Solar Power RC Lake Pool Cleaner Robot

Mr. Vivek Maruti Gaikwad[1], Mr. Sarvesh Vyankatesh Kulkarni[2], Dr. M.S. Chavan[3]

[123]Departmrnt of Electronics and Telecommunication Engineering
Padmabhooshan Vasantraodada Patil Institute of Technology, Maharashtra, India.
Guide: Dr. M.S.Chavan.

---***---

Abstract - Water pollution caused by floating debris is a major concern for lakes, ponds, reservoirs, and recreational water bodies worldwide. Manual cleaning methods are time-consuming, costly, and often expose workers to hazardous conditions.

This paper presents the design and implementation of a Solar Power RC Lake Pool Cleaner Robot — a remotely operated aquatic robot that collects floating waste from water surfaces using renewable solar energy. The system is built around the ESP8266 NodeMCU Wi-Fi microcontroller, an ESP32-CAM module for live video monitoring, a motor driver (L298N), two DC motors with propellers for water navigation, an IR sensor for waste-level detection, a conveyor belt mechanism for automated waste collection, and a 12V rechargeable battery charged by a solar panel through a charge controller.

The operator controls the robot wirelessly via a mobile-based interface. Experimental results demonstrate reliable navigation, real-time monitoring, and effective waste collection, confirming the system as a practical, eco-friendly, and low-cost solution for maintaining clean water bodies.

Key Words: Solar Energy, ESP8266 NodeMCU, ESP32-CAM, Water Surface Cleaning, RC Robot, Floating Waste Collection, IR Sensor, Conveyor Belt, Wi-Fi Remote Control, Embedded Systems.

1. INTRODUCTION

Water bodies such as lakes, ponds, swimming pools, and reservoirs play a vital role in sustaining ecosystems, supporting aquatic life, and providing recreational and domestic water resources. However, rapid urbanisation and inadequate waste management have led to significant accumulation of floating debris — including plastic bottles, wrappers, dry leaves, algae mats, and organic waste — on water surfaces. If left unaddressed, this waste degrades water quality, generates foul odour, disrupts aquatic biodiversity, and increases the cost of conventional water treatment.

Traditional cleaning approaches depend heavily on manual labour or fuel-powered boats, both of which are expensive, environmentally harmful, and potentially dangerous for workers operating in polluted or deep-water environments. There is therefore a clear need for an intelligent, autonomous-capable, energy-efficient solution that reduces human involvement while improving cleaning effectiveness.

This work proposes a Solar Power RC Lake Pool Cleaner Robot that integrates renewable energy technology, embedded control systems, wireless communication, real-time camera monitoring, and a mechanical waste collection mechanism into a single floating platform. The robot is remotely operated by the user through a Wi-Fi-based mobile application and can navigate across water surfaces to collect floating debris using a conveyor belt mechanism. Solar energy harvested by an onboard panel powers all electronics via a rechargeable battery, making the system self-sustaining during daylight operation.

2. PROBLEM STATEMENT

Floating waste in open water bodies poses serious environmental, aesthetic, and public health risks. Despite the clear need for regular cleaning, current solutions remain dependent on either manual labour or expensive fuel-powered equipment. Manual methods are unsafe in deep or heavily polluted water, while diesel-powered boats are too costly for most community or institutional budgets. Neither provides real-time visibility of the cleaning operation, and neither includes automatic detection of when a waste collection container is full.

There is a practical need for a remotely operated, solar-powered robotic platform that can skim floating waste from water surfaces without direct human involvement, provide the operator with live visual feedback, automatically detect tray fill levels, and be built from affordable, widely available components. This project sets out to fill that gap.

3. OBJECTIVES

The primary goal of this project is to develop a working solar-powered robotic water surface cleaner that is remote-controlled, affordable, and suitable for real-world deployment. The specific objectives are as follows:

- To design and build a buoyant floating robotic platform capable of navigating open water surfaces using DC motor-driven propellers.
- To implement Wi-Fi-based wireless control using an ESP8266 NodeMCU microcontroller and the Blynk IoT mobile application.

