International Journal of Environmental Chemistry
E-ISSN: 2456-5245
Volume- 12, Issue- 01, Year- 2026
Research Article
Received Date: February 13, 2026
Accepted Date: May 11, 2026
Published Date: May 20, 2026

Transportable Water and Air Quality Monitoring Equipment

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Abstract

The purpose of this article is to provide a broad summary of recent discoveries, identify important constraints, and suggest future lines of inquiry. In recent years, pollution has surpassed the environment's bearing capacity. There hasn't been much progress despite the installation of multiple pollution-control initiatives. Natural resources are occasionally exploited by unavoidable waste discharges, despite our government's best attempts to safeguard them. For instance, the water-intensive and polluting sectors of textiles, leather, sugar, and paper have altered in recent decades due to their large-scale water extraction and untreated effluent discharge. To address this, better pollution-linked databases and ecosystem-balancing technologies are needed. There are several pollution tracking technologies in the literature, however they are all based on traditional databases. The integration of IoT-based technologies enables real-time monitoring of critical parameters, such as temperature and humidity, in industrial waste and air management systems. Continuous assessment of environmental pollution is essential for preserving biodiversity, preventing ecosystem degradation, and safeguarding human health. While traditional methods for evaluating air and water quality are scientifically reliable, they often suffer from limitations including high operational costs, low spatiotemporal resolution, slow data processing, and restricted scalability. Recent advancements in machine learning have facilitated the development of more efficient and robust solutions to address these challenges. Supervised learning paradigms like random forests, support vector machines, and deep neural networks are especially notable since they have shown great success in low-cost sensor array calibration, anomaly detection, and

pollution forecasting. The groundwork for future intelligent stewardship systems that will be transparent, scalable, and successful after 2025.

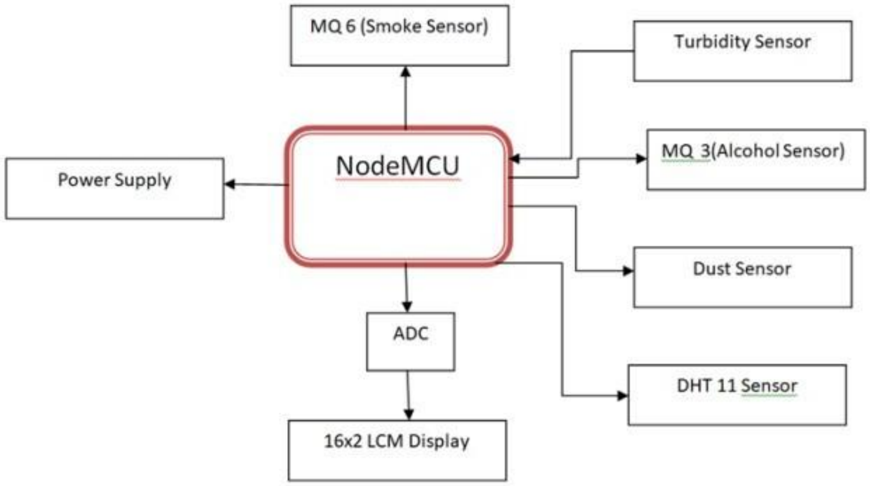
Key Words - Arduino, Environmental Monitoring, MQ135, pH Sensor, Turbidity Sensor, DS18B20, Air Quality, Water Quality, LCD Display.

