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Water Quality Monitoring Using IoT and AI

Real-Time Analysis and Disease Prediction for Safe Drinking Water

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Abstract :
This study focuses on developing a water quality monitoring system using Internet of Things (IoT) and Artificial Intelligence (AI) to ensure the safety of drinking water and predict potential health risks. The system employs NodeMCU v3 ESP8266 , Arduino Uno integrated with sensors, including a temperature sensor, turbidity sensor, and TDS sensor, to measure key water quality parameters. Based on the sensor data, SMS alerts are sent to users indicating whether the water is safe or contaminated, along with the measured values. Additionally, AI algorithms analyze the sensor data to predict possible diseases associated with specific water quality parameters, enabling proactive health measures. This system aims to prevent waterborne diseases by combining real-time monitoring with predictive analytics

Keywords **- Water Quality, IoT, Artificial Intelligence, Arduino Uno, Disease Prediction, SMS Alert**

I. INTRODUCTION

In this era of rapid technological advancements and developmental progress, pollution continues to pose a significant threat, affecting essential resources such as water. Borewell water, a primary source for many households, is increasingly at risk of contamination due to factors like sewage leakage and industrial waste discharge into rivers. The global lack of access to safe and clean drinking water remains a pressing issue, with the World Health Organization (WHO) estimating that approximately 844 million people are deprived of even basic water services. Additionally, waterborne diseases claim the lives of approximately 829,000 individuals annually, underscoring the urgent need for effective water quality monitoring and management systems.

Water contamination has severe implications for human health, including the spread of diseases such as cholera, typhoid, and diarrhea. Beyond microbial contamination, the ingestion of harmful chemicals, heavy metals, and pollutants from polluted water sources can result in long-term health conditions, including cancer, neurological disorders, and reproductive issues. Despite these dangers, current methods for assessing water quality remain inadequate. In most households, the perception of contamination is often based solely on changes in smell or color, which are unreliable indicators of water quality. Further, water quality adjustments, such as fixing total dissolved solids (TDS) or hardness, typically occur only after service personnel provide assessments, often based on periodic testing rather than real-time monitoring.

To address these gaps, a real-time water quality monitoring system integrated with predictive analysis for disease risk assessment is imperative. Such a system would enable timely intervention, safeguard public health, and enhance the overall quality of water management practices. This research focuses on developing a comprehensive solution that utilizes IoT and AI technologies to provide continuous water quality analysis and predict potential health risks based on sensor data.

II. LITERATURE REVIEW

Kai Chen, Xiaoli Wang, and Chengyou Wang introduced a high-precision turbidity monitoring system for drinking water using the scattering method in their 2023 publication. It is equipped with alarm functions to notify users when turbidity levels exceed the standard limits. The authors suggest future research directions to further enhance the system's performance.

A.P.U. Siahaan, Nogar Silitonga, Muhammad Iqbal, Solly Aryza, and Wirda Fitriani (2020) presented an Arduino Uno-based water turbidity meter that uses LDR and LED sensors. The system is noted for its ease of use and reliable measurements, ranging from clear to cloudy water conditions. The study concludes that this tool is a valuable resource for monitoring water turbidity levels efficiently. Rab Nawaz, Iqra Nasim, Ali Irfan, and colleagues (2023) explored the water quality index and human health risks associated with drinking water in urban areas. Their work highlights the importance of real-time water monitoring systems

for accurately detecting pollutants and ensuring water safety. They emphasize the flexibility and reliability of these systems for urban applications.

Md. Mahbubur Rahman, Chinmay Bapery, and Mohammad Jamal Hossain, among others, proposed an IoT-based water quality monitoring system in 2020. Their approach focused on creating a low-cost, real-time solution with scalability. The system allows for modular sensor additions, advocating for automated and cost-effective solutions to enhance water monitoring.

In 2022, Liping Yang and Joshua Driscol reviewed AI methods for automating water body detection and monitoring using remote sensing. They emphasized the potential of AI and machine learning in enhancing scalability and intelligent decision-making for water resource management. Their findings underline the importance of integrating AI with remote sensing technologies to optimize monitoring systems.

Irina Yaroshenko, Dmitry Kirsanov, and their team (2020) introduced chemical sensors for real-time pollutant detection in water. Their work highlighted the flexibility of molecularly imprinted polymers in designing effective monitoring systems. The study underscores the importance of real-time detection for addressing water contamination.

Robert Daren Harmel, Heather Elise Preisendanz, and others (2020) reviewed data quality and cost considerations for water quality monitoring at the field scale and in small watersheds. Their findings stress the critical role of accurate and reliable data for effective decision-making and resource protection. They call for improvements in data quality to enhance monitoring outcomes.

