IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⪤ Peer-reviewed & Refereed journal ⪤ Vol. 14, Issue 12, December 2025

DOI: 10.17148/IJARCCE.2025.141246

Eco-Friendly Marine Monitoring: Solar Powered Buoy For Ocean Data

Mrs. Hema C[1], Praveen K[2], Raj chilshetty[3], Vinay NA[4], Rohan CM[5]

Assistant Professor, Department of ECE, East West Institute of Technology, Bangalore, India[1]

Student, Department of ECE, East West Institute of Technology, Bangalore, India[2]

Student, Department of ECE, East West Institute of Technology, Bangalore, India[3]

Student, Department of ECE, East West Institute of Technology, Bangalore, India[4]

Student, Department of ECE, East West Institute of Technology, Bangalore, India[5]

Abstract: The Solar Sea Weather and Pollution Transmitter Buoy is an important step forward in ocean monitoring technology. It runs on solar power, allowing it to work efficiently and on its own without depending on external energy sources. This not only makes it cost-effective but also environmentally friendly. The project involves creating a solar-powered buoy that can stay afloat and continuously track sea weather conditions and pollution levels in real time. The buoy is equipped with sensors that measure factors such as temperature, humidity, wind speed, and water quality. All the collected data is sent wirelessly to a main control unit, where it can be analyzed and displayed right away. The results show that the buoy works well in delivering fast and accurate environmental information, helping researchers and authorities make better decisions to protect marine ecosystems.

Keywords: STM32, ATMEGA328P Controller, Wireless, IOT and Cloud Computing, Ocean Management, Sensor Suite, Real-Time Data Collection.

I. INTRODUCTION

As environmental damage continues to rise, finding sustainable ways to protect our oceans has become more important than ever. The Eco-friendly Marine Monitoring System, a Solar Powered Buoy for Ocean Data, offers an innovative solution to this challenge. Powered entirely by solar energy, the buoy works on its own and provides real-time updates on sea weather and pollution levels, even in distant ocean areas where regular monitoring systems cannot function effectively.

The buoy is fitted with several advanced sensors that measure key factors like temperature, wind speed, humidity, turbidity, and pH levels. It gathers this crucial environmental data and sends it wirelessly to monitoring stations on land for further study. The real-time data helps in managing marine environments more efficiently, understanding the effects of climate change, and taking quick action to prevent or reduce marine pollution.

II. LITERATURE SURVEY

Based on a comprehensive survey, several studies have reviewed and analysed advancements in Eco friendly marine monitoring: Solar powered Buoy for ocean data, The work in [1] describes a new type of buoy that uses both solar power and wave motion to generate energy on its own. Because of this dual-energy system, the buoy can run for long periods without needing maintenance. It also supports IoT technology, allowing it to send real- time ocean data efficiently and sustainably.

The paper [2] introduces smart buoys that use LoRaWAN communication to record and transmit marine weather information across long distances. This method is energy-efficient and supports wide-area environmental monitoring with very low power usage.

Research [3] discusses an IoT-based buoy system created for monitoring rivers. It measures flow rate, turbidity, and different water quality indicators in real time. The study highlights its accuracy, ability to be accessed remotely, and suitability for scaling up for better water resource management and pollution tracking.

The study [4] explains a buoy fitted with an Acoustic Doppler Current Profiler (ADCP) to track coastal currents and turbidity. The system can run continuously and provides clear, detailed data about water clarity and sediment movement. It shows how ADCP-based buoys help in studying coastal behaviour, improving marine research, and supporting coastal protection efforts.

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III. METHODOLOGY

The development of the Solar-Powered Oceanic Environment Monitoring Buoy follows a clear and organized process that combines engineering, technology, and environmental awareness. It starts with designing a strong, floating structure fitted with solar panels to keep the system powered at all times, even in distant ocean areas. The buoy is equipped with advanced sensors that measure temperature, humidity, wave height, water clarity, and pH levels to track both weather and pollution conditions.

These sensors are carefully adjusted to stay accurate and dependable in different sea environments. The solar panels charge built-in batteries so the buoy can work independently without needing outside power. The collected data is sent wirelessly to a land-based monitoring station using communication modules like LoRa or RF. This real time information is displayed on small OLED screens and through the Blynk IoT platform, making it easy to access from anywhere. By providing continuous, accurate updates about ocean conditions, the system helps scientists and authorities make quick, informed decisions to protect marine life and reduce pollution.

