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Remote Controlled Boat for Water Pollution Monitoring

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Abstract

The global issue of water quality degradation caused by pollution has become a critical environmental concern. Leaving water unchecked for an extended period make it unfit for human needs and eradicate the entire water ecosystem. Water being considered as a vital element in sustaining living things need to be protected. To address this challenge, novel technological solutions are being devised to effectively monitor and manage water resources. This study introduces a remote-controlled boat equipped with sensors for real-time monitoring of water pollution parameters such as pH, turbidity, and temperature. These parameters can be collected regularly and stored. The stored data can be studied to find out whether there have been any changes to the water quality or whether the water is polluted. The boat's design and construction are detailed, emphasizing its agility and versatility in different aquatic environments. The integrated sensor system on the boat allows for continuous data collection, offering valuable insights into water quality dynamics. The system allows communication with the user, this helps in viewing the water parameters on smart phone through an application at every instant. The pH sensor measures the water's PH levels, while the turbidity sensor quantifies suspended particles, providing information on sedimentation and pollution levels. Furthermore, the temperature sensor records thermal fluctuations, which impact aquatic ecosystems and the dispersion of pollutants. In conclusion, the development of a remote-controlled boat for water pollution monitoring signifies a significant advancement in environmental monitoring technology. By delivering accessible and actionable data, this innovative approach contributes to proactive pollution management strategies, aiding in the conservation and restoration of water resources for future generations.

Keywords: Arduino, sensors, RC boat, IOT, temperature, turbidity

INTRODUCTION

Water pollution is an increasingly prevalent problem in our country. Despite two-thirds of the Earth being covered in water, the availability of fresh water remains insufficient. The primary cause of water pollution is the over exploitation of natural resources. The rapid rise in industrialization and the use of pesticides and insecticides contribute significantly to water pollution. Man-made activities, such as the discharge of sewage, also play a significant role in water pollution. According to reports, by 2050, the world may face water scarcity due to the declining quality of water. Therefore, it is humanity's responsibility to maintain both the quality and quantity of water. Water pollution has adverse effects on the food chain and the ecosystem of nature. Poor water quality leads to waterborne diseases and the spread of various infectious diseases, causing severe health issues [1]. So, to ensure safe drinking water for humans and save haven for aquatic life water quality monitoring technique is used. This is done with the help of IoT and various other technologies [12]. In [2] PH and

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temperature sensor are used to determine the water parameters. In [3] the proposed system uses PH, temperature, and dissolved oxygen sensors to monitor water quality and the data are received via SMS on mobile phone. The main objective of remote-controlled RC boat is to constantly monitor the water quality [4-6]. The measure values can also be viewed via blynk application in real time [7, 10]. Data transmission and receiving can also be done with the help of ESP8266 microcontroller [8, 9], shows the provision to store the data in and SD card via SD card module. ESP32 cam module can be used to monitor the surroundings to the boat which makes it easier to maneuver the boat at distance and any kind of obstacles can be avoided and provides safety to the system [11]. A GPS module can be used to get location of water bodies where there is a possibility of poor water quality [13]. The proposed system holds significant value as it can be adapted and implemented for widespread applications by expanding and adding more sensors and by adjusting the programs. The main goal of this paper is to build an RC boat equipped with sensors to detect water quality parameters such as pH, turbidity, total dissolved solids, and temperature. Arduino is used to control these sensors, collect data, transmit it via network and store data in an SD card module for further access. The proposed system also helps to collet location data with the help of a GPS module. The data collected can also be viewed in real time on smart phone with the help of NODE MCU. ESP32 cam module to view the surroundings of the boat and act as link to drive the propulsion system of the boat. The proposed system is capable of automatically monitoring water parameters and analyse water quality, thus reducing human effort and improving time management. It also facilitates work in remote areas with water bodies, making the process more economical, convenient, and faster. This system holds significant value as it can be adapted for widespread applications and extended by replacing corresponding sensors and adjusting the program.

Conventional Method

In the existing system two key sensors are used along with a Node MCU microcontroller to monitor the water quality. These sensors assist in monitoring the water's temperature and cloudiness, respectively. They include a temperature sensor and a turbidity sensor. Real time monitoring and analysis are made possible by the transmission and display of the sensor data via an Internet of Things (IoT) platform. The system incorporates a buzzer to signal the degree of pollution. When the water quality falls below a certain level, this buzzer triggers an alarm to alert users of possible pollutants or potential risks in the water.

