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SMART WATER MANAGEMENT SYSTEM IN IOT

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Abstract- A Water quality monitoring system can aid in preserving the environment, ensuring the security of nearby water sources, and fostering economic growth in rural areas. As a result, this will help to develop a system here that employs Internet of Things and Machine Learning to monitor the quality of water. This paper discusses the characteristics of water to let us know whether it is fit for human consumption or not. The sensors dipped in water samples acquired from wells, lakes, rivers, ponds, or other places are used to inform the development of an effective model made up of TDS, pH and turbidity sensors. The data will be delivered from the sensors as soon as they are received to the IDE, where it will then be sent to the cloud server. The model effectively accounts for test tables, where 1 indicates the water is fit for drinking and 0 indicates the water is not. The values were classified differently using Machine Learning models like SVM, RF and XG Boost method. Training data is pre-processed before being fetched from the cloud. Over that data, machine learning models like Support Vector Machine, Random Forest & Extreme Gradient Boost has been implemented. The maximum accuracy of 95.12% was observed using XG Boost. After testing, we will be able to determine whether the water is fit for drinking using the binary indicators of 1 and 0, where 1 indicates the water is fit for drinking and 0 indicates the water is not .

Keywords: Smart Water Management, Internet of Things (IoT), Water Level Monitoring, Water Flow Sensor Leakage Detection, Water Conservation, Real-Time Monitoring, Cloud-Based Data Management, Automated Pump Control, Sustainable Water Management.

INTRODUCTION:

According to the World Health Organization (WHO), 368 million people use unprotected wells and springs and 122 million people gather untreated surface water from lakes, ponds, rivers, and streams. This means in 2020, approximately 2 billion people were without access to safe water. Cholera, diarrhoea, dysentery, Hepatitis, typhoid, and polio are just a few of the diseases that can spread as a result of contaminated water and inadequate sanitation. People are exposed to avoidable health risks when water and sanitation infrastructure is inadequate, poorly maintained, or managed improperly. Poor income, technological advancements, internal community management, water contamination from agricultural chemicals, industries, and waste disposal all contribute to rural villagers limited access to clean drinking water. Since 2000, more than 50% more city dwellers lack access to safely regulated drinking water. TDS and Turbidity are one the major qualities of water, as the drinking water should have a proper amount of TDS and turbidity in it .In rural areas, the water quality of wells and ponds is assessed using two crucial parameters: pH and turbidity. The effectiveness of water treatment procedures, the taste and odour of drinking water, the corrosion of infrastructure, and the health and survival of aquatic species can all be impacted by the pH of water, which is a crucial parameter. Turbidity is a unit used to describe how cloudy or hazy a liquid, results suspended particles. Turbidity is a crucial metric that tells us about the transparency of the water. Turbidity can change the physical, chemical, and biological properties of water. The presence of suspended particles like silt, clay, and organic matter can cause a variety of issues, including high levels of turbidity in water. A solution's acidity or alkalinity can be determined by its pH value, which ranges from 0 to 14, pH readings below 7 signifies acidity while above this value signifies alkalinity whereas pH 7 is regarded as neutral. To guarantee that the water is safe and fit for use in rural regions where wells and ponds are frequently used as sources of drinking water, it is crucial to routinely test the pH and turbidity of the water. Indicators of the presence of pollutants or other contaminants in the water, which may have detrimental effects on both human health and the ecosystem, include high levels of turbidity or low or high pH. Frequent monitoring of these characteristics.

RELATED WORK:

TDS and turbidity can have negative health effects when present in high levels in drinking water. High TDS levels can lead to mineral imbalances in the body, while high turbidity levels can harbour harmful pathogens. As such, it is important to ensure that drinking water meets the acceptable limits for both TDS and turbidity as recommended by local authorities. Low TDS can result in bacterial infiltration, bad taste, and bad odour. It can cause a lack of vital minerals, which are necessary for good health. It may lead to high levels of heavy metals in drinking water, it may also reduce the efficacy of water treatment and increase bacterial contamination and can cause dehydration, especially in hot environments or after strenuous activity. High turbidity can reduce water clarity, making it murky or discoloured. It can reduce aesthetics, making water unpleasant to drink which also increases the risk of waterborne illnesses. It

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can cause clogging of water treatment equipment and can lead to corrosion. It can reduce efficiency and quality of industrial processes.Total Dissolved Solids, or TDS, is a crucial indicator of water quality. It refers to the total amount of minerals, salts, metals, and other compounds that are dissolved in water, both organically and inorganically. Both natural resources like rocks and soil as well as human endeavours like farming, manufacturing, and urban growth can provide these materials. High TDS levels in water can have an impact on its flavour, aroma, and appearance as well as on how suitable it is for different uses, including drinking, irrigation, and industrial activities.

