IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

Smart Microplastic Detection and Water Quality Monitoring System

Monica S, Nithya Sri A, Priyadharshini K, Tanu Sri G
Dept. of Electronics and Communication
K Ramakrishnan College of Technology Trichy, Tamil Nadu, India

Abstract : *The issue of microplastics in the environment has become a growing concern, particularly in rivers, lakes, and other water sources. Microplastics are tiny plastic particles and fibres that can enter water bodies through waste disposal, wastewater, and environmental activities. This project presents a low-cost Microplastic Detection and Water Quality Monitoring System using an ESP32 development board, laser module, and Light Dependent Resistor (LDR) sensor. A 12V water pump is used to transfer the water sample through a tube into the detection area. The laser module directs light through the flowing water sample, while the LDR sensor detects variations in light intensity caused by suspended particles. The ESP32 processes the sensor readings and compares them with a predefined threshold to identify significant optical variations. The proposed system demonstrates the integration of optical sensing, water pumping, and embedded technology for preliminary water sample analysis. It provides a simple and affordable approach for educational and experimental applications. However, factors such as turbidity, sediment, air bubbles, and other suspended particles may influence the sensor readings. Therefore, further testing and independent analysis are necessary to confirm the presence of microplastics.*

Keywords: Microplastics, Water Quality Monitoring, ESP32, Laser Sensor, Light Dependent Resistor, Optical Particle Detection, Embedded Systems, Internet of Things

I. INTRODUCTION

Water pollution has become one of the major environmental problems in recent years. Among the different types of pollutants, microplastics have received considerable attention because of their small size and ability to remain in water for a long time. These particles are mainly formed from the breakdown of plastic materials and can enter rivers, lakes, ponds and other water sources through domestic waste, industrial activities and wastewater discharge.

Since microplastics are very small, identifying them through normal observation is difficult. Their presence in water may also affect aquatic organisms and the overall quality of the environment. Traditional methods used for identifying microplastics generally involve collecting water samples and examining them through laboratory-based techniques. Although these methods can provide useful information, they often require special equipment, trained personnel and more time for analysis. This creates a need for a simple and affordable system that can help in the preliminary observation of suspended particles in water samples. Optical sensing is one possible approach because it uses light to observe changes caused by particles present in the water.

The proposed system is developed using an ESP32 development board, a laser module and a Light Dependent Resistor (LDR) sensor. A 12V water pump is used to move the water sample through a small tube placed in the detection area. The laser module produces a light beam that passes through the flowing water, while the LDR senses the changes in light intensity caused by suspended particles. The ESP32 receives the sensor readings and processes them based on a predefined threshold value.

The main aim of this project is to develop a low-cost prototype for preliminary microplastic detection and water quality monitoring. The system combines water pumping, optical sensing and embedded technology in a single setup. It can be useful for educational activities and experimental water sample analysis. However, the optical readings may also be

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

affected by dust, sediment, air bubbles and other particles. Therefore, laboratory testing is required to confirm whether the detected particles are actually microplastics.

REQUIREMENTS

The system requires an ESP32 development board, laser module and LDR sensor to detect changes in light intensity. A 12V DC water pump is used to move the water sample through the detection tube. A suitable power supply, resistors and connecting wires are needed to complete the circuit. Arduino IDE is used for programming the ESP32 and processing the sensor readings..

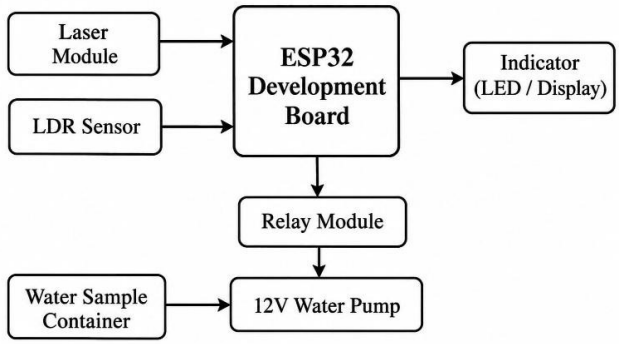


Figure 1: Block Diagram

A. ESP32 Microcontroller

ESP32 is the main controller used in this project. It receives the readings from the LDR sensor and processes them according to the program. It checks the changes in light intensity and compares the values with a fixed threshold. It also controls the operation of the water pump through the relay module.