DC motors and motor drives are used for propulsion. The motor drive manages the DC motor's power supply, enabling it to drive the system like a miniature boat across the water. Using a remote control, this boat may be moved left or right in different directions. Finally, a speed controller has been integrated into the system to keep the boat moving at a constant rate. This ensures that the boat travels at a constant speed, resulting in accurate and reliable information acquiring for the process of monitoring the water quality.

PROPOSED SYSTEM

The proposed remote-controlled boat system for water quality analysis is made to effectively monitor and acquire information about a range of water parameters. This system uses a variety of sensors to assess turbidity, temperature, PH levels, and total dissolved solids (Figures 2, 5). An SD card module is used to store the obtained data, making it easier to analyse the data later. NODEMCU (ESP8266) is used for wireless communication which helps the user to monitor the data's collected by the sensors remotely.

The controlling of boat is done via mobile phone using a control interface. This allows the user to move the boat left or right. The propulsion system of the boat uses a motor drive and 12V, 100 rpm dc motor for propulsion (Figures 3, 6). A camera module (ESP32) is used for real time monitoring. The ESP32 cam module provides real time images of resolution between 2MP to 4MP on the user’s smart phone thereby allowing the user to control the boat efficiently and avoid any kind of obstacles (Figure 1). The boat can be maneuverer with the help of the visuals obtained from the camera module. A GPS module is integrated to get the location data of highly polluted areas. The details of the GPS location

will also be stored into a SD card module (Figure 4). The sensors data is received on Blynk IOT platform.

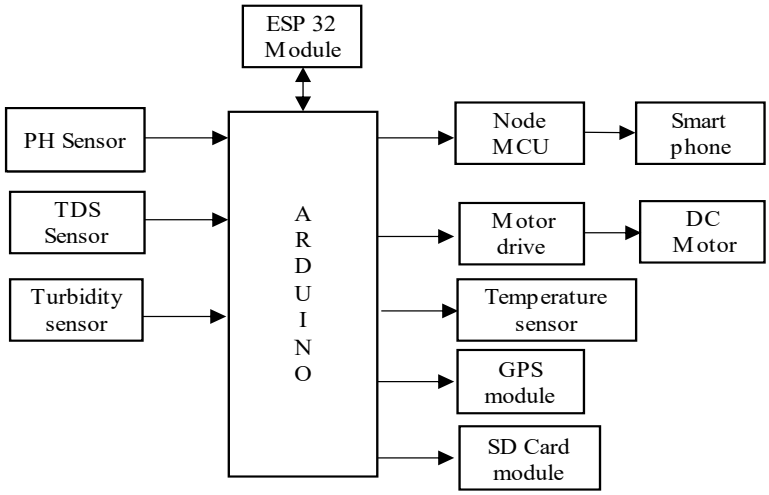


Figure 1. Block diagram of proposed system

FIGURES AND TABLES

Block Diagram of Sensors

The block diagram of sensors is shown below Figure 2.

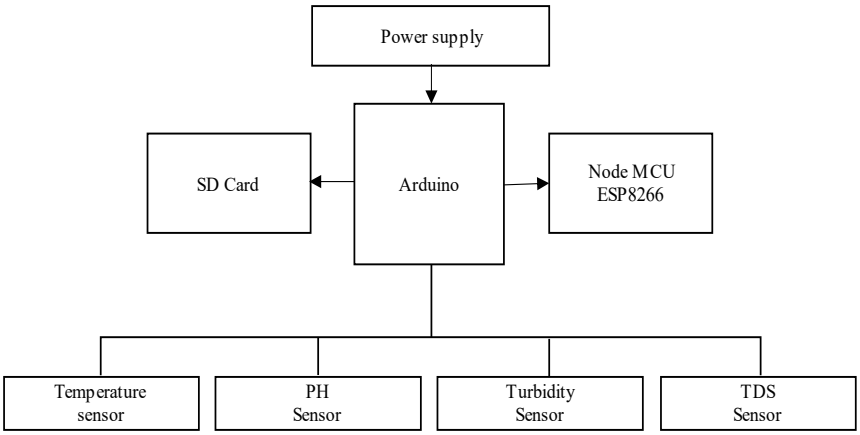


Figure 2. Block diagram of sensors

Block Diagram of Propulsion System

The block diagram of propulsion system is shown below Figure 3.