- To integrate a motorized conveyor belt mechanism that automatically scoops floating debris from the water surface into an onboard collection tray.
- To incorporate an IR sensor that detects when the collection tray is filled and notifies the operator.
- To embed an ESP32-CAM module for live video streaming, enabling the operator to navigate the robot visually and monitor the cleaning process in real time.
- To power all onboard systems through a 12V solar panel and rechargeable battery with charge controller, making the system energy self-sufficient during daylight hours.
- To evaluate system performance in a controlled pool environment covering navigation accuracy, waste collection effectiveness, sensor response, video streaming quality, and battery endurance.
- To produce a low-cost, replicable solution suitable for lakes, ponds, swimming pools, fish ponds, and reservoirs.

4. LITERATURE SURVEY

Automated water surface cleaning has attracted consistent research attention over the past several years, and a number of groups have built and tested working prototypes that informed the design decisions in this project.
Taken together, these studies establish the technical feasibility of solar-powered robotic water cleaners. They also reveal three consistent gaps: most existing systems provide no real-time visual feedback to the operator; few include any automated sensing of collection tray fill levels; and conveyor-based collection is not yet universally adopted despite its demonstrated effectiveness. The system described in this paper directly addresses all three of these shortcomings.

4.1. Comparative Analysis of Previous Research :

Author/ Year	Main Focus	Short Description
Aravind et al. (2021)	Solar + Wi-Fi skimmer	ESP8266-based solar robot with remote control for surface waste removal.
Thomas & Aswathi (2023)	Arduino solar cleaner	Renewable-energy-powered cleaning robot on Arduino platform
Srajan et al. (2025)	Autonomous solar robot	Conveyor + ultrasonic + GPS + ESP32 for real-environment operation
Sahana Kumari et al. (2021)	Low-cost aqua robot	Arduino UNO with basic mechanical collector; affordable and simple
Mankape et al. (2025)	RC solar waste collector	Conveyor + DC motors for lakes, ponds, and reservoirs

5. PROPOSED SYSTEM

The proposed system is a Solar Power RC Lake Pool Cleaner Robot — a remotely operated aquatic robot designed to skim and collect floating debris from water surfaces using solar energy as its sole power source. The robot consists of a waterproof buoyant chassis housing all electronics, two DC motor-driven propellers for navigation, a front-mounted motorised conveyor belt for debris scooping, and an onboard collection tray.
The operator controls the robot's direction — forward, backward, left, right, or stop — through the Blynk IoT mobile application over Wi-Fi. An ESP32-CAM module streams live video from the robot to the operator's smartphone, giving real-time visual access to the water surface ahead of the robot and allowing precise navigation toward waste concentrations. An IR sensor monitors the waste level inside the collection tray and signals the operator when the tray needs emptying.
On the power side, a 20W, 12V solar panel mounted on the top surface of the chassis feeds a solar charge controller, which regulates voltage and current into a 12V/7Ah sealed lead-acid battery. This battery powers all electronics and motors throughout the operation. The system requires no grid connection and can operate continuously during daylight as long as sunlight is available.

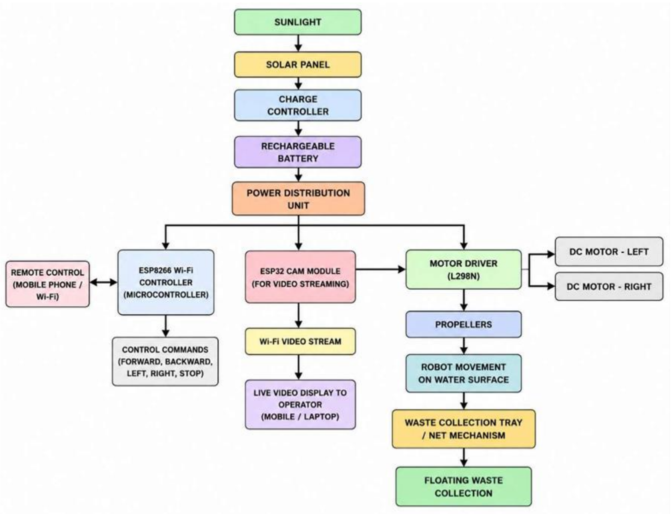


Fig.1. Solar Power RC Lake Pool Cleaner Robot

6.METHODOLOGIES

The development process followed a structured, phase-based approach from problem identification through field testing.
The methodology for this project was developed with the objective of creating an efficient and sustainable solution for cleaning floating waste from water bodies. The system combines solar power, wireless control, live video monitoring, and an automated waste collection mechanism to perform the cleaning operation effectively. The overall functioning of the proposed system is explained through the following phases. The complete working process of the system is described below.

