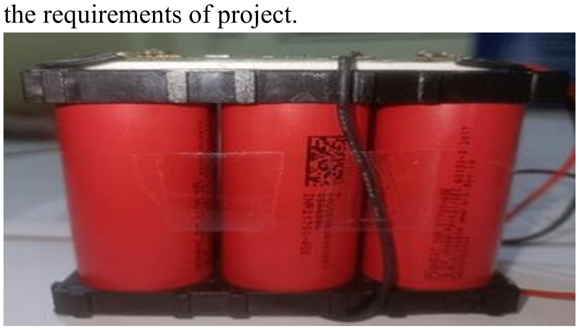

Fig. 4: Lithium-ion battery pack

Table 3: Specifications of Lithium Ion Battery

Nominal capacity (mAh)	4500
Nominal voltage (V)	22.2
Max. charging voltage (V)	25.2
Charging cut-off voltage (V)	19.2
Max. charging current	4.5 A
Nomimal charge current	2.25 A
Max. discharge current (A)	13.5 A
Nominal discharge currrent	4.5 A
Nominal Energy (wh)	111

D) DC geared motor:

These motors drive the boat forward and control its steering by differential speed control. They are connected to the L298N motor driver, which adjusts their speed and direction based on the signals from the ESP32. Another motor drives the conveyor belt mechanism, which is used to collect floating debris and waste from the water and deposit it onto the boat. This geared DC motor provides a stable 30 RPM and is used to operate the conveyor belt mechanism for collecting floating debris from the surface of the river. Two additional DC motors are used for navigation and steering of the boat. Fig. 5 displays the image of the DC geared motor, while Table 4 provides the detailed specifications of the DC motor as per the requirements of this project.

Fig. 5: DC Geared Motor

Table 4: Specification of DC geared motor

Item type	DC geared motor
Gear Type	Plastic
RPM	30
Working Voltage (VDC)	4-12V (12V Recommended and Maximum
Torque(kg-cm)	5 kg-cm
Load Max Current	300mA
No-load Current	60mA

E) pH sensor:

Connected to the ESP32, the pH sensor continuously measures the water quality by assessing the acidity or alkalinity (pH level) of the river water. This data can be transmitted for analysis of water alkalinity to legal authority like Municipal Corporation.

a) Liquid pH value detection sensor:

This sensor is used to measure the pH level of the water, providing real-time data on the acidity or alkalinity of the water body. It is crucial for monitoring pollution levels, as pH is a key indicator of water quality affecting both human and aquatic health. The output of the sensor to the ESP32 is in voltage form. It provides the analog voltage output that corresponds to the pH value of the solution. Fig. 6 displays the image of the pH detection sensor module, while Table 5 provides its detailed specifications.

Fig. 6: pH Detection Sensor Module

Table 5: Specifications of pH Detection Sensor Module

Model type	pH sensor
Detection range	Temperature: 0 to 60º C
Response time (s)	≤5
Power consumption (W)	≤0.5
Operating temperature (ºC)	-10 to 50
Operating humidity	95%RH

b) Electrode probe for liquid pH value detection

This probe works with the pH sensor to provide accurate readings of the water's pH by directly contacting the water and detecting hydrogen ion concentration. It generates an electrical signal that is processed by the sensor, delivering essential data for water quality monitoring within the river cleaning project. Fig. 7 illustrates the electrode probe used for liquid pH detection. Fig. 8 depicts the structure of the pH electrode. Fig. 9 demonstrates the measurement of the water's pH level using the electrode probe. Table 6 presents the nature of liquids at different pH values, while Table 7 provides the detailed specifications of the electrode probe for the pH detection sensor module. In [9], the detailed specifications and working principle of the pH electrode are explained.

