Remote Control Solar Powered Water Surface Waste Collector

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Abstract: [1] The increasing pollution of aquatic environments due to floating solid waste has emerged as a critical environmental issue, demanding efficient and sustainable cleaning solutions. Traditional manual and mechanical methods are limited in efficiency, coverage, and scalability. [2] This project introduces a remote-controlled solar-powered water surface waste, designed to autonomously clean and restore water surfaces using renewable energy. The system utilises solar panels as its primary energy source, ensuring continuous operation with minimal environmental impact. [3] A mechanical collection mechanism equipped with a conveyor assembly effectively gathers floating debris and surface.[4] Remote-control functionality enhances safety and operational flexibility, allowing real-time manoeuvring in polluted or inaccessible zones. [5] The entire design focuses on cost-effectiveness, portability, and energy efficiency, making it suitable for applications in lakes, ponds, reservoirs, and small water treatment facilities. [6] Experimental evaluation confirms that the system efficiently removes waste and oil contaminants under varying water conditions, demonstrating its reliability and sustainability. [7] The proposed model provides a practical and eco-friendly approach to surface water purification, contributing toward cleaner aquatic ecosystems and promoting the integration of renewable energy in environmental conservation technologies.

Keywords: *Solar-Powered Robot, Water Surface Cleaning, Oil Spill Recovery, Floating Waste Removal, Remote Control (RC), Renewable Energy, Autonomous Navigation, IoT Integration.*

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I. INTRODUCTION

The increasing contamination of aquatic environments caused by floating solid waste has become a serious global concern. Plastic bottles, leaves, and other surface debris not only degrade water quality but also disrupt aquatic ecosystems and reduce the usability of water resources for domestic and agricultural purposes. Traditional cleaning methods are mostly manual, labor-intensive, and time-consuming, often relying on non-renewable energy sources. Such approaches are inefficient for large water bodies and pose health risks to human operators. With the advancement of sustainable technologies, solar-powered aquatic robots have emerged as an effective solution for surface waste collection. These systems use photovoltaic panels to generate power, enabling continuous operation without dependence on conventional electricity. Several researchers have developed solar-based cleaning platforms capable of autonomous or remote-controlled movement across water surfaces. These systems demonstrate enhanced cleaning efficiency, reduced maintenance, and minimal environmental impact. Furthermore, integrating microcontrollers and wireless communication technologies such as Arduino and IoT has improved the intelligence and functionality of such systems. Real-time monitoring, remote control, and adaptive navigation enhance performance, making them suitable for dynamic and polluted water environments. This project presents a remote-controlled solar-powered water surface waste collector designed to efficiently remove floating debris while utilizing renewable energy. The system employs a solar panel for power generation, a mechanical conveyor mechanism for waste collection, and a remote-control interface for flexible operation. The proposed design offers a cost-effective, eco-friendly, and portable approach to maintaining clean and healthy water surfaces, contributing to environmental sustainability and resource conservation.

II. LITERATURE SURVEY

In recent years, water pollution due to floating waste has become one of the major environmental challenges around the world. Materials like plastic bottles, leaves, wrappers, and other floating debris reduce the quality of water and harm aquatic life. Manual cleaning of such waste is difficult, time-

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consuming, and requires human effort in unsafe conditions. To overcome these problems, researchers have developed automated and eco-friendly systems that can clean water surfaces using renewable energy sources such as solar power. The use of solar energy helps reduce operational costs, avoids fuel dependency, and supports sustainable development.

Goodarzi, Jazayeri, and Fateri (2014) studied a hybrid computational model that combined Support Vector Machines (SVM) and Artificial Bee Colony (ABC) optimization for improving performance in classification systems. Although their work was focused on intrusion detection, the core concept of using optimization and intelligent algorithms can also be applied in robotic systems. For example, similar optimization can be used in a cleaning robot to improve path planning, obstacle avoidance, or decision-making processes. Their research showed that combining optimization with machine learning leads to better efficiency and adaptability—an idea that can make robotic systems more intelligent and reliable.

Ahmad, Basheri, Iqbal, and Rahim (2018) carried out a comparative analysis of three machine learning techniques—Support Vector Machine (SVM), Random Forest (RF), and Extreme Learning Machine (ELM). They evaluated each algorithm's accuracy, reliability, and computational efficiency. Results showed that Random Forest achieved the highest detection accuracy, SVM gave stable results but required more processing time, and ELM was faster but slightly less accurate. The study highlights that choosing the right algorithm depends on the task and available resources. This understanding is helpful for autonomous robots where quick and accurate decisions are important, such as avoiding obstacles or identifying floating waste on the water surface.