1. Introduction

In recent years, pollution levels have exceeded the environment's capacity to sustain them. No progress has been made despite the introduction of numerous pollution-control regulations. Been produced. Furthermore, uncontrolled waste discharges do occasionally occur due to unforeseen events, despite our government's best attempts to protect the atmosphere. Industries such as textiles, leather, sugar, and paper—known for their high water consumption and pollution—have experienced significant transformation in recent decades. These industries use enormous amounts of water and discharge effluents carelessly. To combat this, effective databases pertaining to pollution and ecosystem-balancing techniques should be reinforced. Internet of Things (IoT)-based technologies integrate sensors capable of measuring parameters such as pH, temperature, turbidity, and carbon monoxide concentration, enabling real-time data transmission to online databases for effective monitoring of pollutants in industrial wastewater and air treatment systems. Despite these advancements, environmental pollution in air and water remains a critical challenge, significantly impacting human health, ecological balance, and the achievement of global sustainability objectives. Precise assessment of pollutants is necessary to comprehend environmental risk, devise mitigation methods, and facilitate evidence-based policymaking [1,2,3]. Air pollution monitoring has historically relied on site-specific stations and sampling, which is frequently time-consuming, expensive, and limited in both space and time [2,4]. Higher-resolution environmental data may now be obtained more affordably thanks to recent developments in sensor networks, Internet of Things sensors, and remote sensing technologies [2,5]. This advancement has significantly increased the capacity to monitor pollution more effectively and in real-time, increasing the accessibility, scalability, and affordability of pollution detection [5].

2. Methodology

Every analog sensor in this device will be linked to the NodeMCU. The DHT11 temperature sensor functions within a voltage range of 0–5 V and exhibits a resistance between 55 and 1500 ohms. The turbidity sensor operates across a 0–100% range with an output of 3–5 V and requires a 12 V power supply. The MQ-6 and MQ-3 gas sensors are highly sensitive to combustible gases, including LPG, propane, hydrogen, and methane (Fig 1). All analog sensors have input voltages between 0 and 5 volts, and their Vcc pins are linked to the NodeMCU's digital ports Vin and GND.



[6,7,8]

(Fig.1 Node MCU Multi-Sensor System)

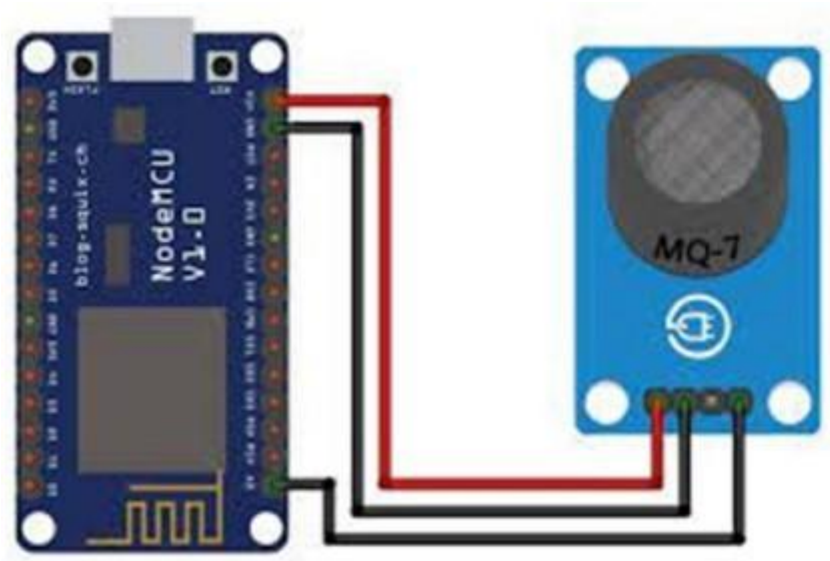
3. 3.1. Integration of NODE MCU

The ESP32 is equipped with antenna switches, RF baluns, power amplifiers, lownoise receive amplifiers, filters, and power control modules. ESP32 delivers invaluable flexibility and agility to your applications with minimal Printed Circuit Board (PCB) specifications.[9-11]