Fig. 7: Electrode Probe for Liquid pH Detection Sensor

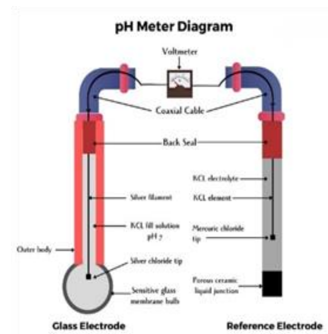

Fig. 8: Structure of pH electrode

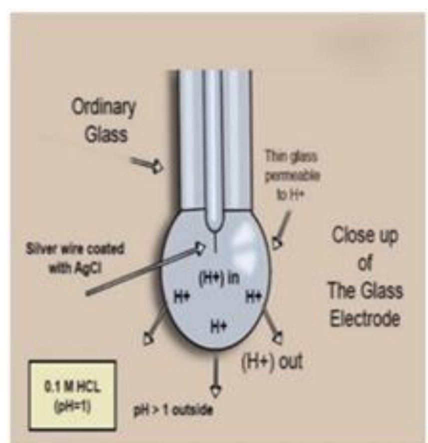

Fig. 9: Measuring of pH level of water from electrode probe

Table 6: Nature of liquid at different pH value

pH value	Nature of liquid (Water)
0-6	Acidic
7	Neutral
8-14	Basic

Table 7: Specifications of Electrode Probe for Liquid pH Value Detection Sensor Module

Model Type	pH Sensor
Range	0-14 pH
Operating Temperature (ºC)	0 to 80
Internal Resistance (Ohm)	≤250 MΩ
Additional Specs	Alkali error: 0.2 pH, Theoretical percentage slope: ≥98.5% , Zero Point: 7±0.5 pH

IV. CIRCUIT DIAGRAM OF RSCB

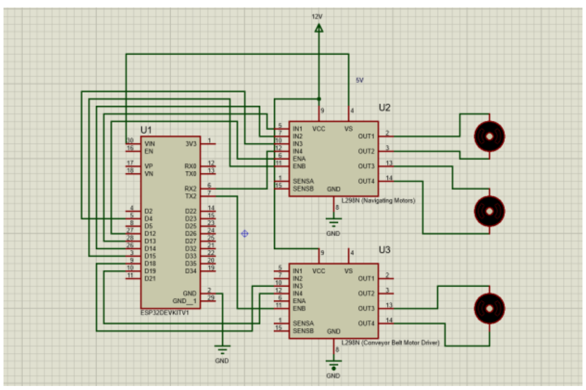

Fig. 10: Circuit diagram of RSCB

Fig. 10 shows the overview of Circuit Diagram of RSCB, illustrates the connection of an ESP32 microcontroller to two L298N motor drivers for controlling multiple DC motors.

4.1) Hardware Implementation:

The hardware implementation of the river surface cleaning boat integrates multiple components to enable autonomous cleaning and monitoring of water surface. At the core of the system is the ESP32 microcontroller, which facilitates wireless control and real-time signal processing. It interfaces with two L298N motor driver modules (U2 and U3) that control three DC motors. Two of these motors are geared motors and are responsible for the boat's navigation via differential steering, while the third motor drives the conveyor belt used to collect floating debris. Each L298N module receives directional and speed control signals from the ESP32 through its IN and EN pins, which are connected to the GPIO and PWM-capable pins of the microcontroller. The power supply for the motors is provided by a lithium-ion battery pack configured in a 6S arrangement, offering a total capacity of 4500mAh at 22.2V. This ensures stable and long-lasting performance during operation. Additionally, a common ground connection is established between the ESP32 and the motor drivers to ensure a shared voltage reference. pH sensor is connected to one of the ESP32's analog pins to monitor pH level of the water. This well-coordinated hardware setup enables the boat to autonomously navigate, collect waste, and monitor the quality of water using its pH value.

4.2) pH Sensor Integration

The circuit diagram does not currently include the pH sensor because of unavailability of pH Sensor Library in Proteus 8.13 software. The pH sensor is connected to an analog input pin on the ESP32. The sensor outputs a voltage that corresponds to the pH level of the river water. The ESP32 reads this analog value and converts it to a pH reading using a calibration formula. This reading is then transmitted wirelessly to a monitoring interface. This setup allows real-time water quality assessment, enabling authorities to take timely action when abnormal pH levels are detected.

V. METHODOLOGY

5.1) Overview

This project provides a comprehensive overview of the technical specifications and design considerations for the RSCB project. The boat is engineered to operate using a 22.2V, 4500mAh (4.5Ah) battery and is designed to manage a total load of 4 kg, which includes the boat structure, debris, and waste collected from the river surface. The propulsion system consists of two DC motors with propellers, an additional DC motor powers a conveyor belt designed to collect debris, and a pH sensor is integrated to monitor water quality. This report details motor selection, power consumption calculations, battery life estimation, charging time analysis, sensor integration, and recommended boat dimensions to ensure optimal performance, stability, and efficiency.