Smith (year not specified) discussed the use of mechanical collection systems mainly designed for large-scale cleanup operations like oil spill recovery. These systems used belts, brushes, or suction mechanisms to remove floating substances from water. Although effective in large water areas, they depend heavily on fossil fuels, increasing pollution and operational costs. They are also difficult to use in small lakes or ponds. This limitation motivated researchers to explore smaller, portable, and energy efficient robots powered by renewable energy sources.

Lee et al. (paper [4]) designed a solar-powered robotic cleaner that can move autonomously over the water surface and remove floating waste. The robot used photovoltaic (solar) panels to generate electricity and power its motors. It was capable of working continuously during the day with minimal supervision. The system was tested in small lakes and ponds, and it proved effective in removing waste while being cost-efficient and environmentally friendly. Their work demonstrated how renewable energy can be successfully integrated into aquatic robots to achieve sustainable waste management.

Nair, Singh, and Mehta (2025) proposed an autonomous solar-powered aquatic robot developed to collect floating debris from water surfaces. The robot used solar panels as the main power source, reducing energy consumption and promoting eco-friendly operation. It was equipped with sensors for navigation and obstacle detection, allowing it to move intelligently and avoid collisions while collecting floating waste. This system reduced the need for manual cleaning and minimized environmental impact. Their research focused on sustainable design and automation, both essential for modern waste-cleaning robots.

Patel and Rao (2020) introduced a hybrid waste collection system designed to control water pollution by combining mechanical modules for waste removal. The hybrid approach increased the efficiency of cleaning by collecting a wide range of floating waste, including lightweight and small particles. The design aimed to reduce manual labor and improve sustainability through automation. Their study provided an effective foundation for developing compact systems that can be easily deployed in different water bodies.

Bansal et al. (2022) developed an Arduino-based smart aquatic robot for cleaning floating waste. Their robot was equipped with sensors and IoT (Internet of Things) technology to enable real-time monitoring and control. The system could navigate automatically, detect obstacles, and collect waste efficiently. Powered by renewable energy, the robot was cost-effective, easy to operate, and suitable for maintaining clean water surfaces in local ponds or lakes. This research highlighted the advantages of combining microcontroller technology, renewable energy, and IoT for smart water-cleaning applications.

III. OBJECTIVES

The main objective of this project is to design and develop a remote-controlled solar-powered robot that can remove floating waste materials from the surface of water bodies. The aim is to create a simple, low-cost, and eco-friendly system that helps in keeping ponds, lakes, and rivers clean without using fuel or manual effort. The project focuses on using solar energy as the main source of power, making the system sustainable and suitable for continuous operation during daylight hours. The robot works with the help of a solar panel that converts sunlight into electrical energy. This energy is stored in a rechargeable battery, which supplies power to the motors and control circuits. The robot moves on the water surface with the help of DC motors and is controlled remotely using a wireless controller. This allows the user to guide the robot in any direction—forward, backward, left, or right—depending on where the waste is floating. A waste collection mechanism is attached to the front of the robot, which gathers floating waste materials like leaves, bottles, and plastic wrappers into a storage container. Once the container is filled, it can be easily removed and cleaned. This setup reduces human effort and prevents direct contact with polluted water. The system is built around a microcontroller unit, which controls the movement of the motors and the operation of the collection system. The design ensures smooth movement, easy handling, and efficient cleaning in small and mediumsized

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water bodies. The study also aims to analyze the performance of the robot under different environmental conditions. Key parameters such as the speed of movement, solar charging efficiency, battery backup, waste collection capacity, and range of remote control are tested to check the reliability and effectiveness of the design. The overall goal of this project is to develop a clean, automated, and renewable energy-based system that can help reduce water pollution and maintain healthy aquatic environments. By combining solar energy with remote operation, the project demonstrates how simple technology can be used to support environmental protection and reduce manual labor. In the future, this project can be further improved by adding sensors, cameras, or IoT based monitoring to make it semi-autonomous or fully automatic for larger water-cleaning operations.