In 2023, Mithra Geetha, Sumalatha Bonthula, and colleagues explored research trends in cost-effective water quality monitoring systems, focusing on artificial intelligence. Their work highlights AI-driven real-time data analysis as a cost-reduction tool while preserving ecosystems and ensuring sustainable water management.

Farmnullah Jan, Nasro Min-Allah, and their team (2021) reviewed IoT-based smart water quality monitoring systems. Their study emphasized the recent techniques, trends, and challenges in designing efficient systems for domestic applications. They highlighted the potential of IoT in creating smarter, more effective water monitoring solutions.

III. PROPOSED SYSTEM

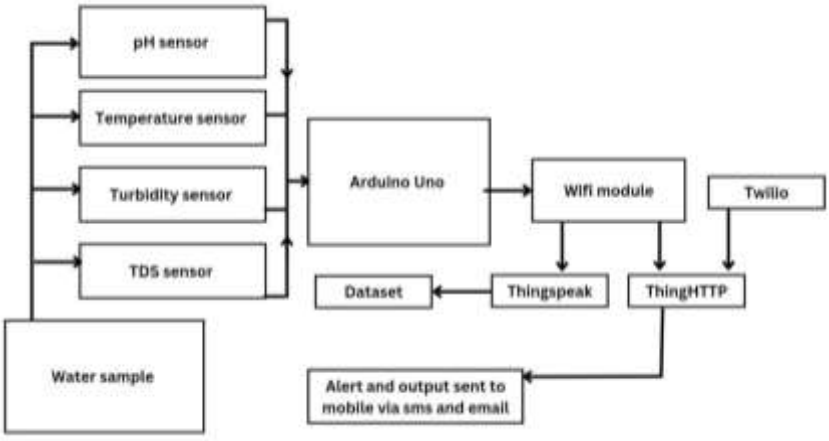


Fig.Block Diagram

The proposed system is an advanced water quality monitoring solution that integrates IoT and AI technologies to provide real-time contamination detection and health risk assessment. This system uses a combination of sensors, including TDS, turbidity, and temperature sensors, interfaced with NodeMCU ESP8266 and Arduino Uno, to ensure accurate and reliable measurements of water quality parameters.

The collected data is transmitted to the ThingSpeak IoT platform for visualization and storage. Through ThingHTTP and SMS alerts, users receive real-time notifications about water quality status and contamination levels. Additionally, the system incorporates an AI-based predictive model developed using Google Collab to analyze the relationship between TDS, turbidity, and temperature data. This model predicts potential waterborne diseases based on contamination levels, providing actionable insights for users.

The modular design of the system ensures scalability and adaptability, allowing it to be deployed in diverse environments. By integrating real-time monitoring with predictive health analysis, this proposed system bridges the gap between water quality assessment and proactive health management, offering a comprehensive and user-friendly solution for addressing water contamination challenges.

