

IOT BASED WATER AND AIR QUALITY MONITORING SYSTEM AND ANALYSIS

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Abstract

Air and water are crucial for sustaining life. Traditionally, testing their quality requires manually collecting samples and analyzing them in a laboratory, which is time-consuming, labor-intensive, and costly. This project focuses on designing and developing an IoT-based system for monitoring air and water quality in real time. The system utilizes multiple sensors to measure key parameters, including pH, TDS, temperature, turbidity, MQ3 (for gas detection), and dust levels. A Wi-Fi module facilitates data transmission from the sensors to a microcontroller, which then sends the information to a smartphone or PC using the ThinkSpeak API. Additionally, an alert mechanism is integrated to notify Pollution Control Board (PCB) officials whenever the quality of air or water falls below safe thresholds. By enabling continuous monitoring, this system helps in effectively managing pollution levels and safeguarding environmental and public health.

Index Terms - IOT, Turbidity, TDS, Temperature, pH, Gas, Dust, ADC, ThinkSpeak.

I. INTRODUCTION

The Internet of Things (IoT) is a network of interconnected computing devices, mechanical and digital machines, objects, animals, or individuals, each assigned a unique identifier (UID) and capable of transmitting data over a network without requiring human-to-human or human-to-computer interaction. IoT enables remote control of objects using existing network infrastructure, making it an innovative and efficient technology that reduces human effort while providing seamless access to physical devices.

One of the key features of IoT is its autonomous control capability, allowing devices to function independently without human intervention. In an article published in the RFID Journal in 1999, Kevin Ashton stated, *"If we had computers that knew everything there was to know about things—using data they gathered without any help from us—we'd be able to track and count everything and greatly reduce waste, loss, and cost. We need to empower computers with their own means of gathering information so they can see, hear, and smell the world for themselves in all its random glory."*

This is exactly what IoT platforms accomplish. They enable devices to monitor, detect, and analyze situations or environments without relying on human input. The Internet of Things connects embedded devices across various systems to the internet, allowing them to be digitally represented and controlled from anywhere. As a transformative technology, IoT helps businesses enhance efficiency through IoT analytics and security, ensuring improved performance and decision-making. Industries such as utilities, oil and gas, insurance, manufacturing, transportation, infrastructure, and retail can benefit significantly from IoT by leveraging the vast amount of real-time interactive and transactional data available.

Water pollution arises from multiple factors, leading to environmental and health hazards.

Water pollution occurs due to various factors, with some of the major causes including sewage and wastewater discharge, industrial waste, dumping, oil spills, acid rain, global warming, and eutrophication. Similarly, the rapid rise in the number of vehicles and industries in urban areas has significantly contributed to the deterioration of air quality. Air pollution refers to the presence of harmful contaminants in the atmosphere, such as gases, in concentrations that can negatively impact humans, animals, and plants. These pollutants are typically measured in Parts per Million (ppm).

The Central Pollution Control Board (CPCB) has been actively working to reduce pollution levels and has established standardized methods for monitoring air and water quality. However, pollution levels continue to rise daily, prompting researchers and scientists to explore solutions for maintaining and improving environmental quality.

This paper primarily focuses on monitoring and analyzing the quality of water and air. The objective is to assess whether environmental conditions are suitable for living beings and plant life. While numerous factors influence air and water quality, this study emphasizes key parameters such as Total Dissolved Solids (TDS), pH, turbidity, and temperature in water, as well as gases and dust in the air. The research introduces a novel approach to developing a water and air quality measurement system, which can serve as a foundation for future advancements in environmental monitoring technology. This work aims to assist new researchers in designing improved systems for evaluating and maintaining water and air quality.

II. PROPOSED METHODOLOGY

The proposed system simplifies the process while enhancing performance by collecting real-time data on key water and air quality parameters. For water, it monitors temperature, Total Dissolved Solids (TDS), pH, and turbidity, while for air, it measures dust and gas concentration. The collected data is continuously updated to the ThinkSpeak server, allowing remote access from anywhere in the world using a unique channel ID. If pollution levels exceed safe limits, making the air or water unsuitable for consumption, breathing, or other uses, an alert is automatically sent to the Pollution Control Board (PCB) officials. This system is suitable for deployment in urban and industrial areas, such as SIPCOT in Perundurai, Tamil Nadu, to effectively monitor and regulate pollution levels.