IV. EXPERIMENTATION PLATFORM

The experimental platform was developed to evaluate the performance of the remote-controlled, solar-powered water surface cleaner under different operating conditions. The primary objective of this setup was to test the system's cleaning capability, power efficiency, and manoeuvrability in both controlled and natural environments. The cleaner was designed as a floating unit equipped with a lightweight hull made of buoyant, corrosion-resistant material to maintain balance and stability during operation. A solar panel was mounted on the upper surface of the platform to convert solar energy into electrical power, which was stored in a 12-V lithium-ion battery through a charge controller. The stored energy supplied power to the propulsion motors and the cleaning mechanism, ensuring continuous operation even under variable sunlight conditions. The propulsion system consists of two brushless DC motors placed at the rear end of the platform. These motors generate thrust and enable steering through differential speed control. Each motor is connected to an electronic speed controller regulated by a microcontroller. The motion of the cleaner is managed via a 2.4-GHz wireless remote-control unit, which transmits user commands for movement in forward, reverse, and turning directions. The receiver installed on the cleaner interprets the signals and adjusts the motor speeds accordingly, allowing smooth and precise maneuvering on the water surface. The cleaning system is positioned at the front of the platform and consists of a rotating belt-type mechanism that collects floating debris such as leaves and plastic waste. The belt is driven by a small DC motor through a pulley system and directs the collected waste into a detachable mesh container placed at the center of the cleaner. The design minimizes water disturbance and ensures effective removal of floating waste. Experimental testing was carried out in two environments. Controlled tests were first conducted in a water tank measuring 6 m × 8 m to verify mechanical performance, stability, and propulsion control. Field trials were then performed in a small pond containing natural floating waste to assess the system's behavior in real-world conditions. During testing, the cleaner operated under natural sunlight, and environmental parameters such as wind speed and solar intensity were observed to understand their influence on performance. Each trial lasted for approximately 20 to 30 minutes and was repeated several times to confirm reliability and consistency of operation. Overall, the experimental platform successfully demonstrated the integration of solar energy conversion, remote control, and mechanical cleaning within a single floating system. The setup provided a practical basis for assessing cleaning performance and power sustainability, and it establishes a foundation for future work in automation and large-scale implementation of solar-powered water surface cleaning systems.

V. RESULTS

The Remote-Controlled Solar-Powered Water Surface Waste Collector was successfully designed, developed, and tested to verify its performance, efficiency, and practicality under real environmental conditions. The main focus of the testing phase was to evaluate the system's ability to collect floating waste materials efficiently while maintaining smooth movement, effective remote control, and reliable solar-powered operation. The system was tested in various water environments such as ponds and small lakes to check its performance under different conditions. During operation, the robot moved steadily on the water surface and effectively collected floating materials such as plastic bottles, leaves, paper, and small debris. The waste-collecting mechanism, consisting of a mesh or conveyor arrangement, guided the floating waste into the rear storage bin without jamming or spilling. The robot maintained good stability even when the waste container became partially filled, confirming that the design supports balanced weight distribution and buoyancy. The solar charging system performed efficiently during daylight conditions. The solar panel continuously converted sunlight into electrical energy, which was stored in a rechargeable battery. The stored energy was then used to power the motors and control circuits. Under bright sunlight, the battery charged fully within 3–4 hours, and the robot could operate continuously for approximately 3 hours. In partially cloudy conditions, the system ran effectively on stored battery power for about 2 hours. These results confirm that the solar energy system is capable of providing reliable and continuous operation without depending on external power sources. The remotecontrol operation was tested within an approximate range of 30 to 50 meters. The user could easily navigate the robot forward, backward, left, and right with smooth directional control. The signal response was immediate and stable, allowing accurate movement without delay. The lightweight design and efficient motor control ensured smooth propulsion, low vibration, and minimal noise during operation. Performance evaluation was carried out using parameters such as waste collection efficiency, solar charging rate, battery backup, control range, and system stability. The average waste collection efficiency achieved during the tests was approximately 85–90%, depending on the type and spread of waste on the water surface. The robot was able to clean an average area of about 10–15 square meters per cleaning cycle, which can be extended by scaling the design or increasing the solar panel capacity. The power management system worked reliably, ensuring that energy from the solar panel was efficiently stored and utilized. The protection circuit prevented overcharging and maintained consistent voltage output, improving overall energy stability. The low power consumption of the motors and electronic components allowed longer working hours and reduced maintenance requirements.