1: System Initialization
When sunlight falls on the solar panel, the charge controller begins transferring energy into the 12V battery. Once the main switch is turned on, the ESP8266 NodeMCU boots up and connects to the designated Wi-Fi network. The operator launches the Blynk IoT mobile application and establishes communication with the robot.

2: Remote Navigation
The operator uses the directional buttons in the Blynk application to send movement commands over Wi-Fi. The ESP8266 receives these commands and drives the L298N motor driver, which activates the left and right DC motors accordingly — producing forward, reverse, left-turn, right-turn, or stop motion.

3: Live Video Monitoring
Simultaneously with navigation, the ESP32-CAM module streams live MJPEG video to the operator's mobile device over Wi-Fi. The operator watches this feed to identify waste concentrations on the water surface and steer the robot toward them accurately.

4: Waste Collection
As the robot moves forward across the water surface, the rotating conveyor belt at the front lifts floating debris out of the water and deposits it into the onboard collection tray. The belt operates continuously whenever the robot is powered on.

5: Tray-Level Detection
The IR sensor inside the collection tray continuously monitors the fill level. When accumulated waste reaches the detection threshold, the sensor output changes state and the operator is notified to steer the robot back to the bank for manual tray emptying.

6: Continuous Operation
After the tray is emptied, the robot returns to the water and the cleaning cycle continues. Solar charging replenishes the battery throughout the day, enabling extended operation without grid intervention.

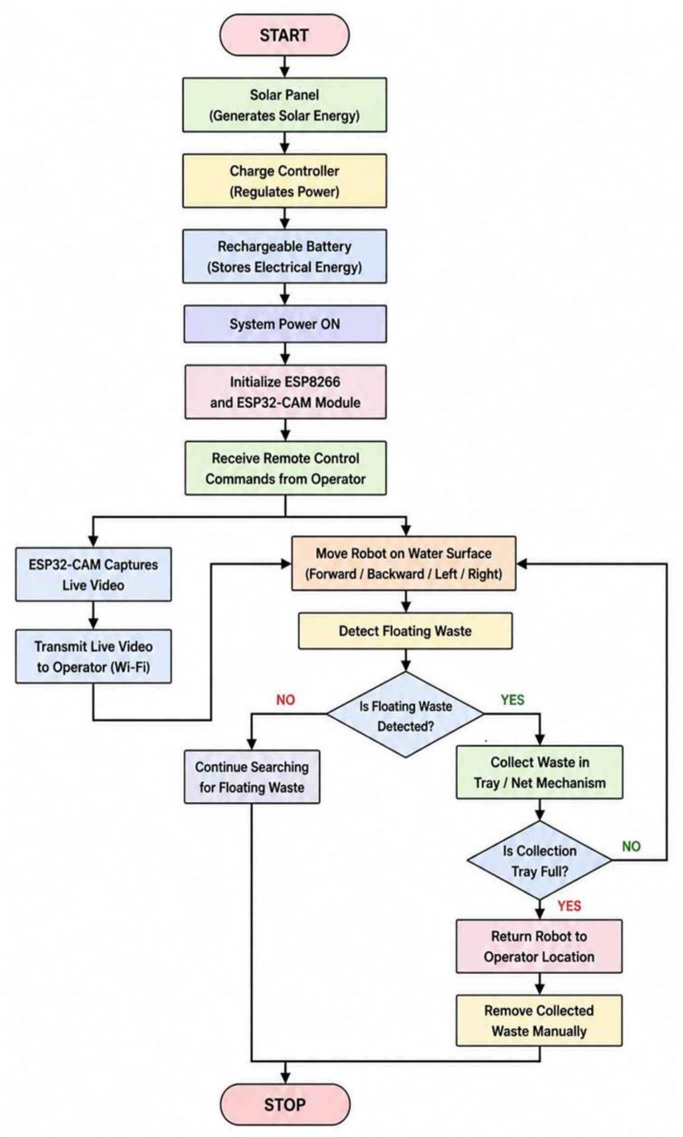


Fig.2. System Flowchart

7.Hardware Design:

The hardware design centres on the ESP8266 NodeMCU as the main control unit, supported by the ESP32-CAM, L298N motor driver, DC motors, solar charging circuit, IR sensor, and conveyor belt motor — all mounted on a waterproof floating chassis.

1. ESP8266 NodeMCU
The ESP8266 NodeMCU serves as the central controller of the robot. It connects to the Wi-Fi network, receives directional commands from the Blynk application, processes IR sensor data, and drives the L298N motor driver through its GPIO pins (D1–D4 connected to IN1–IN4 respectively).

2. ESP32-CAM Module
The ESP32-CAM is programmed separately to host a web server that delivers a live MJPEG video stream over Wi-Fi. It is mounted at the front of the robot to capture the water surface directly ahead, giving the operator first-person visual guidance.

3. L298N Motor Driver
The L298N dual H-bridge motor driver receives control signals from the ESP8266 GPIO pins and drives the two 12V DC motors. OUT1/OUT2 drives the left motor; OUT3/OUT4 drives the right motor. It can handle the 12V supply directly from the battery.

4. DC Motors and Propellers
Two 12V DC motors are coupled with plastic water-type propellers to generate thrust and steer the robot across the water surface. Differential motor speed and direction produce all required movements.

5. Solar Panel and Charge Controller
A 20W, 12V solar panel is mounted flat on top of the chassis. Its output feeds a 12V solar charge controller, which protects the battery from overcharging and over-discharging. The controller's load output connects to the battery positive rail.

6. Battery
A 12V/7Ah sealed rechargeable battery provides energy storage. It powers the L298N motor driver directly at 12V and, through a 5V step-down voltage regulator, supplies the ESP8266 and ESP32-CAM.

7. IR Sensor
A digital infrared sensor is positioned inside the collection tray. When floating waste accumulates to the sensor's detection level, it outputs a HIGH signal to an ESP8266 GPIO input, triggering the full-tray notification.

8. Conveyor Belt Mechanism
A small DC motor drives a continuous belt positioned at the front edge of the robot. As the robot moves forward, the belt lifts floating debris from the water surface and transfers it into the collection tray behind it. The conveyor motor is controlled through the motor driver or a relay module.

9. Floating Chassis
The chassis is constructed from a waterproof, buoyant material with sufficient displaced volume to keep all electronics, the battery, and a loaded waste tray afloat with adequate freeboard.

Working of Hardware Circuit:
The 18V/20W solar panel feeds power into the U1 Solar Charge Controller, which regulates and stores energy into the 12V/7Ah rechargeable battery. Once SW1 is turned on,

the battery distributes +12V to the L298N motor driver, +5V to the ESP32-CAM, and +3.3V to the ESP8266 NodeMCU across the circuit.

The ESP8266 receives wireless commands from the operator's smartphone via Wi-Fi and sends control signals through GPIO12–GPIO15 to the IN1–IN4 pins of the L298N motor driver, which then drives the left motor (M1) and right motor (M2) for navigation. At the same time, the ESP32-CAM streams live video to the operator's device through its serial connection with the ESP8266, enabling real-time visual monitoring during operation.