Arduino:

The Arduino UNO is the best board to get started with electronics and coding. If this is your first experience tinkering with the platform, the UNO is the most robust board you can start playing with. The UNO is the most used and documented board of the whole Arduino family.



Fig: Arduino

ESP32

ESP32 is a series of low-cost, low-power system-on-chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth.



Fig: ESP32

Temperature Sensor

The water temperature sensor enables the control unit to identify engine overheating or an unusual rise in temperature. Depending on the car manufacturers, it is usually installed next to the thermostat or inside it



Fig: Temperature sensor

Features

- Power supply range is 3.0V to 5.5V
- Measures temperatures from -55°C to +125°C. Fahrenheit equivalent is -67°F to +257°F
- $\pm 0.5^\circ\text{C}$ accuracy from -10°C to +85°C
- Converts 12-bit temperature to digital word in 750 ms (max.)

Turbidity Sensor

Turbidity sensors detect the level of suspended particles in water by measuring how much light is scattered. Higher concentrations of total suspended solids (TSS) result in increased turbidity, making the water appear cloudier or hazier.

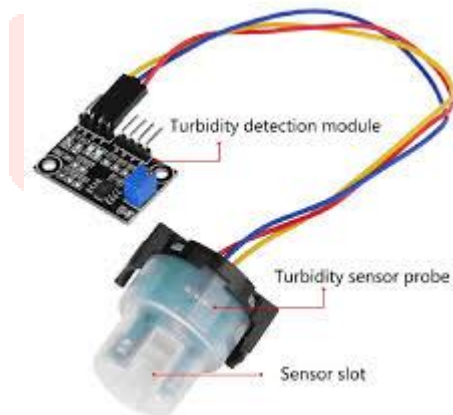


Fig: Turbidity Sensor

Features

- Operating Voltage: 5V DC
- Response Time: <500ms
- Output Method: Analog
- Analog output: 0-4.5V
- Digital Output: High/Low level signal (you can adjust the threshold value by adjusting the potentiometer)
- Operating Temperature: -30 °C~80 °C.

Total Dissolved Solids (TDS) Sensor

TDS (Total Dissolved Solids) indicates that how many milligrams of soluble solids dissolved in one liter of water. In general, the higher the TDS value, the more soluble solids dissolved in water, and the less clean the water is. The TDS value can be used as one of the references for reflecting the cleanliness of water.



Fig: TDS sensor

Features

- Wide Voltage Input: 3.3~5.5V
- Good Compatibility Output: 0~2.3V analog signal output, compatible with 5V or 3.3V controller
- Waterproof Probe
- TDS Measurement Range: 0 ~ 1000ppm
- TDS Measurement Accuracy: $\pm 10\%$ F.S. (25 °C)

PH sensor

An analog pH meter is a specialized device used to measure the pH level of a solution, indicating its acidity or alkalinity. It is widely used in applications such as aquaponics, aquaculture, and environmental water quality testing



Fig: pH Sensor

Features

- Hardware-filtered output signal with minimal interference.
- Easy plug-and-play setup with Gravity and BNC connectors.
- Standardized size and connectors for seamless integration into mechanical designs.

Signal Conversion Board (Transmitter) V2

- Output Voltage: 0~3.0V
- 3.3~5.5V wide voltage input
- Probe Connector: BNC
- Signal Connector: PH2.0-3P
- Measurement Accuracy: $\pm 0.1@25^{\circ}\text{C}$
-

pH Probe

- Probe Type: Laboratory Grade
- Detection Range: 0~14
- Temperature Range: 5~60°C
- Zero Point: 7±0.5
- Response Time: <2min

Gas sensor (MQ-135)

The MQ-135 Gas sensors are used in air quality control equipment and are suitable for detecting or measuring of NH₃, NO_x, Alcohol, Benzene, Smoke, CO₂. The MQ-135 sensor module comes with a Digital Pin which makes this sensor to operate even without a microcontroller.