IV. SOFTWARE FLOW DIAGRAM

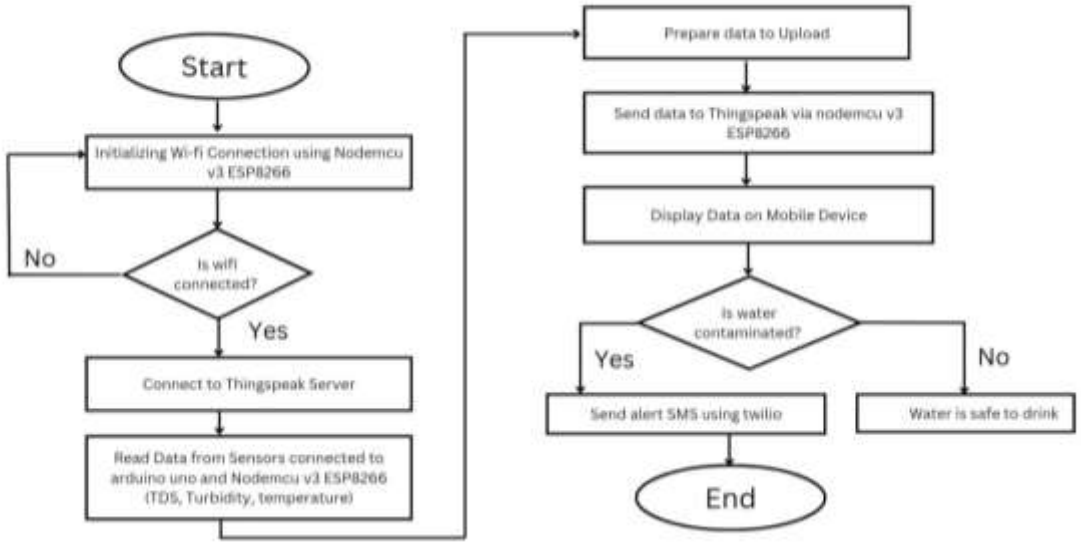


Fig. Iot flow diagram

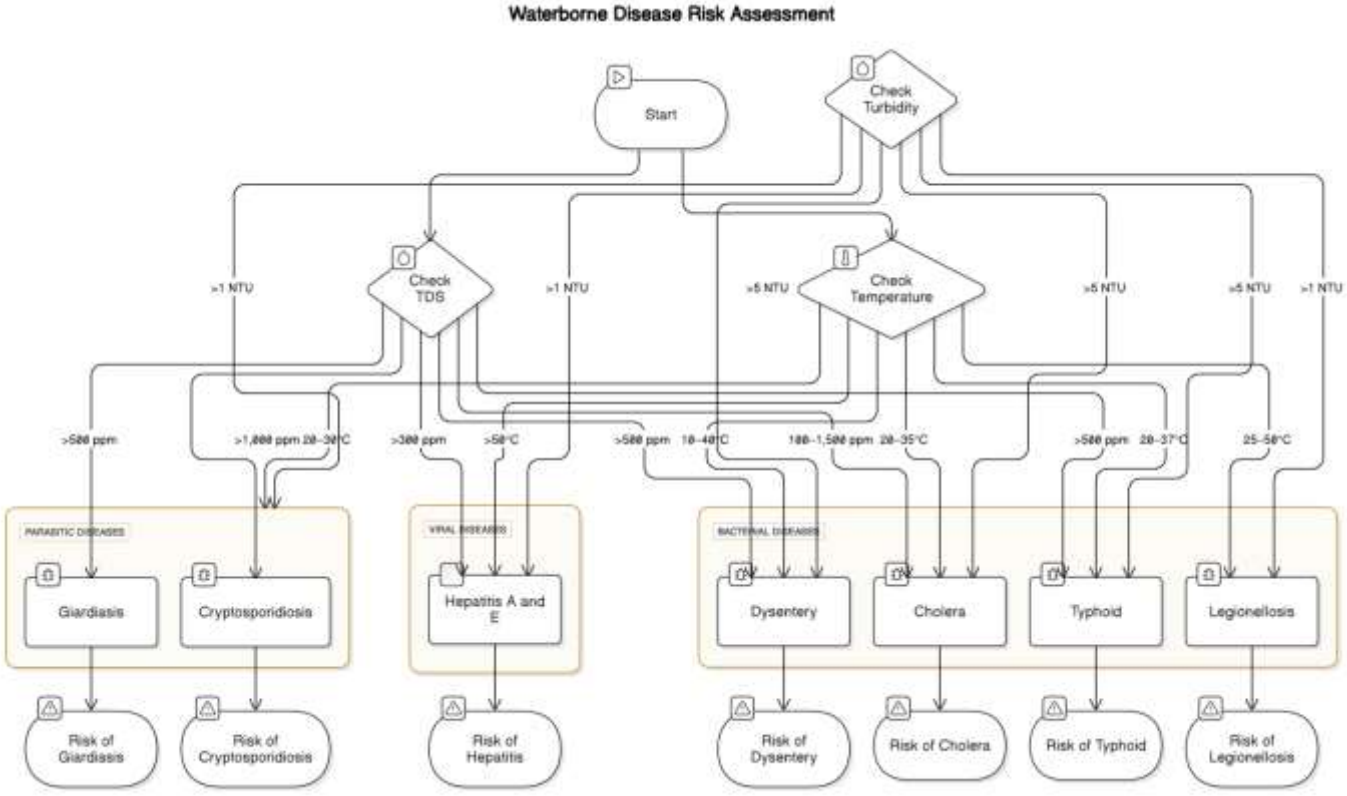


Fig. AI Predictive model flow diagram

V. METHODOLOGY

5.1 Hardware

-Arduino Uno
-NodeMCU v3 ESP8266
-Temperature sensor -DS18B20
-Turbidity Sensor
-TDS sensor and meter
-2.2K ohm Resister
-1K ohm Resister
-Breadboard

5.2 Software
-Thingspeak
-ThingHTTP
-Twilio
-Google Collab
-Arduino IDE

1. **Arduino UNO board**:- Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins.It allows users a simple pathway to creating interactive objects that can take input from switches and sensors, and control physical outputs like lights, motors.