B. Lasor module

The laser module is used to produce light in the detection section. It is placed in front of the LDR sensor so that the light passes through the water sample. When particles are present in the water, the light passing through the sample may change. This change is used for observing the presence of suspended particles.

C. LDR Sensor

The LDR sensor is used to measure the light received from the laser module. Its resistance changes depending on the amount of light falling on its surface. When the water sample passes through the tube, suspended particles may affect the light reaching the sensor. The sensor sends the corresponding voltage readings to the ESP32.

D. 12V Water Pump

A 12V water pump is used to move the water sample from the container to the detection tube. It helps the water flow through the sensing area during the process. The pump provides a continuous water supply for testing the sample.

E. Relay Module

The relay module is used to switch the water pump ON and OFF. It receives the control signal from the ESP32 and operates the pump when required. It also helps control the pump using the low-voltage controller circuit.

F. Power supply

The power supply provides the required voltage to the different components. The 12V supply is used for the water pump, while the ESP32 and sensor circuit require their respective operating voltages. Proper power connections are important for the smooth working of the system.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

G. PCB and Connecting Wires

The PCB is used to arrange the electronic components and maintain proper circuit connections. Connecting wires are used to link the ESP32 with the laser module, LDR sensor and relay module. These components help keep the circuit organized and make the hardware setup easier to assemble..

II. IMPLEMENTATION

A. Circuit Diagram

The circuit diagram shows the complete connection of the Microplastic Detection and Water Quality Monitoring System. The ESP32 development board acts as the main controller and is connected to the laser module and LDR sensor. The laser produces a light beam through the water sample, and the LDR receives the light from the opposite side. When suspended particles are present in the water, changes may occur in the received light intensity. The LDR converts these changes into voltage signals and sends them to the ESP32 for processing.

The water pump is connected to the ESP32 through a MOSFET driver circuit. The ESP32 controls the pump using a signal from GPIO26, while the LDR output is connected to the analog input GPIO34. A flyback diode is connected across the pump to protect the circuit from voltage spikes. The power supply section consists of two

3.7V lithium-ion batteries, a battery protection circuit, a boost converter and a voltage regulator. The boost converter provides 12V for the water pump, while the regulated supply provides the required voltage for the ESP32 and sensor circuit. All the components share a common ground connection to ensure proper circuit operation.