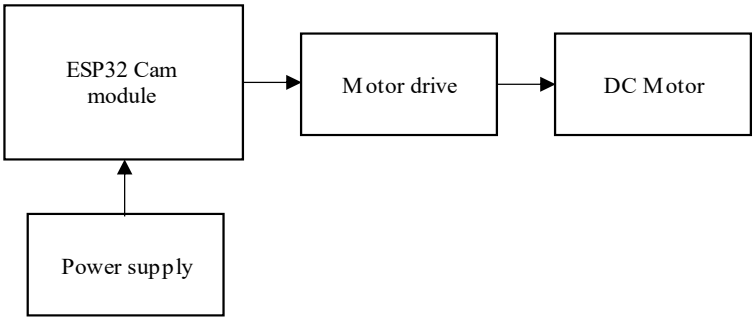


Figure 3. Block diagram of propulsion system.

Block Diagram of GPS Module Integration

The block diagram of GPS module integration is shown Figure 4.

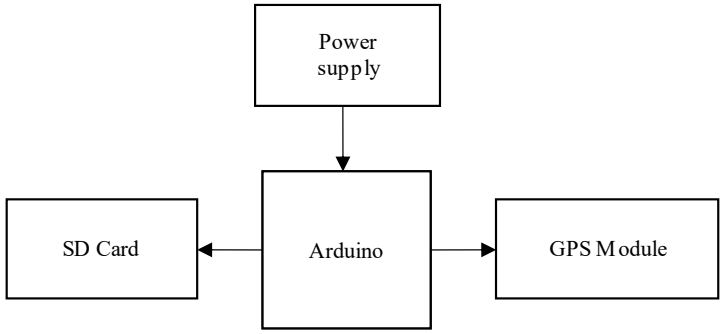


Figure 4. Block diagram of GPS integration.

Pinout diagram of sensors

The pinout diagram of sensors is shown in Figure 5.