Fig.Arduino Uno

2. **Turbidity Sensor**:-Turbidity Sensor measure the amount of light that is scattered by suspended solids in a liquid, such as water. When the concentration of total suspended solids (TSS) and total dissolved solids (TDS) in a liquid increase, the turbidity also increases.

Fig.TDS sensor **Fig.Turbidity sensor**

3. **TDS Sensor**:- TDS Sensor detects the Total Dissolved Solids (TDS) levels in the water which can be used to indicate the water quality. The Grove - TDS Sensor can be applied in water quality applications such as TDS meter, well water, aquarium, hydroponics, etc.

4. **Temperature Sensor**:- A Temperature Sensor is an integrated circuit sensor that measures the centigrade temperature and provides an output voltage that is linearly proportional to the temperature. It can be used in various applications such as microwave ovens, fridges, air conditioners, and water temperature monitoring.

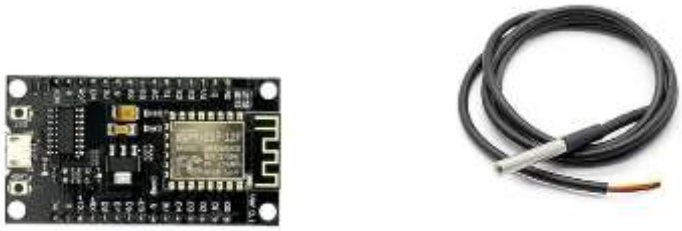


Fig.NodeMCU v3 ESP8266 **Fig.Temperature sensor-DS18B20**

5. **NodeMCU v3 ESP8266**:-The NodeMCU V3 ESP8266 is a cost-effective Wi-Fi-enabled development board designed for IoT applications. It features an ESP8266 microcontroller with built-in Wi-Fi, GPIO pins, and compatibility with Arduino IDE and MicroPython. Its compact design and easy programmability make it ideal for wireless data communication and smart device integration.

The whole design of the system is based mainly on IOT and AI which is newly introduced concept in the world of development. There is basically two parts included, the first one is hardware & second one is software. The hardware part has sensors which help to measure the real time values, another one is Arduino Uno that converts the analog values to digital one, which shows the displays output from sensors, NodeMCU gives the connection between hardware and software. In software we developed a program for Arduino Uno and NodeMCU using Arduino IDE.

ThingSpeak an IoT platform, we are using it to collect, store, and analyze real-time water quality data from sensors, enabling visualization of key parameters like turbidity, temperature, and TDS. Twilio was integrated to send SMS alerts to users when contamination was detected, ensuring timely notification of unsafe water conditions. Additionally, ThingHTTP was employed to facilitate seamless communication between the hardware and cloud services, ensuring efficient data transmission and response handling for system automation.

5.3 Theoretical framework

1. Turbidity: Turbidity refers to the cloudiness of water caused by suspended particles like dirt, silt, and organic matter. It affects water clarity and is measured in Nephelometric Turbidity Units (NTU). Safe Turbidity Levels for Drinking water should ideally have a turbidity of less than 1 NTU. Water with turbidity up to 5 NTU is still acceptable but may appear cloudy. High turbidity can shield harmful microorganisms and make water unsafe.

$$\text{Turbidity (NTU)} = a \times \text{Voltage} + b$$

Where: a and b are calibration constants determined experimentally or provided by the sensor documentation.

2. TDS: TDS measures the concentration of dissolved substances in water, such as salts, minerals, and metals. It is expressed in parts per million (ppm) or milligrams per liter (mg/L).Safe TDS Levels for drinking water, the ideal TDS range is 50–150 ppm, which ensures good taste and a balanced mineral content. The acceptable limit is up to 300 ppm, as per WHO and BIS standards. TDS levels above 300 ppm are considered unsafe due to excessive salinity and potential contaminants.

$$\text{TDS (ppm)} = k \times EC$$

Where: k is a conversion factor (usually 0.5 to 0.7) depending on the water type and EC is measured in µS/cm (microSiemens per centimeter) and can be obtained from the TDS sensor

3. Temperature: Room temperature ideal for drinking is (20–22°C or 68–72°F) . It should not be excessively cold or hot to avoid harm to the body. Water above 35° is not suitable for drinking as it can burn mouth. Higher temperatures can promote the growth of harmful microorganism