Fig: Gas sensor (MQ-135)

Features

- Broad detection range.
- Quick response time with high sensitivity.
- Durable, stable performance with a long lifespan.
- Capable of detecting NH₃, NO_x, alcohol, benzene, smoke, CO₂, and more.
- Analog output voltage ranges from 0V to 5V.
- Digital output voltage operates at 0V or 5V (TTL logic).
- Functions as both an analog and digital sensor.
- Sensitivity of the digital output can be adjusted using a potentiometer.

Dust Sensor

A dust sensor helps assess air quality by measuring dust concentration in the environment. It determines the Particulate Matter (PM) level by calculating the Low Pulse Occupancy (LPO) time within a specific period, where a higher LPO time indicates a higher PM concentration. This sensor provides accurate data for air purification systems and is particularly sensitive to particles with a diameter of 1µm.



Fig: Dust Sensor

Features

- Grove compatible interface
- Supply voltage range: 5V
- Minimum detect particle: 1µm
- PWM output

In this system, it makes use of six sensors (Turbidity, temperature, pH, TDS, Gas sensor [MQ135], Dust sensor) and the Raspberry Pi controller connected. The six sensors capture the data in the analog signals. The ADC converter which converts the six-signal information into the digital format. The digital signals are passed to the Raspberry Pi controller which is together with the Wi-Fi. This system employs sensors such as pH, temperature, TDS, and turbidity in the water will analyze the quality of the water resources and the Gas and Dust sensor get data from the atmosphere.

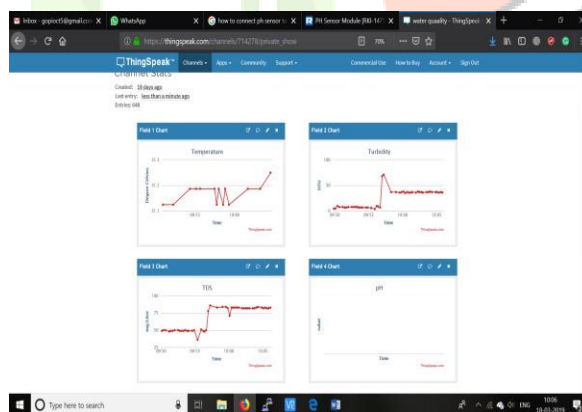
Working with Things peak

To begin using things peak, sign up to create a new account and set up a channel to store sensor data. ThingSpeak includes a 'status update field' for sending additional information. Assign appropriate field names, and if you choose the 'public' option, others will be able to access your data. After clicking 'Save Channel,' an API key will be generated.

An API key is a unique code used by applications to communicate with an API, identifying the calling program, developer, or user. If the setup is successful, the ThingSpeak API will return a '200 OK' status. Users can continuously add values and grant access to others. Sensor data is imported and transmitted to the channel in real time. Additionally, an alert system is in place to help prevent water and air pollution disasters.

III. EXPERIMENTAL RESULTS

The designed sensor node was deployed for monitoring the environmental air and water quality. Obtained sensor data from each node are archived in the corresponding local database and ThingSpeak cloud database. Below figure shows the screen shot on the ThingSpeak cloud channel creation. The local database is for remote monitoring, future retrieving and trend analysis. ThingSpeak cloud services is used for storing the data in the online cloud database mainly for running analytics services. Private and public view for the channel are configured in this cloud service.



The sample data are collected from SIPCOT Industrial area, Perundurai, Tamil Nadu, India. The result obtained shows increase in the pollution at a moderate rate. The Pollution Control Board officials will be alerted when the pollution goes high than the desired level.

IV. CONCLUSION

A cost-effective, efficient, and real-time system for monitoring water and air quality has been successfully developed and tested. This system allows authorities to continuously track pollution levels in water sources and the atmosphere, ensuring timely alerts to the public. By enabling early intervention, it helps reduce health risks caused by contaminated air and water. Additionally, immediate actions can be taken to control high pollution levels, particularly in rivers, industrial areas, and urban regions. Designed for easy installation, the system requires minimal training for operation, with the base station placed near the monitoring site.

The Internet of Things (IoT) and its related services have become an integral part of everyday life, industries, and business operations. Extensive research is being carried out to establish core frameworks and models for future web services, driven by a vast network of interconnected smart devices.

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