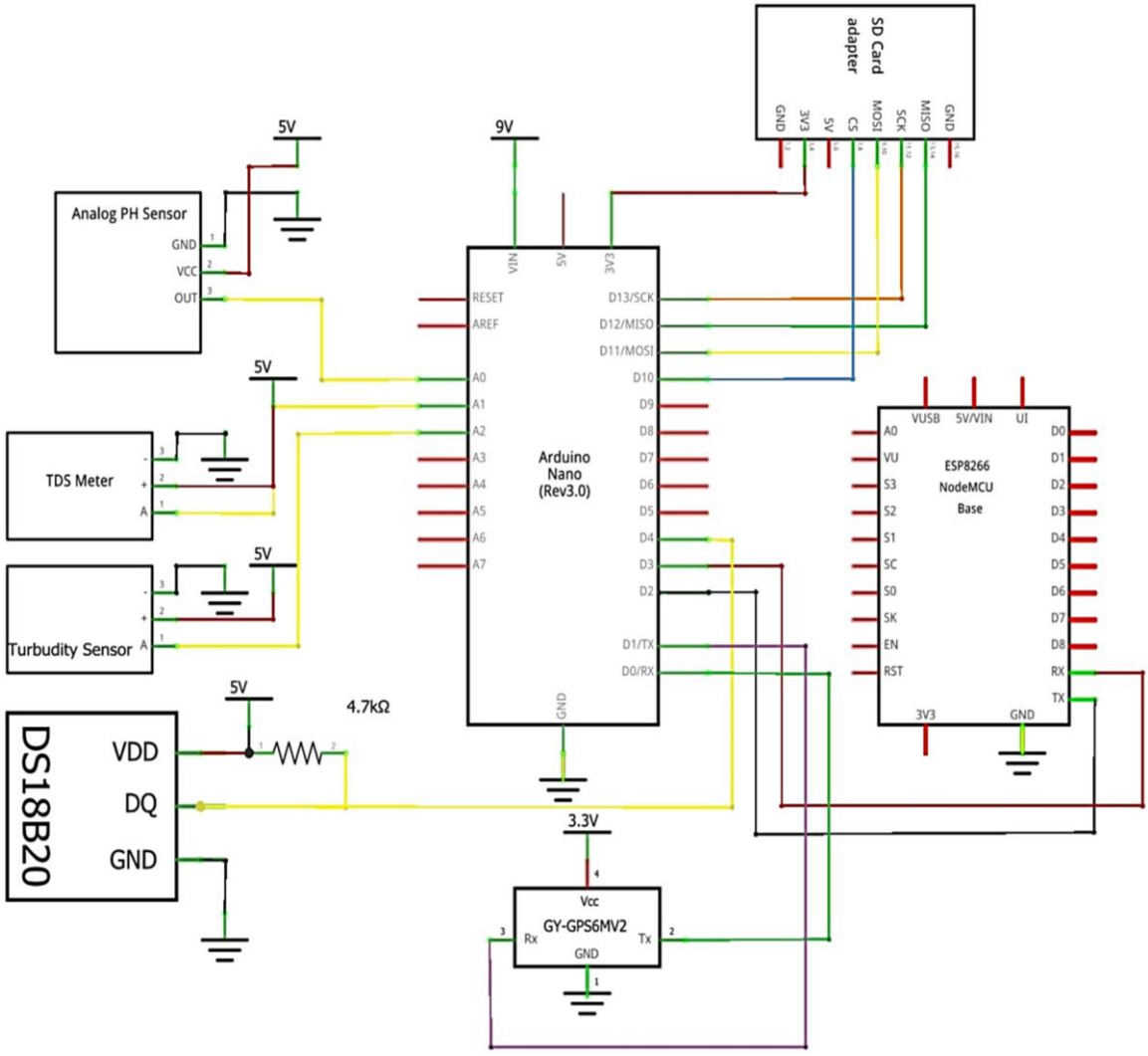


Figure 5. Pinout diagram of sensors.

Pinout Diagram of Propulsion System

The pinout diagram of propulsion system is shown in Figure 6.

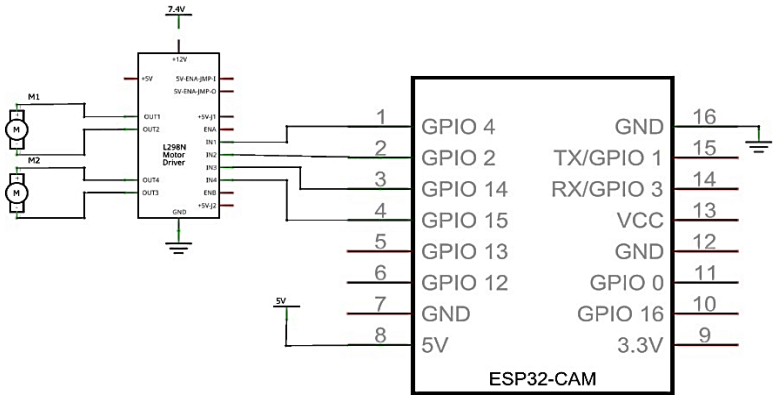


Figure 6. Pinout diagram of propulsion system

Experimental Result

The experimental analysis and graph of variation in temperature are shown in Figures 7-11.