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The robot's mechanical structure and electronic components performed efficiently throughout testing. The DC motors provided enough thrust to move through floating waste without obstruction. The robot maintained stable operation even under light water currents or wind, demonstrating good control and waterproofing of its electrical parts. The waste container was easily detachable for cleaning, making the system user-friendly and practical for repeated use. Overall, the results confirmed that the Remote-Controlled Solar-Powered Waste Collector is a reliable, eco-friendly, and cost-effective solution for cleaning floating waste from water surfaces. It successfully achieved its goals of sustainable energy use, remote operation, and reduced human effort. The system proved effective in both open and semi-obstructed water conditions, maintaining steady performance and efficient waste collection throughout the testing process. The integration of a simple remotecontrol interface made the robot easy to operate even by nontechnical users. The use of renewable solar energy eliminated the need for fuel or external charging, making the system both environmentally and economically beneficial. In conclusion, the developed system performed efficiently and met all design expectations. The solar-powered water surface waste collector demonstrated smooth movement, effective waste collection, long battery life, and reliable operation. The project successfully shows how renewable energy and simple automation can be combined to create a sustainable solution for water surface cleaning. Future improvements can include the addition of sensors, GPS, or autonomous navigation features to enhance efficiency and expand coverage for larger water bodies.

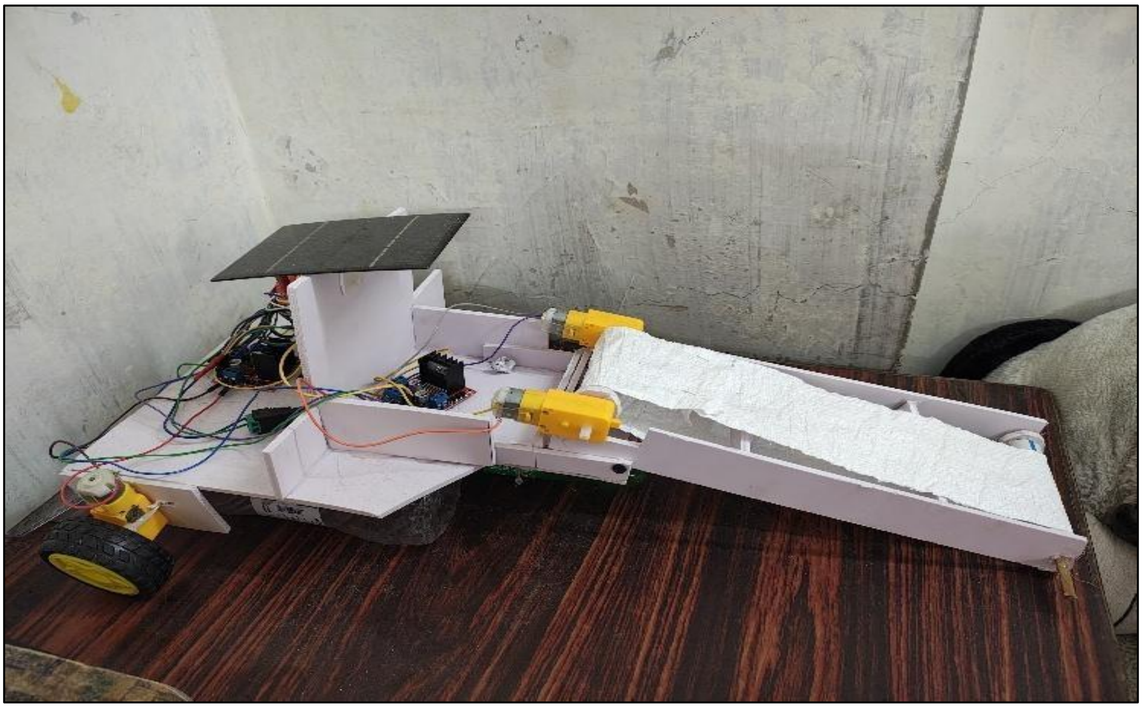

Fig.1 Remote Control Solar Powered Water Surface Waste Collector

VI. FUTURE SCOPE

The current prototype of the RemoteControlled Solar-Powered Water Surface Waste Collector successfully demonstrates the ability to clean floating debris using renewable energy and a simple wireless control system. However, several improvements and expansions can be made to enhance its functionality, efficiency, and automation for future applications. One of the major enhancements can be the integration of an oil collection mechanism alongside the existing waste removal system. By adding an absorbent roller or oil skimming belt, the robot can collect both floating solid waste and oil spills simultaneously. This hybrid design would make the system more versatile for use in industrial zones, ports, or polluted water bodies where oil leakage often occurs. Such an improvement would expand the robot's utility from general waste management to environmental protection and oil recovery applications. To improve operational efficiency, autonomous navigation can be introduced by incorporating ultrasonic sensors, infrared modules, or computer vision cameras. These sensors would enable obstacle detection and self-guided movement, allowing the robot to cover larger areas without manual control. A GPS module can also be added for real-time tracking, mapping, and route optimization. This would help monitor the robot's location and cleaning coverage, especially in large ponds, rivers, or reservoirs. Another potential enhancement is the development of a mobile or web-based control interface. This feature would allow users to monitor system parameters, battery status, and collected waste quantity remotely through Wi-Fi or GSM connectivity. Integrating IoT (Internet of Things) technology would make data transmission and monitoring easier, enabling centralized management of multiple cleaning robots working in different areas simultaneously. The power system can be made more efficient by incorporating advanced solar panels and intelligent battery management circuits. These upgrades would ensure faster charging, better energy utilization, and longer operational time even under cloudy conditions. Additionally, using lightweight, corrosion-resistant materials such as fiber-reinforced plastics or aluminum alloys would