- Memory: 520 KB SRAM and 448 KB ROM
- CPU: Xtensa® 32-bit LX6 single/dual core microprocessor
- Among the oscillators used in clocks are an external 2 MHz to 60 MHz crystal oscillator, an internal 8 MHz oscillator, and an internal RC oscillator.
- Timers: One RTC timer, two sets of timers, and one RTC watchdog 34 GPIOs, 4 SPIs, 2 I2S, 2 I2C, 3 UART, CAN 2.0, 1 host (SD/eMMC/SDIO), 1 slave (SDIO/SPI), 34 GPIOs, 4 SPIs, 2 I2S, 2 I2C, 3 UART, CAN 2.0, 1 host (SD/eMMC/SDIO), 1 slave (SDIO/SPI)
- ADC: 12-bit SAR ADC with up to 18 channels
- Digital-to-analog converter (DAC): 2 x 8-bit DAC

3.2. NodecMCU interfacing with MQ-06 and MQ-03

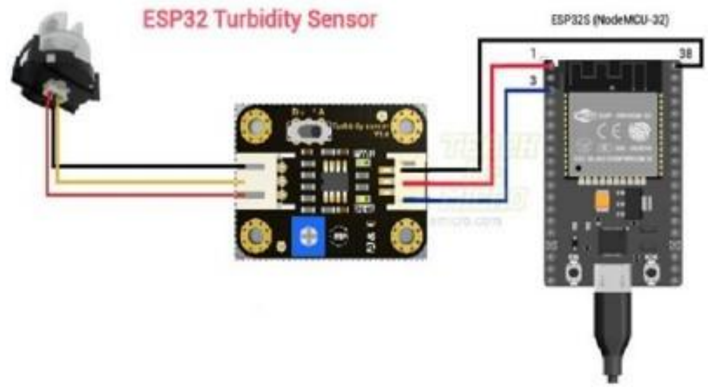
H2, alcohol, LPG, CH4, and smoke are among the gases that the MQ-06 and MQ-03 gas sensors can identify. It reacts quickly when it detects smoke. Gas produces voltage as it approaches the coil field. Since the output voltage is directly proportional to the gas concentration, an increase in gas concentration results in a corresponding rise in output voltage. An ESP32 board-based microcontroller, orMCU, readsthisvoltage.[9,10].The programming determines what has to be done based on the voltage calculation. This user-friendly sensor measures the amount of liquefied petroleum gas (LPG) in the air, mostly propane and butane (Fig 2). Gas concentrations between 200 and 10,000 parts per million (ppm) can be detected using the MQ-6.[12,13]



(Fig. 2 NodeMCU with MQ-7 Gas Sensor)

3.3. Node MCU interfacing with turbidity sensor

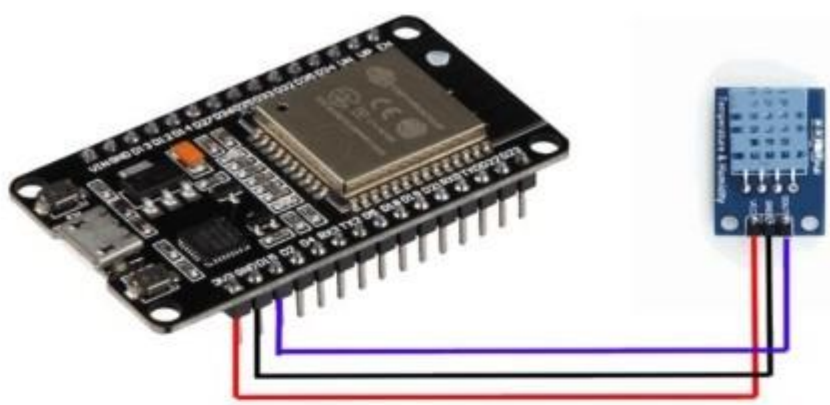
The turbidity sensor from DFRobot consists of a submersible probe and a surface-mounted controller. A switch on the controller board allows selection between digital and analog output modes. In digital mode, the sensor outputs a low voltage when the water contains a high level of suspended particles. The threshold for detecting “turbidity” can be adjusted through the controller’s sensitivity, which is regulated using the blue potentiometer (Fig 3).