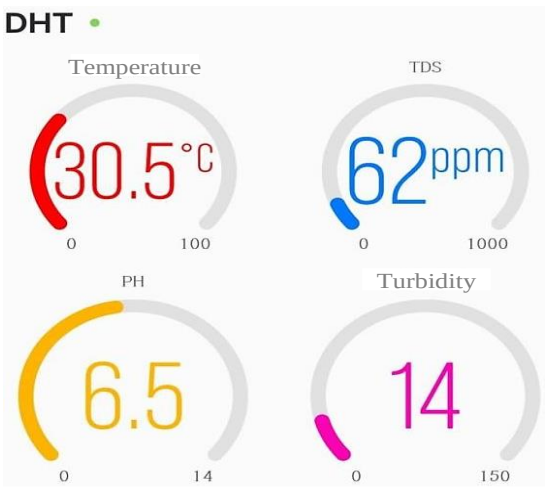


Figure 7. Experimental analysis of trial 1

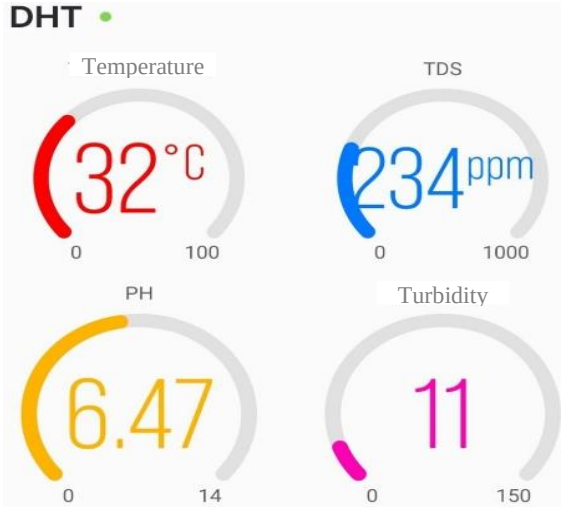


Figure 8. Experimental analysis of trial 2

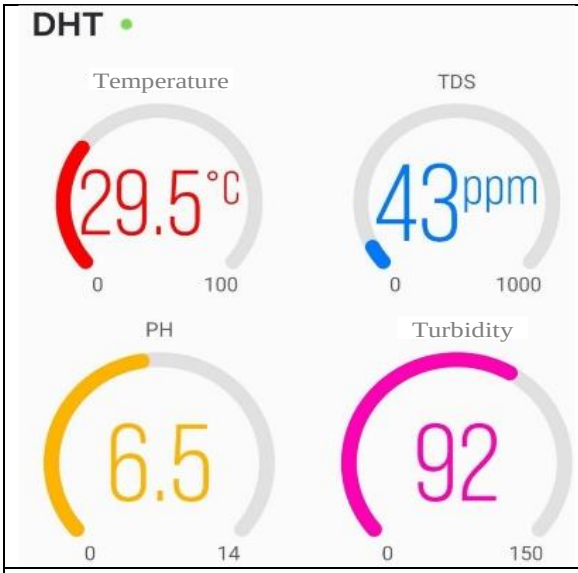


Figure 9. Experimental analysis of trial 3.