VI. CIRCUIT

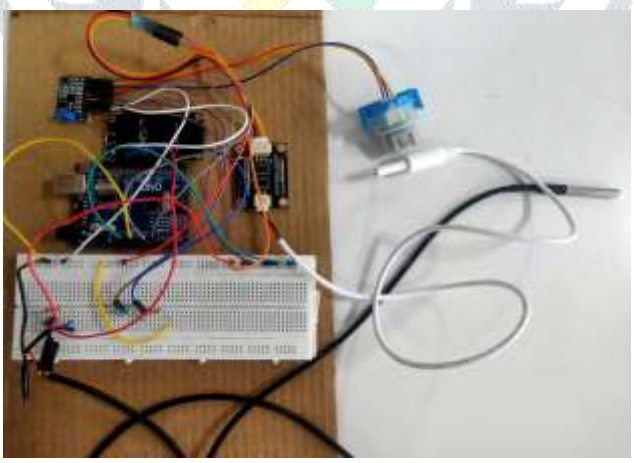


Fig.Circuit

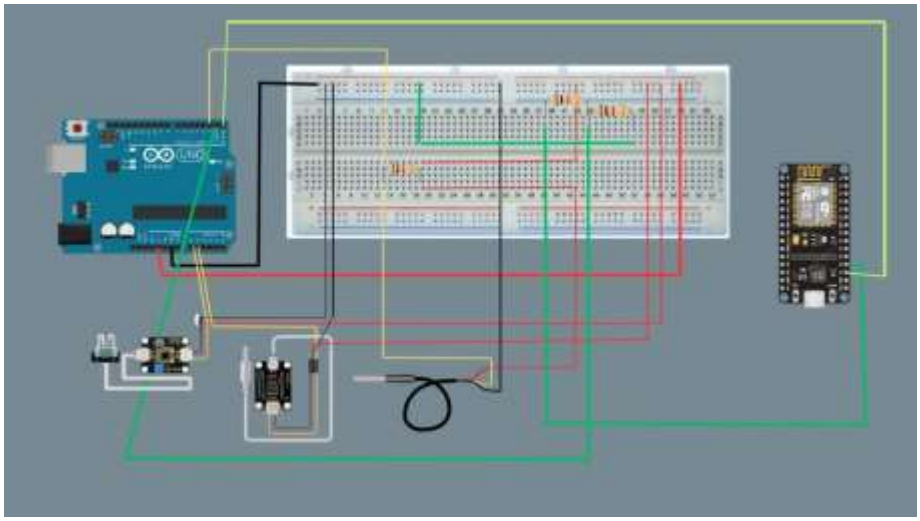
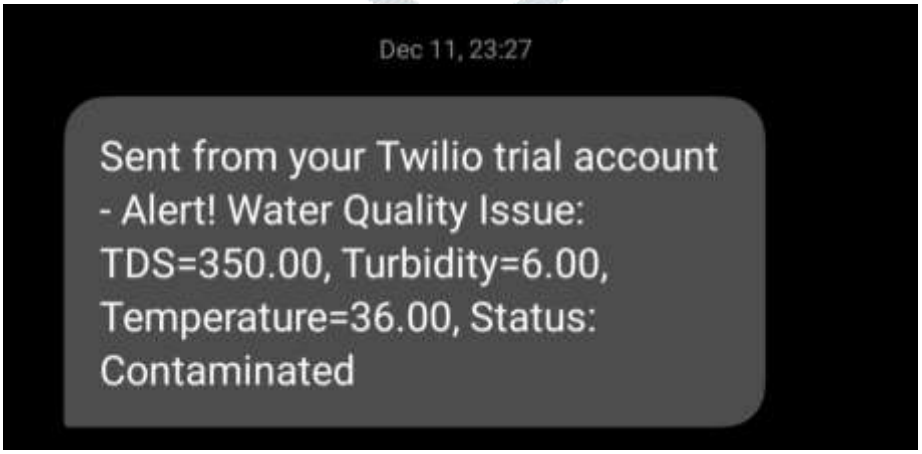


Fig.Circuit Diagram

VII. RESULTS

Table 1.Water Quality Measured

Entry ID	TDS	Turbidity	Temperature
1	100	0.04	25
2	100	3.5	25
3	350	6.0	36



IX. CONCLUSION

In conclusion, maintaining safe drinking water temperature and monitoring water quality are critical for public health. Elevated water temperatures above 35°C can encourage microbial growth and compromise safety, emphasizing the need for efficient cooling and treatment systems. Advanced methods, such as IoT-based monitoring and AI predictive models, can enhance real-

time water quality management and provide timely alerts for contamination risks. Implementing these technologies ensures safer drinking water and contributes to sustainable health practices.

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