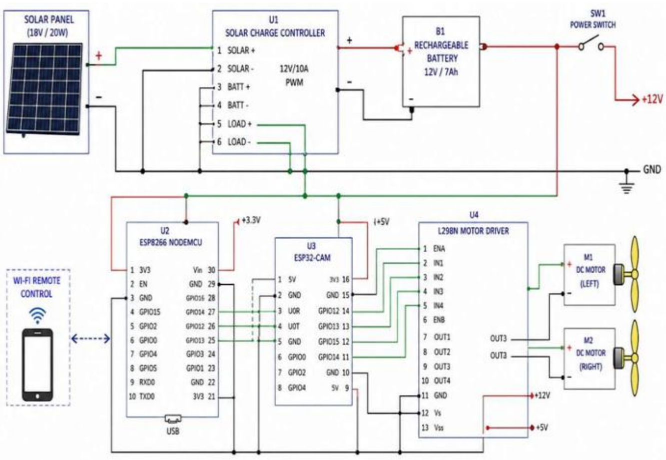


Fig. 3. Schematic of Solar Power RC Lake Pool Cleaner Robot.

8. SYSTEM ARCHITECTURE

The system architecture is divided into three main layers: the power subsystem, the control and communication subsystem, and the mechanical subsystem.

The power subsystem begins with the solar panel, which converts sunlight into electrical energy. This energy passes through the charge controller into the 12V battery. The battery feeds the L298N motor driver directly at 12V and supplies 5V to the ESP8266 and ESP32-CAM through a step-down regulator.

The control and communication subsystem is built around the ESP8266, which maintains a Wi-Fi connection and communicates with the Blynk IoT application on the operator's smartphone. Commands received from the app are translated into motor driver control signals. The ESP8266 also reads the IR sensor to monitor tray fill status. The ESP32-CAM operates independently on the same Wi-Fi network, continuously streaming video to the operator's device.

The mechanical subsystem comprises the two DC motors with propellers that propel and steer the robot, and the conveyor belt motor that drives debris collection. All motors are interfaced through the L298N or a relay module.

These three subsystems work in parallel during operation. The power subsystem sustains the electronics; the control subsystem steers the robot and monitors the tray; the mechanical subsystem performs the actual cleaning work. Together, they form a cohesive, self-sustaining water surface cleaning platform.