PROPOSED METHODOLOGY:

The proposed models were created using ML models. TDS and Turbidity parameters are used as attributes to classify whether the water is fit for human consumption. The Turbidity and TDS sensors were submerged in water, allowing the microcontroller (ESP32) to obtain real-time information. Before transferring the data to the ThingSpeak Cloud server, the Arduino IDE will first show the data. To assess whether the data is linear or variable, the data will be graphed. The data will then be analysed using machine learning methods. Support vector machines and random forests were both used in this study. Using the two water characteristics, Extreme Gradient Boost has been utilized in this instance to combine both approaches, giving exact information on whether the water is fit for human consumption. The Extreme Gradient Boost model, which consists of SVM and RF, has been trained using a dataset that contains water quality metrics for TDS and turbidity along with the labels that correspond to those metrics' water quality. They are less prone to overfitting than other tree-based models because they can handle non- linear correlations between the input features and the output labels.

System Overview:

The Smart Water Management System is designed to monitor, control, and optimize water usage using Internet of Things (IoT) technology. The system consists of sensors, a microcontroller, a communication network, and a cloud-based monitoring platform. Sensors such as water level, flow, and quality sensors are installed in water tanks and pipelines to collect real-time data. This data is processed by a microcontroller like the Arduino Uno or ESP8266 NodeMCU, which sends the information to a cloud server through wireless communication such as Wi-Fi or GSM. The cloud platform stores and analyzes the data to monitor water levels, detect leaks, and track water consumption. Based on the analysis, the system can automatically control pumps and valves to maintain proper water distribution and reduce wastage. A user interface, such as a mobile or web application, allows users to view real-time data, receive alerts, and manage the system remotely, ensuring efficient and sustainable water resource managemen

SYSTEMREQUIREMENTS:

Study Population and Sample Framework – Smart Water Management System :

The study population for the Smart Water Management System includes households, residential buildings, or institutions where water usage is monitored and managed using IoT-based technologies. These locations represent the target users of the system and provide real-time data on water consumption, storage levels, and distribution patterns. For the sample framework, a selected number of households or buildings within a specific study area are chosen as the sample units for system implementation and testing. The sampling may be done using a convenient or purposive sampling method to ensure that the selected sites have water tanks, pipelines, and regular water usage suitable for monitoring. Sensors and IoT devices are installed at these selected locations to collect data on water level, flow rate, and leakage conditions. The collected data from the sample units is then analyzed to evaluate the efficiency, reliability, and effectiveness of the proposed smart water management system in reducing water wastage and improving water distribution

Data analysis:

Systems for monitoring water quality are crucial for ensuring the security and well-being of societies, ecosystems, and economies. The development of automated and intelligent water quality monitoring systems that can help identify pollution sources, spot abnormalities, and forecast future water quality levels is made possible by machine learning techniques.

Using machine learning techniques, the following methodology has been applied to create a model for monitoring water quality:

1. Identify Key Parameters: Finding the important metrics to monitor is the first stage in creating a machine learning-based water quality monitoring system. These could be chemical parameters like nutrient levels, heavy metal concentrations, and organic pollutants, as well as physical parameters like pH, TDS, and turbidity.

2. Collect Data: Data on these characteristics must be gathered from a variety of sources, including water quality sensors, remote sensing data, and laboratory examination, once the critical parameters have been identified. Databases can also be used to extract historical data to establish a baseline and spot trends and patterns.

3. Data Pre-processing: Pre-processing is necessary to get rid of outliers, mistakes, and missing values from the acquired data. Data normalisation, data cleaning, and data transformation may all be part of this process.

4. Feature Selection and Extraction: While feature extraction involves turning raw data into useful features that can be used in machine learning models, feature selection entails choosing the parameters that have the greatest influence on water quality.

5. Machine Learning Model Selection and Development: For the purpose of monitoring water quality, a variety of machine learning models, such as decision trees, random forests, support vector machines, and neural networks, can be utilised. The chosen model should take into account the features of the data, the complexity of the issue, and the desired results. The machine learning algorithm is calibrated to forecast levels of water quality using past data.