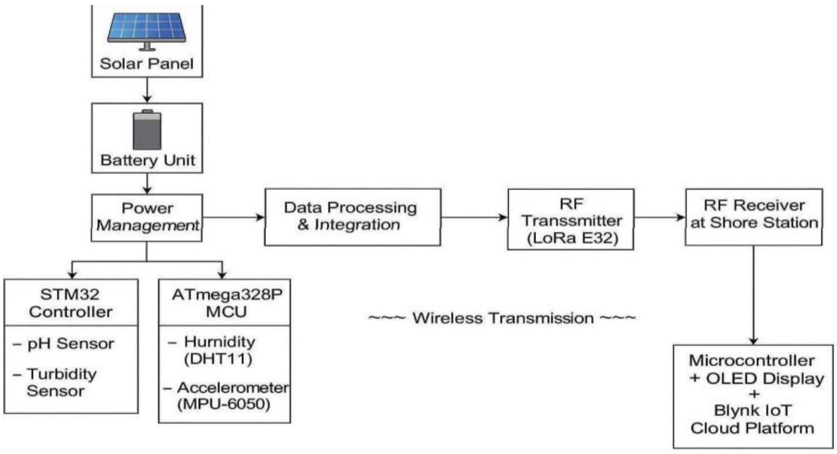

Figure 1: Block Diagram of Proposed System

IV. IMPLEMENTATION

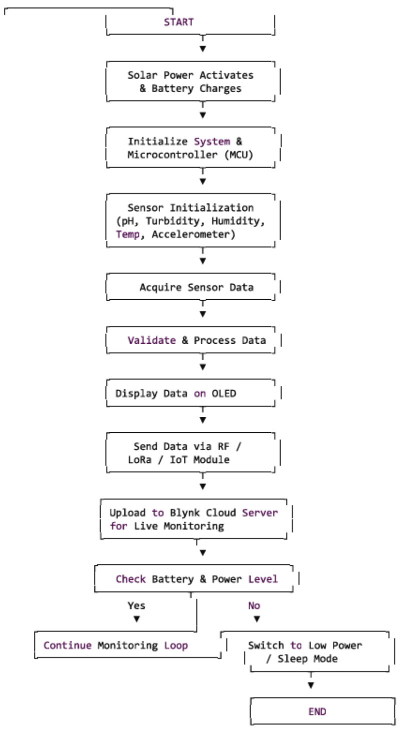

Figure 2: Flow Chart of Proposed System

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1. Structural & Power Setup
- Buoy Design
- A floating waterproof enclosure is designed using SolidWorks.
- Solar panel placed on top surface.
- Battery compartment placed centrally for balance.
- Power System
- Solar panel → Charge controller → Battery → Microcontroller
- Battery supplies stable 5V to sensors and control boards.

2. Controller Setup
- Microcontrollers Used
- STM32 → Main data processing
- ATmega328P → Handles sensor readings and local display
- Initialization Steps
- Configure GPIO pins
- Enable ADC for analog sensors
- Initialize I2C/SPI for OLED and digital sensors
- Set up UART/SPI for RF/LoRa communication

3. Sensor Integration
- Sensors Connected
- pH Sensor → Ocean acidity level
- Turbidity Sensor → Water clarity
- Temperature & Humidity Sensor
- Accelerometer → Detect wave motion
- Wind/Weather sensors (if included)
- Sensor Calibration
- Calibrate pH sensor using buffer solutions
- Turbidity sensor calibrated using clean vs muddy water
- Temperature & humidity auto-calibrated internally

4. Data Acquisition
- Process
- ATmega328P reads all sensor values
- Sensor data is filtered (noise removal)
- STM32 formats data packets

Example Data Packet:
TEMP=28.6C | HUM=73% | PH=7.5 | TURB=220 NTU | WAV=0.6m

5. Wireless Transmission
- Modules
- RF Transmitter/Receiver or LoRa Module
- Process
- STM32 sends packet to RF transmitter
- Receiver at ground station collects the data
- Data is forwarded to monitoring PC or IoT cloud

