Water Quality Monitoring System for Dhule Region using IOT

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Abstract - In the face of increasing contamination and pollution of drinking water, a significant threat to both human health and ecosystem stability emerges. Waterborne diseases have the potential to disrupt the delicate balance of ecosystems. Timely detection of water contamination is essential to prevent harmful consequences. To ensure the delivery of clean water, continuous real-time water quality monitoring is imperative. The demand for intelligent solutions to monitor water contamination is escalating with the advancements in sensor technology, connectivity, and the Internet of Things (IoT). The study advocates for an IoT-based smart water quality monitoring system, which offers both cost-effectiveness and efficiency. The integrated model undergoes testing with water samples, and the parameters are transmitted to a cloud server for further analysis.

Keywords - Arduino Uno, pH sensor, turbidity sensor, Wi-Fi Module.

I. INTRODUCTION

Water exerts an indescribable influence on all living organisms. The management of water resources is emerging as an increasingly pressing concern, particularly in the face of rapid global population growth, with specific ramifications for sectors such as industry and agriculture. Access to safe drinking water remains a challenge for a significant portion of the world's population, resulting in numerous fatalities from waterborne diseases annually. Research has consistently demonstrated that the consumption of contaminated water is the leading cause of approximately 5 million deaths each year. Furthermore, investigations carried out by the World Health Organization (WHO) have shown that ensuring children have access to clean drinking water could prevent more than 1.4 million child fatalities. In the realm of water quality monitoring systems, the 2023 paper titled "A Novel Sensor-based Water Quality Monitoring System using Internet of Things (IoT)" stands as a pioneering work. This paper offers a comprehensive discussion on the integration and harmonization of various migration theories within the domain of water quality monitoring. The focal point of this research is a Smart Water Quality Monitoring (SWQM) device capable of discerning distinct physical water characteristics, specifically pH and turbidity. These parameters are evaluated using well-suited machine learning techniques.[1][2] The foundation of this IoT-based Smart Water Quality Monitoring system comprises a network of sensors, including those designed for measuring pH and turbidity. These sensors are strategically deployed at key junctures in the water system, encompassing locations like reservoirs, treatment facilities, and distribution systems, where they consistently collect data. Subsequent to data acquisition, a microcontroller or processor, such as an Arduino, undertakes the critical task of digitizing analog sensor data. This digitized data is then relayed to a cloud-based platform for further analysis. All these new advancement in various applications allows more machines to be more intelligent and more easily accessible from various remote locations. Also, the ability to share information and keep track of the changes in various fields helps to avoid future unexpected problems. In various applications and fields, the main principals and models of Industry 4.0 has found its way. All the systems which are equipped with the Internet of Things (IoT) capabilities can be adopted in the new industry models. This Internet of Things (IoT) helps to connect with a cloud environment. As a result, we can send and store data and connect different devices remotely. Also, with IoT we can integrate different types of sensors and devices to collect various types of data. Later this collected data can be used to compare with the decisions which are already has been loaded to a database. With the help of the IoT it will be easier to monitor and improve the sustainability of the environmental resources in an optimized way, and in this case, it is water source. As the aquaculture industry is growing rapidly and technologies are getting more advanced, various quality of water like turbidity, pH, temperature are becoming most important factors to be monitored and measured. Like, the growth of fish gets affected by the quantity of dissolved oxygen in water and this quantity is less in warm water compared to cold water[4,5]