6. Model Evaluation: The efficiency of the machine learning model is evaluated using metrics including accuracy, precision, recall, and F1 score. To make sure the model can generalise to fresh data, cross- validation techniques can also be used to test it[22].

7. Deployment: The created machine learning model can be used as a real-time water quality monitoring system to continually track water quality levels, spot abnormalities, and forecast future water quality levels. To give stakeholders useful information, the system can be connected with dashboards and data visualisation tools.

MODEL TRAINING AND EVALUATION:

Hardware Description:

Here are some of the hardware elements that have been used to test the water quality using Different parameters:

1. ESP 32 Microcontroller:

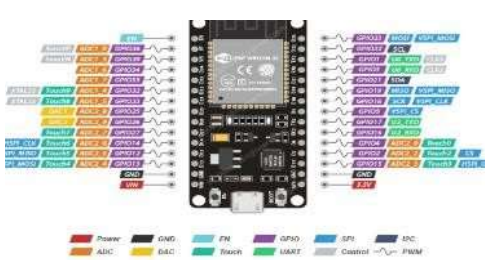


Fig 1. ESP32[29]

The ESP32 is a well-liked system-on-chip (SoC) microcontroller that is frequently used in Internet of Things (IoT) and other embedded systems applications. It is based on a chip called the ESP8266 The ESP32 has the following salient qualities and features:

- **Dual-core processor:** The ESP32 has a dual-core processor with a maximum 240MHz clock speed. As a result, it can handle more complicated tasks and applications than the ESP8266.
- **Connectivity via Wi-Fi and Bluetooth:** The ESP32 has built-in Wi-Fi and Bluetooth features that make it simple to connect to wireless networks and other devices.
- **Interfaces for peripheral devices:** The ESP32 has a variety of interfaces for external devices, including GPIO, I2C, SPI, UART, and others. This makes it appropriate for a variety of uses and applications.
- **Low power requirements:** Because of its power-saving design, the ESP32 is perfect for battery- powered applications and other low-power use cases.
- **Integral security features:** The ESP32 has hardware-accelerated encryption and decryption, support for SSL/TLS encryption, and other integrated security measures.
- **IoT devices:** The ESP32 is frequently used in IoT devices, including wearables, sensors, and smart home gadgets.
- **Robotics:** The ESP32 is a viable choice for robotics projects and applications due to its robust CPU and peripheral ports.
- **Industrial automation:** The ESP32 is a great choice for use in industrial automation and control systems because to its low power consumption and integrated connectivity.
- **Audio and multimedia applications:** The ESP32 is appropriate for use in audio and multimedia applications since it supports digital signal processing (DSP) and other multimedia features.

2. TDS Sensor:

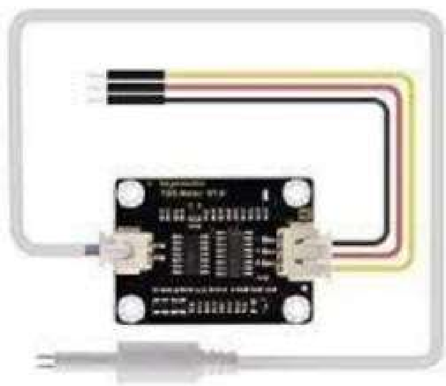


Fig 2. TDS SENSOR

The concentration of dissolved solids in a liquid is measured using an electrical device called a TDS (Total Dissolved Solids) sensor. The following are some of the main traits and qualities of TDS sensors:

- **Principle of measurement:** To determine the number of dissolved particles in a liquid, TDS sensors commonly employ electrical conductivity. A modest electrical current is used to do this, and the conductivity that results is measured.
- **Range**: Depending on the sensor, TDS sensors can measure concentrations at levels as low as a few parts per million (ppm) and as high as several thousand ppm.
- **Calibration**: Calibration is usually necessary before using TDS sensors. In order for the sensor to deliver an accurate measurement, the conductivity of a known solution must be measured.
- **Temperature adjustment:** To take into account temperature variations that may alter conductivity measurements, TDS sensors may have temperature adjustment.
- **Type of probe:** There are various probe types that can be used with TDS sensors, including immersion probes, flow-through probes, and in-line probes. Depending on the application and the liquid being tested, a certain type of probe will be utilised.
- **Precision and accuracy:** Depending on the sensor type and measurement range, TDS sensors' precision and accuracy can differ. Some sensors may be accurate to within +/- 2%, while others may be accurate to within +/- 5%.
- **Application areas:** TDS sensors are utilised in a variety of processes, such as industrial operations, food and beverage manufacturing, water treatment, aquaculture, hydroponics, and many other processes.
- **Maintenance:** To provide reliable readings, TDS sensors need to be regularly maintained. This can entail routinely calibrating the sensor and frequently cleaning the probe and sensor cartridge.
- **Output**: Depending on the type of sensor, TDS sensors can produce analogue or digital output signals. RS232, RS485, and USB are examples of digital output signals.
- **Adaptability**: Depending on the sensor type, TDS sensors may be adaptable to many controller types, including microcontrollers and PLCs.