5.2) Motor Selection

a) System Overview

The River Surface Cleaning Boat utilizes a dual-propeller propulsion system combined with a

conveyor belt mechanism for debris collection. Additionally, a pH sensor is incorporated to monitor the water's acidity levels. This configuration necessitates selecting appropriate motors that can efficiently handle both propulsion and debris collection tasks while operating within the constraints of a 22.2V battery system.
Specifications of RSCB:

- Total Load: 4 kg (includes boat, debris, and waste)
- Propulsion: 2 DC motors with propellers (each with a 3.5 cm radius)
- Debris Collection: 1 DC motor for the conveyor belt
- Sensor Integration: 1 pH sensor for water quality monitoring
- Battery: 22.2V, 4500mAh (4.5Ah)

b) Propulsion System Specifications

Load and Torque Requirement:
To determine the propulsion motor specification, the design parameters are specified below:

- Total load (W):
- Boat with Debris and Waste: 4kg
- Force (F)

$$F = m.g = 4\text{kg} \times 9.81 \text{ m/s}^2 = 39.24 \text{ N}$$

Where, m is mass and g is gravitational acceleration.

- Torque (T) (per propulsion motor):

$$T = \frac{F \cdot r}{\text{Number of Motors}} = \frac{39.24 \text{ N} \cdot 0.035 \text{ m}}{2} = 0.687 \text{ Nm per motor}$$

Where, r is radius of propellor

Speed Requirement:
To boat needs to travel at 0.1 m/s. To achieve this speed, the required propeller RPM was calculated:

- Linear speed (v):

$$v = 0.1 \text{ m/s}$$

- Propeller radius (r):

$$\text{r} = 0.035 \text{ m}$$

- RPM (N):

$$N = \frac{v \cdot 60}{2\pi r} = \frac{0.1 \times 60}{2 \times 3.1416 \times 0.035} \approx 27.37 \text{ RPM}$$

Target RPM per Propulsion Motor: 27-30 RPM.
Power Requirement:
The Mechanical Power required from each propulsion motor is calculated as follows:

- Angular velocity (ω):

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 27.37}{60} \approx 2.87 \text{ rad/s}$$

- Power (P):

$$P = T.\omega = 0.687 \text{ Nm} \times 2.87 \text{ rad/s} \approx 1.97 \text{ W per motor}$$

Total power for propulsion:

$$1.97 \text{ W} \times 2 = 3.94 \text{ W}$$

c) Conveyor Belt Motor Selection:
The conveyor belt mechanism is responsible for collecting debris from the river surface. The motor selected for this task must provide sufficient torque to drive the belt at an optimal speed for efficient debris collection.

Load and torque requirements:
Assuming the conveyor belt needs to move debris at a moderate speed without excessive load, below are the estimation for the torque and power requirements.

- Assumed conveyor load (Lc): 1kg (additional debris)

- Force (Fc):

$$Fc = Lc \cdot g = 1 \text{ kg} \times 9.81 \text{ m/s}^2 = 9.81 \text{ N}$$

- Conveyor belt radius (rc): Assume a pulley radius of 2 cm (0.02 m)
- Torque (Tc):

$Tc = Fc \cdot rc = 9.81\ \text{N} \times 0.02\ \text{m} = 0.196\ \text{Nm}$

Speed Requirement:

Assume the conveyor belt needs to move at 0.5 m/s to efficiently collect debris.

- Linear speed (vc):

$vc = 0.05\ \text{m/s}$

- Pulley RPM (Nc):

$$Nc = \frac{vc \times 60}{2\pi rc} = \frac{0.05 \times 60}{2 \times 3.1416 \times 0.02} \approx 23.87\ \text{RPM}$$

Target RPM for conveyor motor: 24 RPM.