6. Local & Cloud Monitoring
- OLED Display

Shows:
Temp: 28.6C
pH: 7.5
Turbidity: 220 NTU
Wave: 0.6m
- Blynk IoT Cloud
- Data uploaded via Blynk Edge

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- Access on mobile app
- Real-time graphs for pH, turbidity, temperature, humidity, wave level

7. Continuous Operation
- Solar panel charges battery during daytime
- Low-power mode activates at night
- Loop repeats continuously
- Data remains available in real-time

V. RESULTS

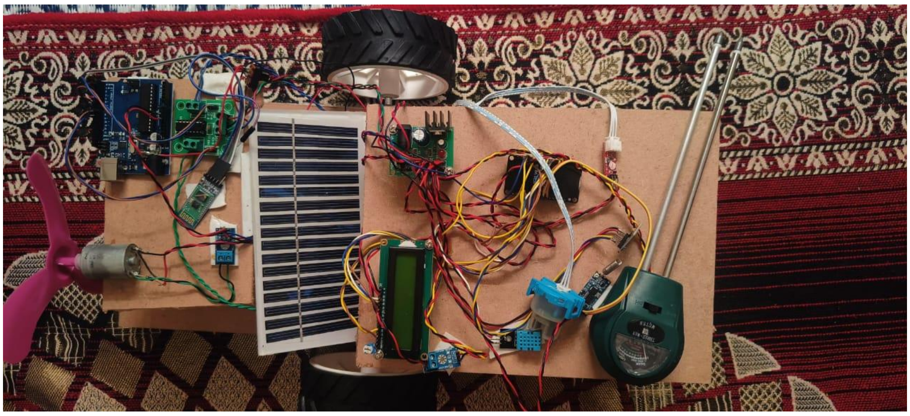

Fig 5.1: Prototype of Proposed System

The proposed system is a solar-powered oceanic monitoring unit designed to continuously measure real-time weather and water-quality parameters. It integrates sensors such as pH, turbidity, temperature, humidity, and an accelerometer to accurately assess environmental conditions. The microcontroller processes the collected data, displays it on the screen, and transmits it wirelessly through LoRa/RF to a remote monitoring station. Powered entirely by solar energy, the system operates autonomously and is suitable for long-term deployment in marine and river environments.