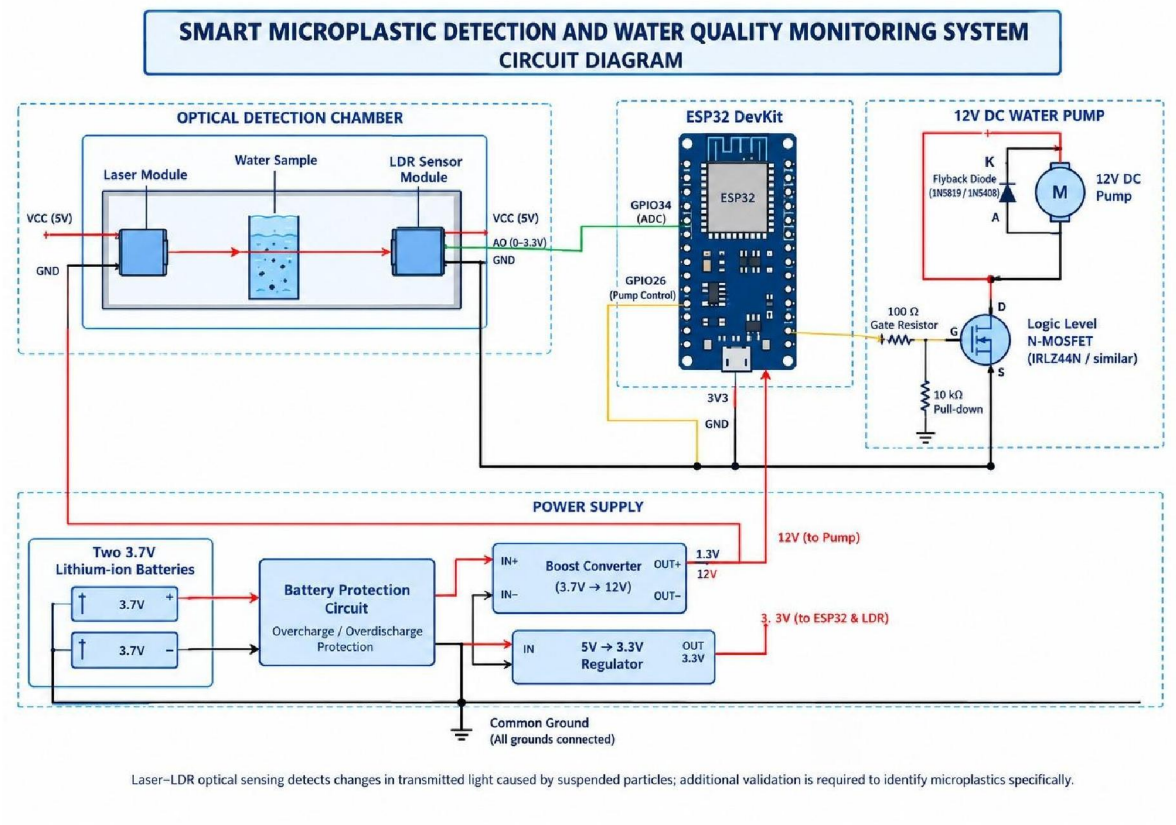


Figure 2: circuit diagram

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

B. Flow Diagram

The working process of the proposed Microplastic Detection and Water Quality Monitoring System starts when the power supply is switched ON. The ESP32 development board is initialized along with the laser module and LDR sensor. All the components are made ready for operation.

First, the water sample is collected in a container. The 12V DC water pump transfers the sample through a tube into the detection chamber. This allows the water to pass through the sensing area during the detection process.

The laser module is placed on one side of the tube and produces a light beam towards the LDR sensor. The light passes through the water sample before reaching the sensor. If suspended particles are present, they may affect the amount of light received by the LDR.

The LDR sensor detects the changes in light intensity and produces corresponding voltage variations. These readings are sent to the ESP32 through its analog input pin. The controller reads the sensor values while the water sample passes through the detection area.

After receiving the readings, the ESP32 compares the values with a predefined threshold. If the reading crosses the threshold, the system gives an indication that suspended particles may be present in the sample. If the reading does not cross the threshold, the system indicates that no significant change has been detected.

Finally, the output is indicated through the connected LED or alert system. The same process is repeated for the next water sample to observe further changes in light intensity. This method provides a simple way to monitor suspended particles in water.

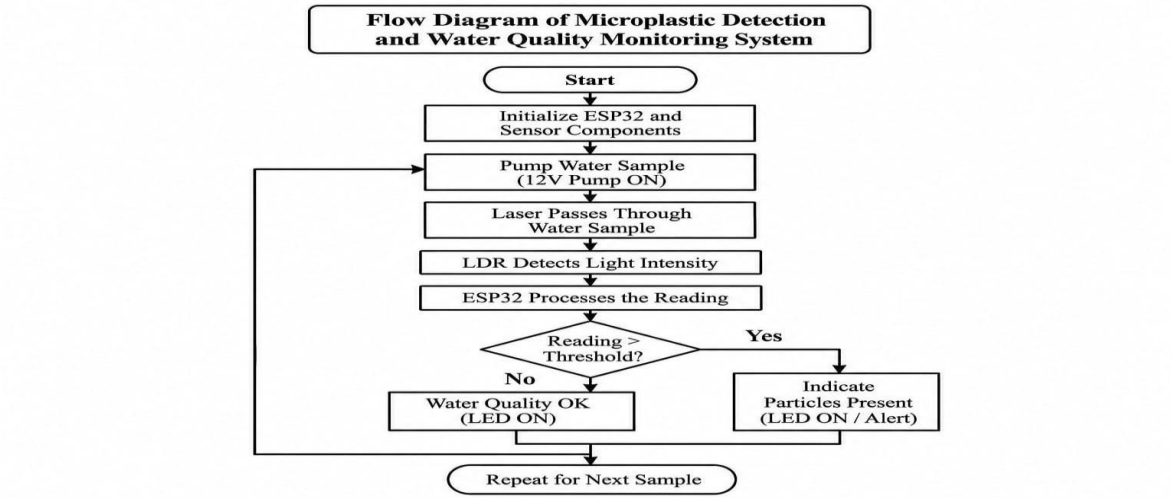


Figure 3: Sequence of Operation

III. OPERATION

The system is switched ON by supplying power to the ESP32 development board and other connected components. Once the power is given, the ESP32 starts working and the laser module and LDR sensor are ready for detection. The water sample is collected in a container, and the 12V water pump is used to move the water through a small tube. The water passes through the area where the laser light is focused. The LDR sensor is placed opposite to the laser module to receive the light passing through the sample.