Power requirement:

- Angular velocity (ω_c):

$$\omega_c = \frac{2\pi Nc}{60} = \frac{2\pi \times 23.87}{60} \approx 2.5\ \text{rad/s}$$

- Power (Pc):

$$Pc = Tc \cdot \omega_c = 0.196\ \text{Nm} \times 2.5\ \text{rad/s} \approx 0.49\text{W}$$

Total power for conveyor: 0.5 W

d) pH Sensor integration

To monitor the water quality, a pH sensor is integrated into the boat's system. This addition requires careful consideration of the sensor's specifications, power consumption, and integration into the existing electrical system.

pH Sensor Specification:

- Sensor Type: Analog Sensor
- Operating Voltage: Typically 5V-12V
- Output: Analog voltage corresponding to pH level
- Power Consumption: Approximately 0.05 A (50 mA) during operation
- Dimensions: Compact, suitable for mounting on the hull or extending into the water.

Power Requirements:

The pH sensor adds approximately 0.05 A to the total current consumption.

e) Battery life estimation

Total current consumption:

Table 8 shows the total current consumption by the components of RSCB.

Table 8: Total current consumption by the components of RSCB

Components	Current
ESP32	0.24 A
2 x L298N motor driver	0.36 A
Propulsion motors (2)	0.60 A
Conveyor belt motor	0.33 A
pH sensor	0.05 A
Total Current	1.58 A

Battery capacity:

- Battery rating: 22.2V, 4500mah = 4.5Ah.
- Since the motor drivers are using the full 22.2V battery voltage, the calculation will be based on the current drawn at that voltage.

Battery life estimation:

To calculate the battery life, use the formula:

$$\text{Battery Life (hours)} = \frac{\text{Battery Capacity (Ah)}}{\text{Total Current Consumption (A)}}$$

$$\text{Battery Life} = \frac{4.5\ \text{Ah}}{1.58\ \text{A}} \approx 3\ \text{hours}$$

Estimated battery life: 3 hours of Continuous operation before the battery is depleted.

Charging Time:

Assuming a typical lithium-ion battery charger with a charging current of 1A:

- $\text{Charging Time} = \frac{\text{Battery Capacity}}{\text{Charging Current}}$

- $\text{Charging Time} = \frac{4500\ \text{mAh}}{1000\ \text{mA}} = 4.5\ \text{hours}$

Summary:

- Battery Life: ~3 hours of continuous operation
- Charging Time**:** ~4.5 hours with a standard 1A charger

VI. RESULTS

6.1) OUTCOMES

Fig. 11 shows the side view of RSCB. Fig. 12 shows the top view of RSCB. Fig. 13 shows interface of boat control using smartphone