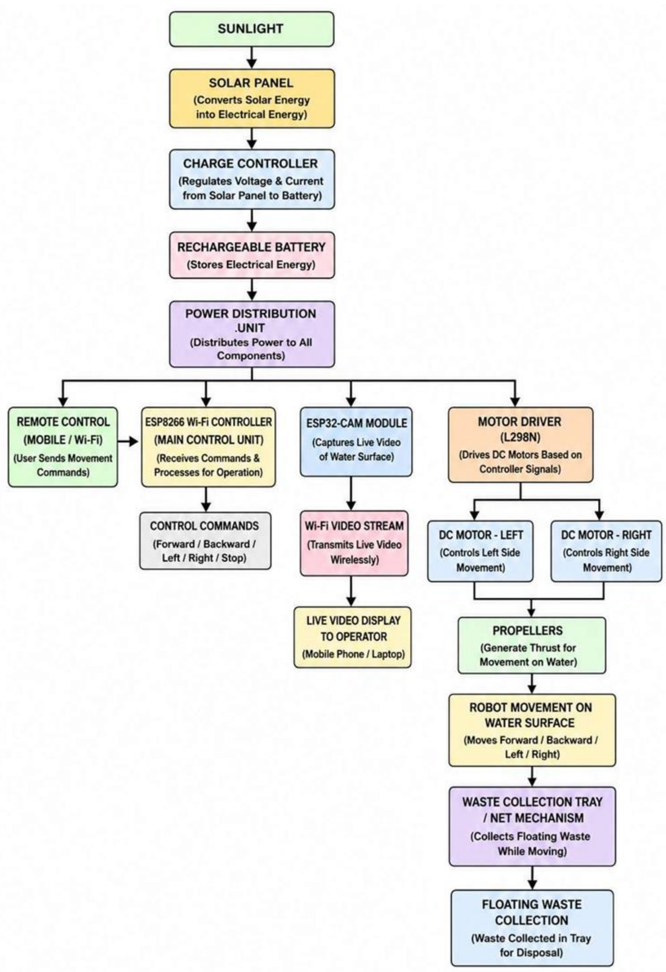


Fig. 4. System Architecture

9. IMPLEMENTATION

All hardware components were mounted on a waterproof floating chassis, with the solar panel fixed flat on top and its output wires connected to the charge controller, which feeds the 12V/7Ah battery. The battery supplies +12V directly to the L298N motor driver and +5V through a step-down regulator to both the ESP8266 and ESP32-CAM. GPIO pins D1–D4 of the ESP8266 were wired to IN1–IN4 of the L298N, driving the left motor via OUT1/OUT2 and the right motor via OUT3/OUT4. The IR sensor output was connected to an ESP8266 GPIO input, and the conveyor belt motor was interfaced through a relay module.

The firmware for the ESP8266 was developed in Embedded C/C++ using Arduino IDE, which initialises the

Wi-Fi connection, links with the Blynk cloud, and handles directional commands by setting appropriate IN1–IN4 logic levels on the motor driver. A dedicated callback function continuously reads the IR sensor and pushes a tray-full notification to the Blynk application when triggered. The ESP32-CAM was programmed separately to run an HTTP web server that captures and serves live JPEG frames as a continuous MJPEG stream, which the operator monitors directly on their smartphone for real-time visual navigation.

Once the complete system was assembled and programmed, a series of functional checks were carried out before water deployment. Each motor direction, the IR sensor response, the camera stream, and the Blynk control buttons were individually verified on the bench. Only after confirming that every subsystem responded correctly was the robot placed on the water surface for actual field testing in the pool environment.

9.1. Hardware Model Implementation:

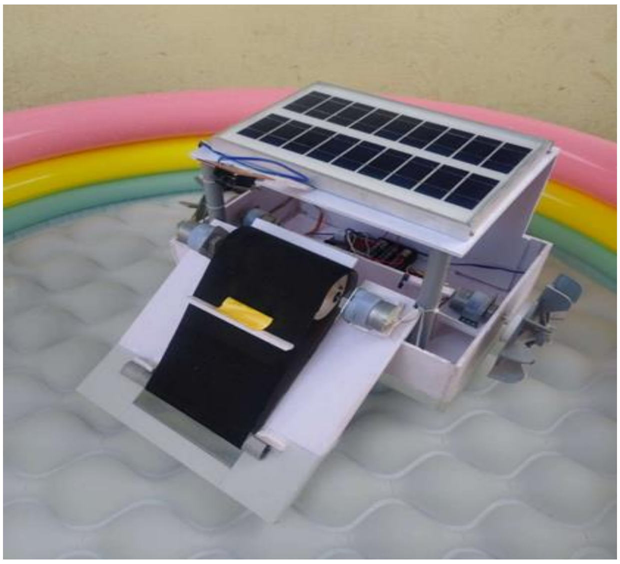


Fig.5. Hardware Model

Fig.6. Hardware Model

9.2. IOT Platform Interface:

Fig.7. IOT Platform Interface

10. Result

The Solar Power RC Lake Pool Cleaner Robot was successfully assembled and tested across multiple trial sessions in a pool environment under natural daylight. The robot responded promptly and accurately to all directional commands — forward, backward, left turn, right turn, and stop — issued through the Blynk mobile application

During active water surface operation, the rotating conveyor belt consistently lifted floating plastic wrappers and lightweight debris from the water and deposited them cleanly into the onboard collection tray. No significant material was missed or pushed aside by the belt across all trials, confirming that the conveyor speed and positioning were well matched to typical surface-floating waste encountered in real water body conditions.