3. Turbidity Sensor:

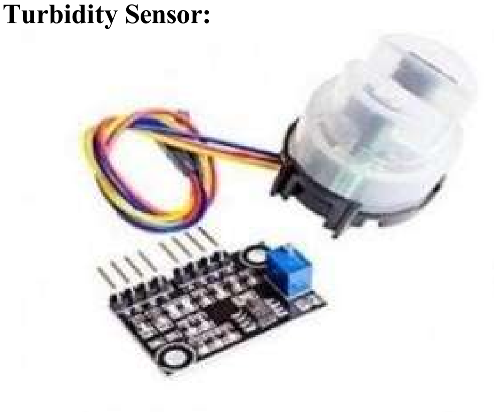


Fig 3. TURBIDITY SENSOR

A turbidity sensor is an electronic tool that assesses the concentration of suspended particles, such as solids or bacteria, in a liquid.

The following list of turbidity sensors' main attributes and traits:

- **Measuring principle:** The number of suspended particles in a liquid is commonly measured using turbidity sensors using either light absorption or light scattering.
- **Range**: Nephelometric turbidity sensors can measure a wide range of turbidity levels, from a few NTU to several thousand NTU.
- **Calibration**: Turbidity sensors need to be calibrated before use. In order to get an accurate reading, the sensor must be adjusted after measuring the turbidity of a known solution.

Health Monitoring Module:

The DS18B20 is a digital temperature sensor made by Maxim Integrated (formerly Dallas Semiconductor). It's widely used in electronics and Arduino projects to measure temperature. In a precise and simple way.

Calculation Process:

1. Temperature Range: -55°C to +125°C
2. Accuracy: ±0.5°C (from -10°C to +85°C)
3. Digital Output:Uses a 1-wire communication protocol (not analog)
4. Temperature (°C)= [Raw Value /16]

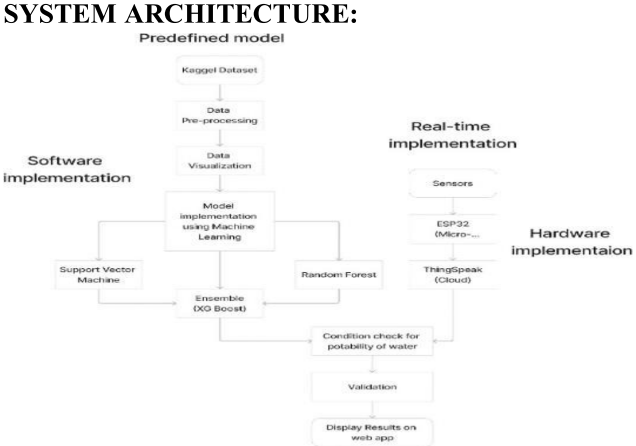
The DS18B20 provides a 12-bit digital output (by default), where:

- LSB (Least Significant Bit) = 0.0625°C
- So, to get the temperature in Celsius, you divide the raw output .
- 16 (since 1/0.0625 = 16).
- Examples:

1. Raw value = 160 Temperature (°C)= [160/16] = 10.0

Raw value = 208 Temperature (°C)= [208/16] = 13.0

SYSTEM ARCHITECTURE:



CONCLUSION AND FUTURE WORK:

The potability of the water, which is determined by factors like turbidity, pH, and TDS, will be properly predicted by our suggested method, indicating whether the water is suitable for human consumption or not. In this project, we offer a model that fuses artificial intelligence with the internet of things. Multiple sensors and microcontrollers are utilised to assess the TDS, pH, and turbidity data that were validated since the model used machine learning techniques. More sensors can be added in the future to expand the range of properties (such temperature, pH, and dissolved oxygen) that our model can examine.

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