II. LITERATURE REVIEW

In the twenty-first century, human life has become more easier and safer because of numerous advances in various technological fields. But at the same time various urban development, poorly designed sewage systems, radioactive and industrial wastes, the oil spills caused by offshore drilling, and various other forms of pollution are forming day by day, and because of this, the quantity of safe drinking water is reducing day by day. In present days various factors like exponential population growth, increasing water scarcity, groundwater pollution, and because of other factors water quality monitoring in real-time is more required. As a result, monitoring water quality metrics in real-time need better approaches [1,3,2]. We measure the acidic or alkaline nature of water by pH metric and this scale ranges from 0 to 14[1].Pure water has a pH metrics of 7[1,4,6], which is neutral in nature. Safe drinking water should have pH metrics between 6.5 and 8.5 ph. Water clarity is measured by the turbidity scale. Higher turbidity means there are more unseen and suspended particles are present in water, which increases the chances of diarrhea, cholera, etc. diseases caused by polluted water. If the turbidity is low or in a safe range, then the water is safe to drink. Wireless communication is getting more and more common and helping people in their daily life and duties. Also, because of Industry 4.0 various new advanced and more optimized technologies are getting introduced[1]. All these new advancement in various applications allows more machines to be more intelligent and more easily accessible from various remote locations. Also, the ability to share information and keep track of the changes in various fields helps to avoid future unexpected problems. In various applications and fields, the main principals and models of Industry 4.0 has found its way. All the systems which are equipped with the Internet of Things (IoT) capabilities can be adopted in the new industry models. This Internet of Things (IoT) helps to connect with a cloud environment. As a result, we can send and store data and connect different devices remotely. Also, with IoT we can integrate different types of sensors and devices to collect various types of data. Later this collected data can be used to compare with the decisions which are already has been loaded to a database. With the help of the IoT it will be easier to monitor and improve the sustainability of the environmental resources in an optimized way, and in this case, it is water source. As the aquaculture industry is growing rapidly and technologies are getting more advanced, various quality of water like turbidity, pH, temperature are becoming most important factors to be monitored and measured. Like, the growth of fish gets affected by the quantity of dissolved oxygen in water and this quantity is less in warm water compared to cold water[7,8,910].

III. PROPOSED METHOD

This is the integrated sensor based portable water quality monitoring system for humans. This is the system which can detect the quality of water at time of drinking the water. When the user can drink the water at that time the user can pour the water into the vessel in which the water quality monitoring system is embedded. When water gate poured then system should be predict the quality of the water that is the water is portable or it is safe for drinking or not. This is the main objective of the project that detect the quality of safe drinking water. The sensors that measure various water quality parameters like pH and turbidity are the first part of the IoT- based smart water quality monitoring system. These sensors are integrated into the water system and they continuously gather data.

The system's primary scope should be clearly defined that it could be ensure the safety of safe drinking water. In the proposed system, the water quality will be checked by various sensors which are connected to the Arduino UNO. The code is embedded into the Arduino UNO by which all the sensors and model will work. The most essential water parameters needed to be monitored by the user are water turbidity, water temperature, TDS level and water pH level and we are used these sensors mandatorily to monitor the quality of water. Temperature is measured using thermometer and turbidity is measured by using turbimeter. We have set the appropriate range of all the sensors which are preferable for safe drinking water. In this proposed system, the result that is water is portable or not can be shown on LED display which is connected to the Arduino UNO. Data is wirelessly transmitted to an online server via wi-fi module. All the sensors are precisely calibrated for accuracy. Arduino UNO check readings against predefined limits. This system can take continuous measurement of water parameters when we use it. To enable this real time data monitoring the proposed system utilizes cloud database which will store and fetch data transmitted from sensor nodes and user can monitor the data in real time.

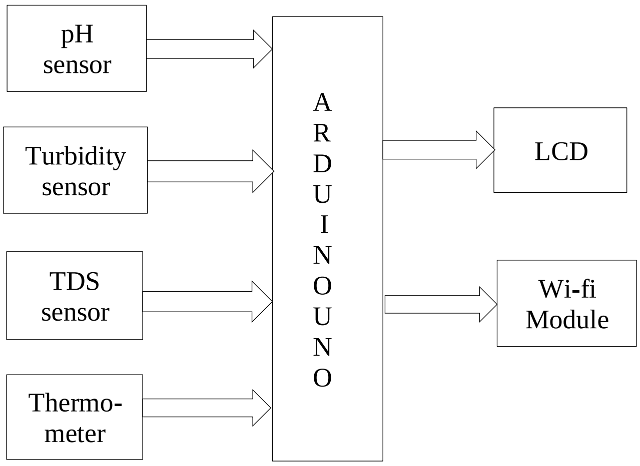

Fig. Block Diagram of Iot-based Water Quality Monitoring System

The research emphasized the significance of water alkalinity and conductivity as critical factors in evaluating water quality, emphasizing their paramount importance for public health and safety.