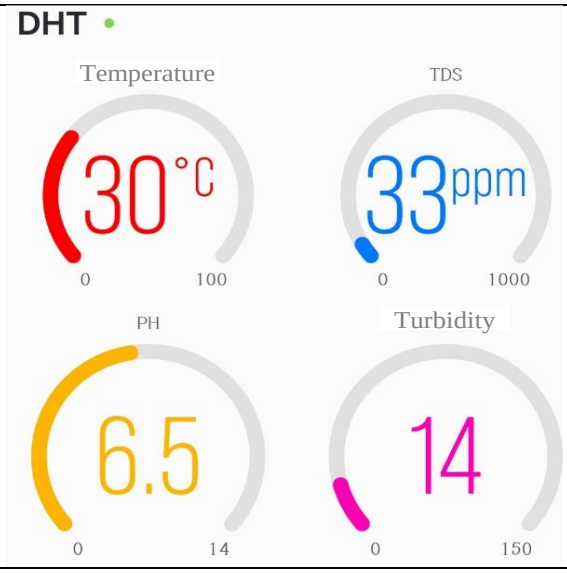


Figure 10. Experimental analysis of trial 4

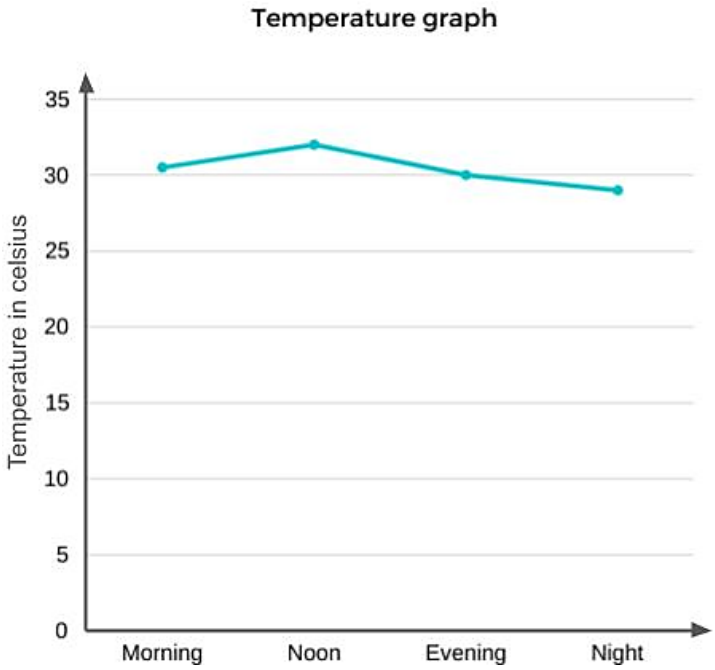


Figure 11. Graph of variation in temperature during different hours of the day.

DESIGN SPECIFICATIONS

1. PH sensor
   - Normal range of water PH is measured in a scale of 0 to 14.
   - 7 is set as neutral value. If the PH value is between 0 and just before 7 the water is said to acidic and if the PH value is between 7 and 14 the water is said to be alkaline.
   - The sensors used here can measure PH levels from 0 to 14.
2. TDS sensor
   - TDS value helps us to determine the total dissolved substances in water.
   - If the TDS value ranges between 50 – 150 ppm the water is said to be in good quality.
   - Range between 150 – 250 ppm the water is in good condition.
   - Range between 250 – 300 ppm the water is fairly in good condition.
   - Range between 300 – 350 ppm the water is in poor condition.
   - The TDS sensor used here measures from 0 to 1000 ppm.
3. Turbidity sensor
   - Turbidity is the measure cloudiness of water or the clarity water.
   - If the turbidity range is between 15 – 25 NTU the water is fairly turbid.
   - Range between 25 – 35 NTU denotes the water is rather turbid.
   - Range between 35 – 50 NTU the water is turbid.
   - If the range is greater than 50 NTU the water is very turbid and in poor condition.
   - The sensor used here measures from a range of 0 to 150 NTU.
4. Temperature sensor
   - The normal temperature of water during morning hours ranges between 25^{o}c to 27^{o}c.
   - During noon time the water temperature can vary ± 2^{o}c from morning hour temperature.
   - During nighttime the water temperature can drop somewhere between 18^{o}c to 20^{o}c.
   - The sensor used here can measure temperature between -55^{o}c to 125^{o}c.
5. NODE MCU (ESP8266)
   - It is a Wi-Fi module used to transmit the data collected by the sensor to the user end.
   - It transmits data over network.
   - The module is used along with an antenna which gives an extended range between 0.5km to 0.8km

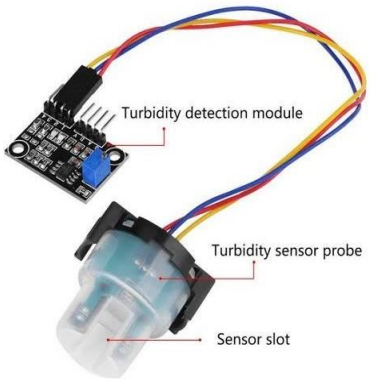
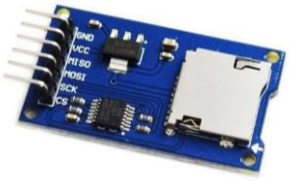
6. ESP32 cam module
   - Wi-Fi based microcontroller.
   - Module has a camera of resolution 2MP to 4MP which enables the user to get real time visuals.
   - The microcontroller is also used to control the propulsion system of the boat which comprises of a motor drive and two DC motors.
7. Motor drive (L298N)
   - The motor drive has provision to connect two DC motors.
   - The drive can control the speed of motor as well as the direction of rotation.

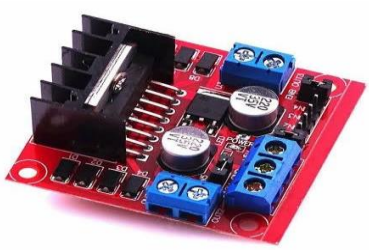
COMPONENTS

The components of remote-controlled boat are mentioned in Table 1.