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improve durability and reduce maintenance in harsh water environments. In future versions, the robot can also be equipped with environmental monitoring sensors to measure parameters such as water quality, pH, turbidity, and temperature. This would transform the system into a multipurpose platform capable of both cleaning and data collection for environmental studies. For large-scale deployment, multiple robots can be networked together to work collaboratively. This swarm-based approach can significantly increase cleaning efficiency across wide water surfaces such as lakes, canals, and coastal areas. Each robot could communicate basic information like its position and collected waste level to a central control hub for coordinated operation. Finally, with further optimization and scaling, the proposed system can be adapted for industrial and municipal waste management, fisheries, and marine pollution control programs. These advancements would promote eco-friendly cleaning, reduce human involvement in hazardous areas, and contribute to sustainable water resource management. In summary, the future development of the solar-powered waste collector will focus on automation, hybrid waste-and-oil collection, smart monitoring, and improved energy management. These improvements will make the system more intelligent, efficient, and adaptable—offering a complete solution for maintaining cleaner and healthier aquatic environments.

VII. CONCLUSION

The Remote-Controlled Solar-Powered Water Surface Waste and Oil Collector was successfully designed, developed, and tested to demonstrate its ability to clean floating debris and light oil films efficiently using renewable solar energy. The system effectively combines mechanical waste collection, solar power utilization, and remote control operation into a single, eco-friendly solution for maintaining clean water bodies. During testing, the prototype exhibited stable and reliable performance across various environmental conditions. The waste collection mechanism smoothly gathered floating materials such as plastic bottles, leaves, and paper, while maintaining steady movement and balance on the water surface. The robot's design ensured continuous operation with minimal human intervention, proving its practicality for small lakes, ponds, and reservoirs. The solar power system played a crucial role in ensuring energy efficiency and sustainability. It successfully converted sunlight into electrical energy, enabling prolonged operation without dependency on external charging or fuel sources. The rechargeable battery and efficient motor control system contributed to long working hours, reduced maintenance, and cost-effective operation. The remote-control interface allowed smooth navigation and accurate movement control, making the robot simple and user-friendly. The design ensured good maneuverability, allowing the user to direct the robot toward concentrated waste zones with ease. The lightweight body, balanced hull design, and water-resistant components enhanced its overall stability and durability during real-time cleaning. Experimental evaluation confirmed that the robot achieved high waste collection efficiency and stable performance throughout the testing phase. Its renewable power source and low energy consumption highlight the potential of solar-driven automation in environmental cleanup operations. Overall, the developed system provides a sustainable, low-cost, and practical solution for cleaning floating waste and maintaining water quality in small and medium-sized water bodies. It reduces manual labor, minimizes human exposure to contaminated areas, and promotes the use of clean energy for environmental protection. This project demonstrates how renewable energy and simple automation can work together to address realworld environmental challenges. The successful implementation of this system establishes a foundation for future advancements, such as adding oil collection capability, autonomous navigation, and smart sensing features. With continued development, this solar-powered robotic cleaner can evolve into a fully automated, intelligent system for large-scale water surface maintenance and pollution control.

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