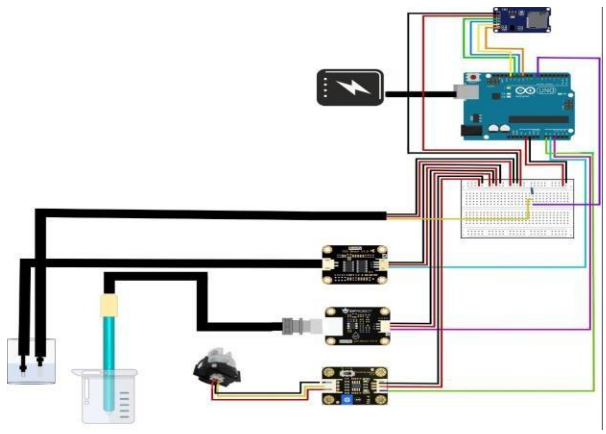

Fig. 1. Architecture diagram for IoT based Smart Water Quality Monitoring System

The specific threshold ranges for each sensor are initialized before the system starts operating. The specified ranges and values are as follows:

A. Sensor:
pH value ranges from 0 to 14. A pH level below 7 is acidic and above than 7 is alkaline. The neutral pH level is 7.
According to WHO, 6.5-8.5 pH levels are safe for water drinking[4].

B. Turbidity Sensor:
The turbidity should not exceed 5 NTU (Nephelometric Turbidity Unit)[4]

C. (TDS)Total Dissolved Solids Sensor:
The average water range that safe water drinking guidelines have approved is 50-150 ppm (parts per million)[4].

D. Temperature Sensor:
The expected water temperature is 25 Celsius but in the range of 24-30 Celsius are acceptable.

Parameters	Quality Range	Units
pH Level	6.5 – 8.5	Ph
Turbidity	Below than 5	NTU
TDS	50 – 150	PPM
Temperature	24 – 30	Degree Celsius

Table 1. Parameters of IoT based smart water quality monitoring system source

Fig. Hardware Model of Iot-based Water Quality Monitoring System

A. pH Sensor:- The water pH sensor is a simple device that makes it easy to measure the quality of the water. One of the most important instrument for measuring the quality of water is the pH sensor.The pH sensor often made of glass and has rod like structure with a bulb at the bottom that holds thesensor. A glass bulb is used to measure pH level of the water. This pH sensor determine whether a solution is naturally acidic or alkaline. pH levels can be detected between 0 and14 by the sensor set. pH sensor offer greater accuracy for measuring the acidity or alkalinity of water.

B.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 sulphate solid and tptal dissolved solids in water increases then the turbidity also increases. Turbidity sensors are used to measure the cloudiness of a water to determine water quality.

C.Temperature Sensor:- Temperature sensors provide data about the water such as changes in temperature patterns, water mixing and thermal pollution which can impact the quality of water. Thishelps the water quality professionals to determine whether the water is safe for consumption or not. Monitoring water temperature ensures that the water is being treated effectively and within the regulatory limits. By monitoring temperature changes, it is possible to ensure that the water you consume is safe.

D.LCD display:- The liquid crystal library allows you to control LCD display that are compatible the driver. The LCD’s have a parallel interface , that the microcontroller has to manipulate several interface pins at once to control the display. The process of controlling the display involves putting the data that form the image of what you want to display into the data registers, then putting instructions in the instruction register.

E.Arduino UNO:- Arduino is an open source electronics platform based on easy to use hardware andsoftware. This platform allows you to create different types of single board microcomputers to whichthe community of creators can give different types of use.

Five samples were collected from different water sources and tested to measure parameters such as pH, temperature, TDS, and turbidity for each sample. Each water sample will be tested five times on consecutive days to obtain accurate values for all four physical parameters. The average of each parameter is important for the system to predict whether it is drinkable or not. pH sensor results were collected daily for five days. The highest pH of the tap water was 7.7 on day 5, and the lowest was 7.1 on day 1. The second water sample is coway water, the pH of the filtered water is almost neutral. The highest pH in the third test was 7.1, and the lowest pH in the first test was 6.8. The pH of river water is relatively high, with a maximum of 8.3 and a minimum of 7.8. The pH of pond water is not much different from tap water. The most elevated pH was 7.7, and the lowest was 7.3. The lake water is moderate, with a maximum pH of 7.8 and a minimum pH of 7.5. Based on the five- day results shown in Table II, the water samples tested did not fall outside the threshold range.

High values of turbidity can affect the taste and quality of water, while high values of TDS are dangerous to humans due to high mineral content. In the long run, it can be concluded that not all clear water seen by the naked eye is safe to drink because it may be low or high in total dissolved solids, or too acidic or alkaline. These two parameters cannot be seen with the naked eye, and unlike turbidity, the colour of the water changes according to the value of turbidity. Temperature also influences chemical reactions in water. This project also successfully analyze several water samples and determine whether it is drinkable or unsafe for drinking. Before using drinking water or household water, it is essential to measure the water quality first.

Step by step process of how the water quality monitoring system operates:

1. Parameter Selection: It is important to identify the specific water quality parameter to be monitored this may includes physical parameters such as temperature turbulent etc., chemical parameters such as pH of water select parameters that are required to measure the quality of drinking water.