(**Fig. 3 ESP32 with Turbidity Sensor)**

3.4. Interfacing Temperature and Humidity sensor with NodeMCU

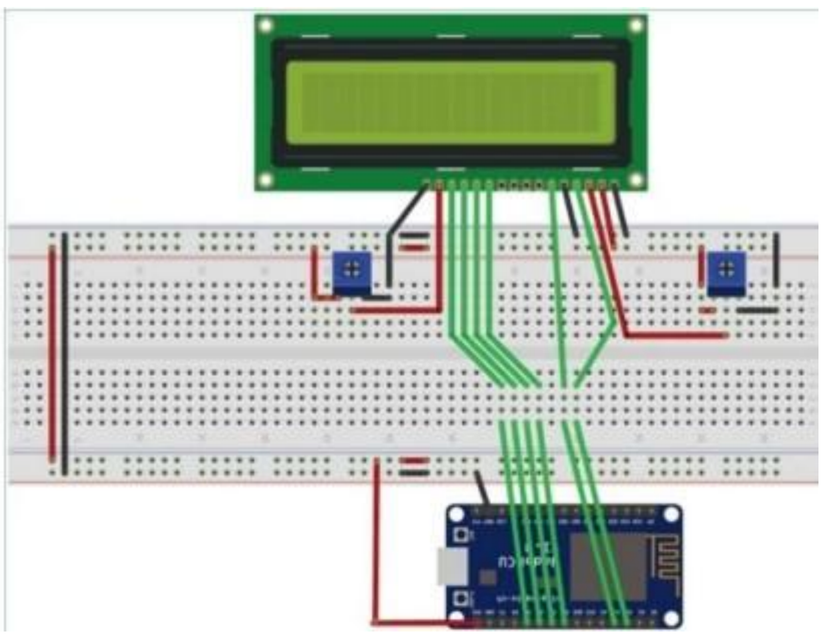
The DHT1 sensor features four pins—GND, VCC, data, and one unused pin. A pull-up resistor in the range of 5K to 10K ohms is necessary to keep the data line high, enabling proper communication between the sensor and the Arduino board. Three-pin breakout boards with an integrated pull-up resistor are included with each of these sensors.[14] 3.5 to 5.5 volts is the voltage regulated current, or Vcc. The data's outputs include temperature and humidity (Fig 4).



(Fig. 4 ESP32 with DHT Sensor Module)

3.5. Interfacing 16x4 LCD display with NodeMCU

Basic data may be viewed quickly and affordably with LCD panels. This tutorial explains how to interface a 16×2 LCD display with an ESP8266 NodeMCU development board using the I2C protocol. The LCD communicates with the NodeMCU through I2C, which simplifies the connection as it requires only two wires. Establishing the connection is straightforward: connect one of the NodeMCU's GND pins to the LCD's GND pin, and link the LCD's VCC pin to the NodeMCU's Vin pin. The Vin pin of the NodeMCU is powered via the 5V supply from the USB input. Finally, connect the SDA pin of the LCD to the D2 pin of the NodeMCU (Fig 5).