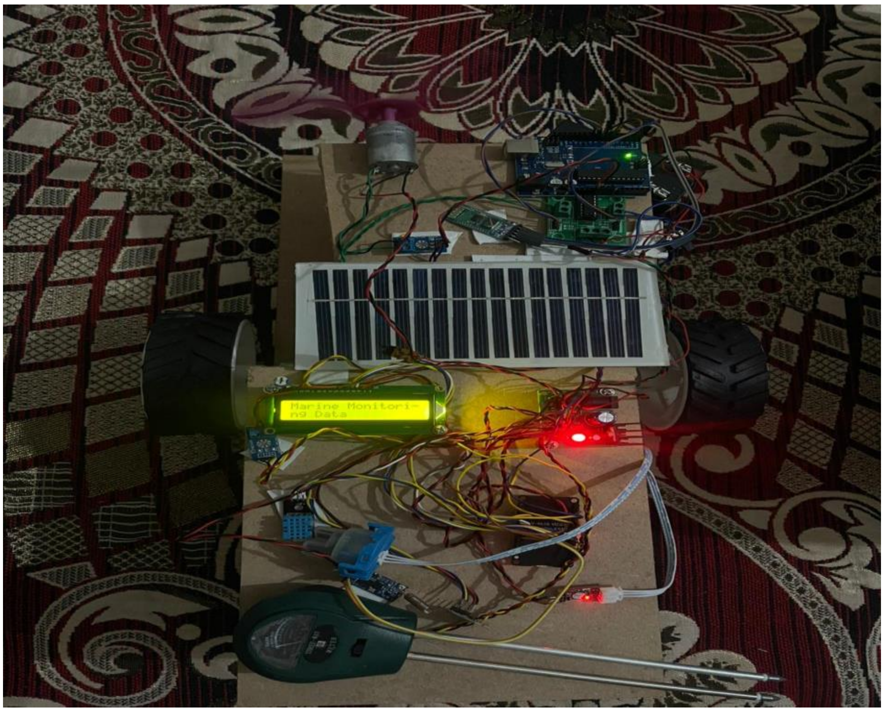

Fig 5.2: Reading values

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The reading values collected from the system represent real-time environmental conditions, including water temperature, air temperature, humidity, pH, and turbidity. The sensors provide stable measurements such as neutral pH levels, moderate turbidity, and consistent temperature values, indicating normal water conditions during testing. Accelerometer readings show slight motion caused by water movement, while battery and solar voltage values confirm reliable power availability. Overall, the recorded readings validate the system's accuracy and effectiveness in monitoring water quality and weather parameters.

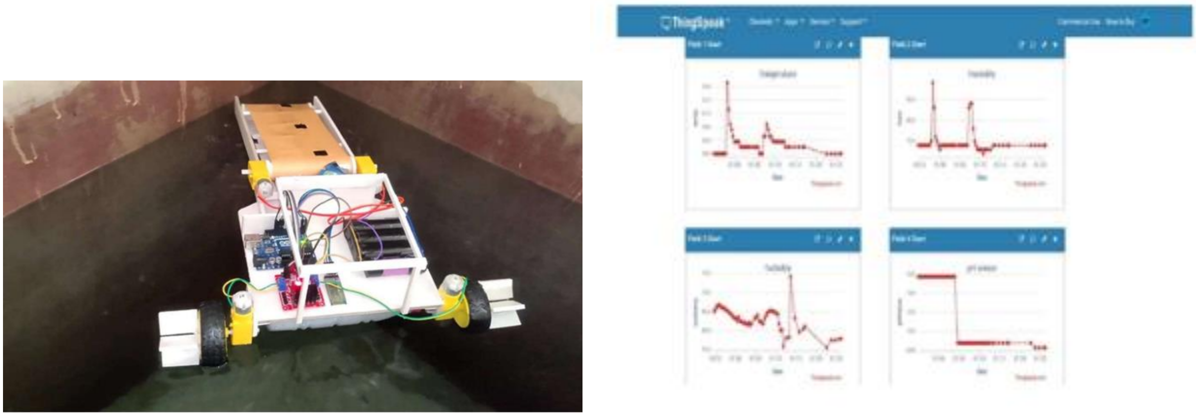

Fig 5.3: Demonstration of system and output waveform

The system was demonstrated by placing the prototype directly in water to test its real-time sensing and stability. As the buoy floated, the submerged sensors such as pH and turbidity began capturing accurate water-quality readings, while the temperature, humidity, and accelerometer sensors measured the surrounding environmental conditions. The data was continuously displayed on the screen and transmitted wirelessly, proving that the system functions reliably even when deployed in water. This demonstration confirmed the buoy's capability to operate effectively in actual aquatic environments using solar power.

VI. CONCLUSION AND FUTURE SCOPE

The solar-powered marine monitoring buoy successfully demonstrates an eco-friendly and efficient solution for continuously tracking ocean weather and pollution parameters in real time. By using renewable energy and reliable sensor technologies, the system provides accurate environmental data that can support marine research, pollution control, and sustainable ocean management.
In the future, the system can be enhanced by adding more advanced sensors, improving communication technologies, strengthening long-term durability, and integrating AI-based analytics to create a smarter, larger-scale ocean monitoring network capable of delivering deeper environmental insights and wider coverage.

ACKNOWLEDGMENT

I would like to express my sincere appreciation to everyone who supported and guided me throughout the development of this project.

First and foremost, I extend my heartfelt thanks to my project guide, Prof. Hema C, for her consistent encouragement, insightful suggestions, and valuable technical guidance. Her expertise and mentorship greatly contributed to the successful completion of this work.

I am also grateful to the faculty members and technical staff of the Department of Electronics and Communication Engineering, East West Institute of Technology, Bengaluru, for their assistance during the project. Their support in laboratory facilities, troubleshooting, and system integration played an important role in overcoming the various challenges encountered during implementation.

Lastly, I owe deep gratitude to my family and friends for their continuous motivation, understanding, and moral support, which helped me stay focused and determined during this work.

This project would not have been possible without the contributions of all these individuals, and I am sincerely thankful for their support.

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