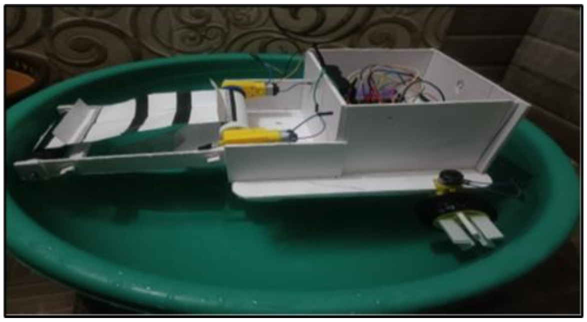

Fig. 11: Side view of RSCB

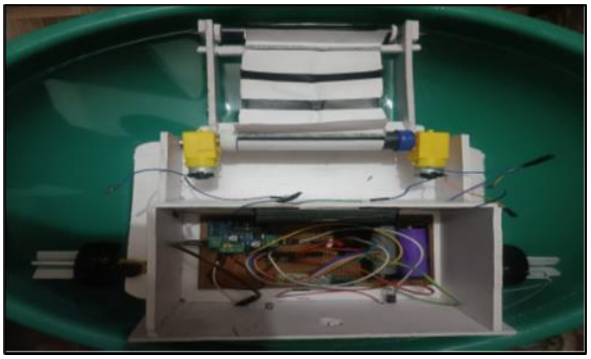

Fig. 12: Top view of RSCB

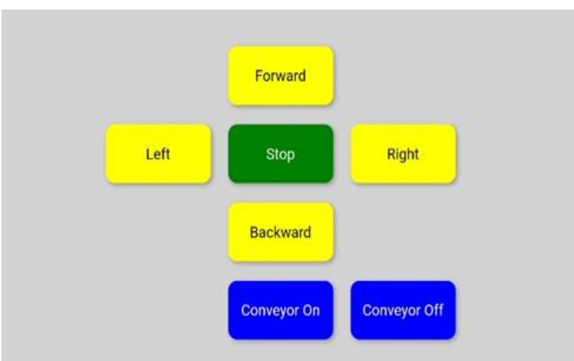

Fig. 13: Boat Control Interface

6.2) ADVANTAGES

1) Energy-Efficient Operation

The system uses low-power DC motors and a lithium-ion battery with optimized power consumption, ensuring up to 2.5 hours of continuous operation per charge (based on calculated load and battery capacity). This extended runtime enables effective waste collection over a larger water surface area without frequent recharging. Additionally, the ESP32 microcontroller allows for wireless control and PWM-based motor management, which helps reduce unnecessary energy usage by adjusting motor speed based on movement needs.

2) Cost-Effectiveness

Entry of the boat into water bodies is facilitated by a simple, lightweight design using readily available components such as conveyor belts, plastic-geared DC motors, and L298N motor drivers. This not only simplifies production but also ensures affordability and ease of maintenance. The system minimizes labour costs by enabling semi-autonomous cleaning without requiring a large workforce or complex infrastructure. Its modular structure supports easy scalability and adaptation to different environments, reducing the need for multiple versions of the same system.

6.3) FUTURE SCOPE

1. Advanced Sensor Integration**:** The boat could be equipped with more advanced sensors to detect various types of pollutants. For example, sensors could be added to measure chemical pollutants or harmful bacteria levels in the water.

2. Solar Power: To increase the sustainability of the project, the boat could be powered by solar energy. Using the solar energy the boat can be use for more period of time.

VII. CONCLUSION

This project demonstrates a practical and efficient solution for monitoring and cleaning water bodies using a remote-controlled river surface cleaning boat. Compared to traditional manual methods, which are labor-intensive, costly, and time-consuming, this system minimizes human intervention and enhances operational efficiency.

Overall, our RSCB project offers an optimized, energy-efficient, and cost-effective alternative to conventional and previously proposed river cleaning solutions. By integrating wireless control, battery efficiency, and automation, this project not only enhances cleaning operations but also supports sustainable environmental management with reduced human intervention.

REFERENCES

[1] A. Sujatha Reddy, T. Gayathri, Ch. Sharanya, and O. Hanisha, "River surface cleaning water boat," International Journal of Creative Research Thoughts (IJCRT), vol. 11, no. 5, pp. c300, 2023.Reference: https://ijcrt.org/papers/IJCRT2305299.pdf

[2] Sankar Naicker, Harsh, et al. "Water Care: Water Surface Cleaning Bot and Water Body Surveillance System." arXiv e-prints (2021): arXiv-2111. Reference: https://arxiv.org/pdf/2111.12579

[3] Kandare, Dharmesh N., et al. "Design & construction of river cleaning mechanism." International Journal of Innovative Science and Research Technology 3.11 (2018): 428-432. Reference: https://ijisrt.com/wp-content/uploads/2018/12/IJISRT18NV07.pdf

[4] Bian, Huai-Qiang, et al. "A propulsion mechanism of cleaning boat applied for non-structural environments." International Journal of Research in Engineering and Science 3.1 (2015): 40-47. Reference: https://www.academia.edu/10257710/A_Propulsion_Mechanism_of_Cleaning_Boat_Applied_For_Non_Structural_Environments

[5] Sharma, Tanmay, and Ashwini Joshi. "Design of River Cleaning Machine." Ashwini, Design of River Cleaning Machine (June 8, 2020) (2020). Reference: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3621962

[6] Chandurkar, Kalyani, and Dr Narendra Bawane ParinayLavatre. "An Improved River Cleaning System." Annals of the Romanian Society for Cell Biology (2020): 333-339.Reference: https://ijcrt.org/papers/IJCRT2106229.pdf

[7] Datasheet for ESP32 development board. Reference: https://www.espressif.com/sites/default/files/documentation/esp32_datasheet_en.pdf

[8] Datasheet for L298N motor driver. Reference: https://www.st.com/resource/en/datasheet/l298.pdf

[9] Datasheet for pH electrode. Reference: https://www.supmeaauto.com/uploads/2101/ph-sensor-datasheet.pdf