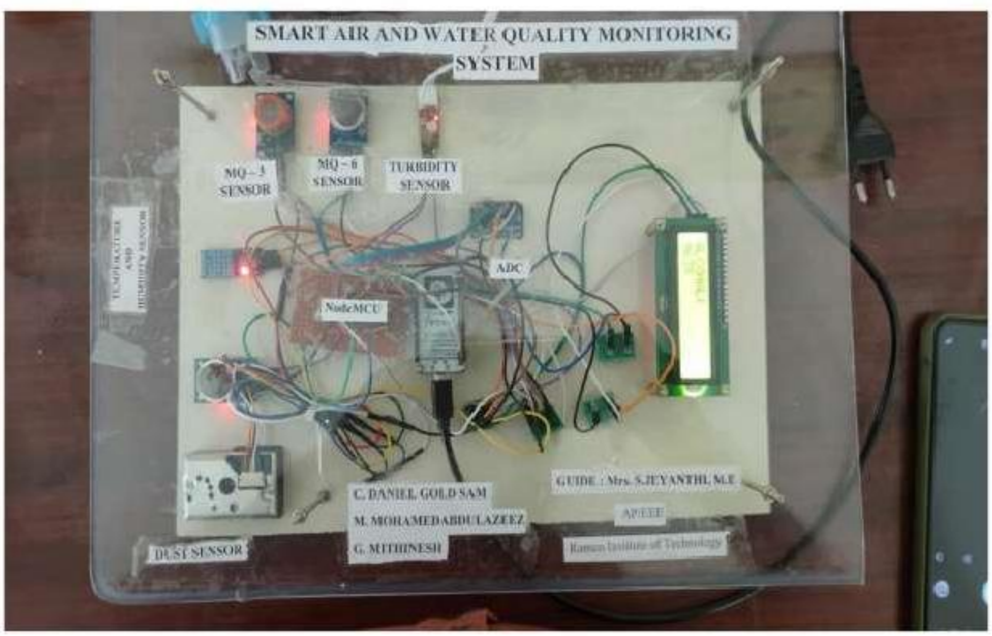
(Fig. 5 Bread Board Setup for LCD Display with Node MCU)

4. Working

The main goal is to utilize IoT technology to design an intelligent monitoring system for tracking air and water pollution. The system incorporates NodeMCU along with MQ-03 and MQ-06 gas sensors, dust sensors, turbidity sensors, and DHT11 sensors to effectively detect and monitor various particulates, gases, humidity levels, and water quality parameters. We are integrating each of these elements, as was already described. The blink mobile app stores the information gathered by the NodeMCU hardware. The data is then processed and changed dynamically in the cloud. [15, 16]

5. Result and Discussion

For instance, smoke, alcohol, temperature, humidity, and dust sensors are all monitored in terms of air quality. Water turbidity is measured. These values will be monitored and transmitted via IoT to a mobile application. The value is displayed on an LCD panel because turbidity cannot be measured. Water in rivers and wetlands is becoming extremely contaminated due to industrial effluents, which raises turbidity and lowers air quality. IoT is proposed as a way to monitor water and air quality using several sensors. The literature claims that laboratory techniques for manual data processing are time-consuming. The systems fail to generate accurate results and lack the capability for long-range communication. This approach has been suggested. It controls the temperature and ppm of the water and air. It can be utilized even when the internet is unavailable because of Bluetooth. The project has many uses in the assessment and control of water and air quality (Fig 6).



(Fig.6 Smart air and water quality Monitoring System)

Conclusion

The development of transportable water and air quality monitoring equipment represents a significant advancement in environmental assessment and management. These portable systems enable real-time, on-site analysis of key physical, chemical, and biological parameters, thereby reducing the dependence on centralized laboratory facilities and minimizing delays in data acquisition. Their adaptability, ease of deployment, and cost-effectiveness make them particularly valuable for remote, resource-limited, and emergency-affected areas.

Moreover, combining sensor technologies with wireless communication and advanced data analytics significantly improves monitoring precision and enables continuous environmental assessment. These systems aid in prompt decision-making, allow early identification of pollution incidents, and support the efficient execution of mitigation measures. In summary, portable monitoring equipment is essential for advancing sustainable environmental management, protecting public health, and ensuring adherence to regulatory standards.

In addition, the integration of Internet of Things (IoT) frameworks and cloud-based platforms further enhances the functionality of portable monitoring systems by enabling real-time data transmission, storage, and remote accessibility. This facilitates collaborative analysis among researchers, policymakers, and environmental agencies, improving transparency and response coordination. The miniaturization of sensors and advancements in battery technology have also increased the mobility and operational lifespan of these devices, making them suitable for deployment in remote and resource-limited regions. Furthermore, the use of machine learning algorithms allows for predictive analysis, helping to forecast environmental trends and potential hazards. Overall, these innovations contribute to more resilient, data-driven environmental monitoring strategies.

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