Table 1. Components

S.N	Names	Figures	Details
1.	Aurduino		• It is a single board microcontroller based on 8-bit Atmel AVR architecture. • It uses Atmega328P microcontroller chip. • It has various analogue and digital pins. • Runs on 5v power supply
2.	Node MCU		• It is based on ESP8266 Wi-Fi chip. • It has Wi-Fi connectivity capabilities. • It helps to communicate with other devices over network.
3.	ESP32 CAM		• Wi-Fi and Bluetooth enabled module. • Based on ESP32 microcontroller. • Based on ESP32 microcontroller. • Helps in exchanging data and communicating with other devices
4.	GY-GPS6MV2GPS Module		• Used as a GPS navigation and tracking module. • Gives accurate information in challenging conditions. • Low power consumption (3.6v).

			• Applications are GPS applications and navigation systems
5.	PH Sensor		• Commonly used to track quality of water. • Measures the alkalinity and acidity of water. • Works on the principal of exchange of ions. • Sensor probe is connected to a transmitter board that has PH limiting setting, analogue reading offset and six IO ports.
6.	DS18B20 Temperature Sensor		• Digital sensor module which is easy to interface with microcontrollers. • Measures temperature between -55°c to +125°c. • Battery powered and low power consumption.
7.	TDS Sensor		• Measures total dissolved solids by checking conductivity of water. • Measures TDS value in ppm. • Range: 0-1000ppm. • The voltage supply required is between 3.3v - 5v.
8.	Turbidity		• Measures clarity or cloudiness of water. • Monitor quality of water by measuring how much light is scattered by suspended particles. • Uses infrared light emitter to measure scattered light. • Range: 0-1000 NTU. • Operating voltage - 5v.
9.	SD Card Module		• Used to store data into an SD card with the help of a micro controller. • Operating voltage: 3.6v.

10.	L298N Motor Drive		• Used to control dc motor. • Controls speed and direction of rotation of motor. • Operating voltage +5v to 42v.
11.	DC Motor		• 12V DC Motor • Rotates at 100 rpm

Result

The proposed system was tested in four different zones in different hours of the day. Figure 7 shows the experimental result obtained from the first zone. The water in the zone has these parameters Temperature- 30°C, TDS-62ppm, pH-6.5, Turbidity -14. Figure 8 shows the experimental result obtained from the second zone. This zone has the parameters Temperature -32°C, TDS-234ppm, pH-6.47, Turbidity -11. Figure 9 shows the experimental result obtained from the third zone. This zone has the parameters Temperature -29.5°C, TDS-43ppm, pH-6.5, Turbidity -92. Figure 10 shows the experimental result obtained from the fourth zone. This zone have the parameters Temperature -30°C, TDS-33ppm, pH-6.5, Turbidity -14.

Future Scope

The measurement of turbidity, total dissolved solids (TDS), pH, and temperature has been made possible by the current study, and the user is supplied the same data. However different options are available to get more adequate results of water pollutants. For this features such as Oxygen Reduction Potential (ORP), Biological Oxygen Demand (BOD) can be incorporated.

- The range of the RC navigation system can be increased by utilizing a Zigbee transceiver [15].
- Contemporary technologies can be used soon to make a more efficient and stable system that provides promising data of water pollutants.
- By adding more sensors, the parameters can be increased.
- Monitoring water quality can be done more thoroughly by combining the powers of RC boats and drones [14]. While RC boats can take water samples and data at precise depths and places, drones can capture aerial photographs and data. Through this partnership, the amount of pollution in aquatic bodies may be better understood in more detail and with greater accuracy.
- By using AI algorithms, the gathered data can be analysed more precisely and quickly. Pollution levels can be predicted by these technologies, and they can also recommend suitable mitigation techniques.

CONCLUSION

Our water quality monitoring RC boat is a cost-effective solution for continuously monitoring the quality of water. The boat can be operated by a user at a safe distance thereby eliminating any kind of physical presence near polluted water bodies. Anyone can operate the boat with the help of remote-control present on the mobile phone. The system has proved its capability to travel and collect various parameters that helps us to determine the quality of water. The system has proven its capability to visually present the data collected in real time to the user through IOT devices ensuring easy

interpretation and analysis for users. The data collected were also stored efficiently for accessing later. The system provides real time and accurate data that contributes to environmental conservation efforts and promotes sustainable water resource management. The effectiveness of the system was confirmed by conducting experiments on stagnated water bodies and water storage tanks as it consistently provided accurate results.

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