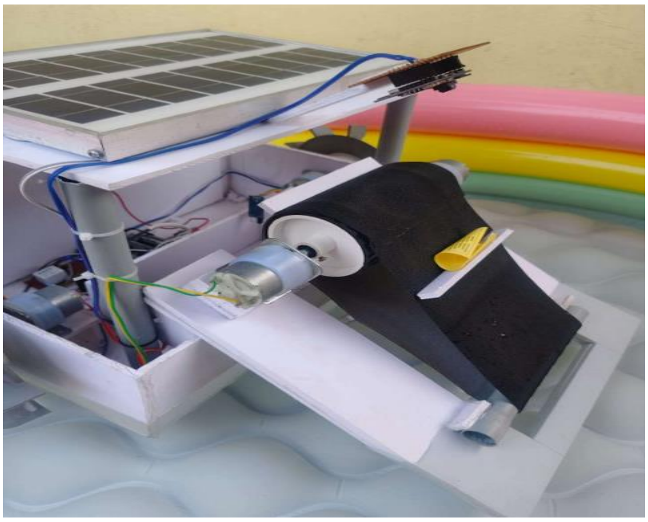
The IR sensor performed reliably throughout all test cycles. When the collection tray was empty, the sensor output held LOW, indicating the system was ready for operation. Once waste accumulated to the detection threshold, the sensor immediately switched to HIGH and the operator received a tray-full notification through the Blynk application, allowing timely retrieval of the robot for manual unloading without any overflow occurring.

The ESP32-CAM delivered a stable and clear live video stream to the operator's smartphone throughout the Wi-Fi coverage area of the test environment. The footage gave the operator a direct view of the water surface ahead, making it straightforward to navigate toward waste concentrations and observe the collection process in real time. Solar charging functioned correctly under direct sunlight, with the charge controller maintaining steady battery voltage throughout all short-duration test sessions, confirming the energy system was reliable for daylight operation.

10.1. When tray is empty:

10.2. When tray is full of waste:

10.3. Collecting the waste:



10.4. ESP 32 camera module working:

11. CONCLUSION:

The Solar Power RC Lake Pool Cleaner Robot was successfully designed, built, and tested as a practical solution to the problem of floating waste in open water bodies. The system integrates solar energy harvesting, ESP8266-based Wi-Fi remote control, ESP32-CAM live video monitoring, motorised conveyor belt waste collection, and IR-based tray fill detection into a single buoyant platform that requires no fuel, no grid connection, and no operator presence on the water.

Pool-based trials demonstrated that the robot navigates accurately under remote command, collects floating surface debris reliably via the conveyor mechanism, detects tray fill status correctly through the IR sensor, and streams live video stably to the operator's mobile device — all while the solar panel sustained the battery charge during daylight operation.

The project confirms that embedded systems engineering, paired with renewable energy and wireless communication technology, can generate meaningful environmental benefit at a component cost accessible to educational institutions, NGOs, and local municipalities. The system is equally applicable to lakes, ponds, swimming pools, fish ponds, and reservoirs. With planned enhancements — including autonomous GPS-guided navigation, AI-based waste detection using the camera feed, IoT cloud monitoring, and water quality sensing — the platform holds genuine potential for scaled deployment in real-world environmental protection programmes.

12. REFERENCES:

[1] Dr. P. Aravind, et al., "Solar Power Water Skimming Robot with Remote Control," International Journal of Innovative Research in Electrical, Electronics,

Instrumentation and Control Engineering (IJIREEICE), 2021.

[2] Simi P. Thomas and Aswathi T., "Solar Power Water Body Cleaning Robot," International Journal of Engineering Research & Technology (IJERT), 2023.

[3] Srajan, et al., "Autonomous and Solar-Power Surface Water Waste Cleaning Robot," International Journal for Research in Applied Science & Engineering Technology (IJRASET), 2025.

[4] Sahana Kumari S., et al., "Development of Aqua Robot for Floating Collection in Water Body," International Journal of Engineering Research & Technology (IJERT), 2021.

[5] Vaishnavi Mankape, et al., "Remote Control Solar Power Water Surface Waste Collector," International Journal of Innovative Science and Research Technology (IJISRT), 2025.

[6] K. Ramesh, et al., "IoT Based Smart Water Cleaning Robot," International Journal of Advanced Research in Science and Engineering, 2022.

[7] M. Pradeep Kumar, et al., "Automatic Water Surface Cleaning Bot using Embedded Systems," International Journal of Scientific Research in Engineering and Management, 2021.

[8] A. Sharma, et al., "Smart Lake Cleaning Robot Using Embedded System Technology," International Journal of Emerging Technologies and Innovative Research, 2023.