When the water flows through the tube, suspended particles may block or scatter some of the laser light. Due to this, the amount of light received by the LDR sensor changes. The LDR converts these changes into electrical signals and sends the readings to the ESP32.The ESP32 receives the sensor values and compares them with a predefined threshold. Based on the readings, the controller identifies whether there is a noticeable change in the light intensity. The result is then indicated through the connected output device.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 2, November 2026 Impact Factor: 8.2

The same process is continued for different water samples. This helps to observe changes in the samples and provides a simple method for preliminary particle detection and water quality monitoring.

IV. ADVANTAGES

1. The system is simple to design and easy to operate.
2. It uses low-cost components, which helps reduce the overall project cost.
3. The ESP32 processes the sensor readings quickly.
4. The water sample can be tested without complicated laboratory equipment.
5. The system can be used for continuous observation of changes in water samples.

V. APPLICATIONS

1. Monitoring suspended particles in drinking water samples.
2. Checking water quality in rivers, lakes and ponds.
3. Preliminary detection of particles in wastewater.
4. Educational and research laboratory experiments.
5. Monitoring water samples in small-scale industries.

VI. DISADVANTAGES

1. The LDR sensor cannot identify microplastics separately from other particles.
2. Dust, air bubbles and sediments may affect the sensor readings.
3. The accuracy depends on the arrangement of the laser and LDR sensor.
4. Regular cleaning of the tube and sensors is required.
5. Laboratory testing is needed to confirm the presence and type of microplastics.

VII. CONCLUSION AND FUTURE WORK

In this paper, it is shown how Smart Component Organizer organizes and manages the components significantly with the use of voice assistant. We believe that the derived smart organizer model is important not only because it helps to improve the efficiency of the operations in the specific domain but it also has good implications to a more general domain. Figure 8 shows the Smart Component Organizer. In future research, we plan to extend our analysis to a more challenging case when the storage space is a decision variable. We also plan to use actuators to push the storage unit of the most promising location identified for the searched component.

REFERENCES

[1] J. Li, H. Liu, and J. P. Chen, “Microplastics in freshwater systems: A review on occurrence, environmental effects, and methods for microplastics detection,” Water Research, vol. 137, pp. 362–374, 2018.
[2] B. O. Asamoah, B. Kanyathare, M. Roussey, and K. E. Peiponen, “A prototype of a portable optical sensor for the detection of transparent and translucent microplastics in freshwater,” Chemosphere, vol. 231, pp. 161–167, 2019.
[3] C. Berkel and O. Özbek, “Methods used in the identification and quantification of micro(nano)plastics from water environments,” South African Journal of Chemical Engineering, vol. 50, pp. 388–403, 2024.
[4] M. Cai et al., “Current status and emerging techniques for sampling, separating, and identifying microplastics in freshwater environments,” Trends in Analytical Chemistry, vol. 184, 2025.
[5] A. A. Liza et al., “Microplastic pollution: A review of techniques to identify microplastics and their threats to the aquatic ecosystem,” Environmental Monitoring and Assessment, vol. 196, 2024.
[6] B. O. Asamoah, M. Roussey, and K. E. Peiponen, “On optical sensing of surface roughness of flat and curved microplastics in water,” Chemosphere, vol. 254, 2020.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

[7] K. E. Peiponen, J. Räty, U. Ishaq, S. Pélisset, and R. Ali, "Outlook on optical identification of micro-and nano plastics in aquatic environments," Chemosphere, vol. 214, pp. 424–429, 2019.
[8] Z. Huang, B. Hu, and H. Wang, "Analytical methods for microplastics in the environment: A review," Environmental Chemistry Letters, vol. 21, pp. 383–401, 2023.
[9] S. Mahapatra et al., "Microplastics and nano plastics in environment: Sampling, characterization and analytical methods," Groundwater for Sustainable Development, 2024.