2. Sensor Deployment: Collect all the sensor that are required for measuring the water quality connect all of them together with Arduino UNO and embed into the system. Set the levels of the all the sensors which are already set by government for safe and clean drinking water.

3. The code is get embedded into the Arduino Uno by which whole system will work. All the sensor are connected to the Arduino and then it will get perform and work accordingly.

4. When all the sensors are deploy into the water then all the sensors measure the water parameters accordingly after that data should pass to the Arduino, it will check all the parameters according to the code embedded into it and then it will generate the output.

5. The LCD display is connected to that already Arduino which can display the output. The message is displayed on the display that water is portable or water is not portable. It can also display the values of parameters detected by the sensors.

A pseudo code for checking the potability was mentioned according to the following step:

Step 1: Initialization

- Set up sensor pins and variables for readings: Define pins for sensors and variables to store sensor readings.
- Initialize IoT communication: Set up communication with the IoT platform (e.g., Wi-Fi or GSM).

Step 2: Main Loop

- Read sensor values: Continuously retrieve data from pH, turbidity, temperature, and TDS sensors.
- Send data to IoT platform: Transmit sensor data to the IoT platform for further processing or storage.
- Wait: Pause execution for a defined interval before repeating the loop.

Step 3: Read Sensor Values

- Read pH, turbidity, temperature, and TDS: Obtain analog readings from each sensor.

Step 4: Send Sensor Data to IoT

- Send all sensor data: Transmit the collected sensor readings to the IoT platform for monitoring or analysis.

Step 5: Repeat

- Continue looping: Reiterate the main loop to continually monitor and send sensor data.

A mathematical model for a water quality monitoring system typically involves equations that describe the relationships between various parameters, processes, and components within the system. Below is a simplified mathematical model outline for a water quality monitoring system:

1. Water Quality Parameters:

Define the variables representing key water quality parameters to be monitored. These may include pH (pH), dissolved oxygen (DO), temperature (T), turbidity (Turb), and concentrations of specific contaminants (C1, C2, ...).

2. Sensor Measurements:

Establish equations that relate sensor measurements to the corresponding water quality parameters. For example:

pH = f(sensor_pH_measurement)

DO = g(sensor_DO_measurement)

Turb = h(sensor_turbidity_measurement)

3. Water Quality Dynamics:

Model the dynamics of water quality parameters over time, considering factors such as natural fluctuations, seasonal variations, and human activities. This may involve differential equations or time-series analysis techniques.

4. Contaminant Transport:

Develop equations to describe the transport and dispersion of contaminants within the water body or distribution network. These equations may consider advection, diffusion, and reaction processes.

5. Data Processing and Analysis:

Define algorithms for processing and analyzing the collected data. This may include statistical methods, machine learning algorithms, or pattern recognition techniques to identify trends, anomalies, or potential water quality issues.

6. Alert Thresholds:

Establish thresholds or criteria for triggering alerts based on predefined water quality standards or regulatory guidelines. These thresholds may vary depending on the parameter and its importance for drinking water safety.

7. Decision Support:

Integrate the mathematical model with decision support systems to assist stakeholders in interpreting data and making informed decisions. This may involve optimization algorithms or scenario analysis to evaluate different management strategies.

8. Calibration and Validation:

Incorporate procedures for calibrating and validating the mathematical model using experimental data or field measurements. This ensures the accuracy and reliability of the model predictions.

9. System Optimization:

Explore optimization techniques to improve the efficiency and effectiveness of the water quality monitoring system. This may include sensor placement optimization, sampling frequency optimization, or resource allocation optimization.

10. Model Evaluation:

- Assess the performance of the mathematical model through validation against independent data sets or through sensitivity analysis to understand the model's robustness to uncertainties.

IV. RESULTS AND DISCUSSION

The examination of various water samples from distinct sources, encompassing tap water, well water, river water, and bottled water, underscores the diverse spectrum of pH and turbidity levels observed. Tap water often registers pH levels within the recommended range of 6.5 to 8.5, considered suitable for human consumption, yet occasional fluctuations suggest potential shifts in water quality. Well water exhibits varying pH levels, with some falling within permissible limits while others display irregularities, possibly indicative of mineral content or impurities. Notably, river water samples consistently exhibit heightened turbidity levels compared to tap and well water, signaling increased presence of suspended particles or contaminants. Elevated turbidity underscores the imperative for thorough treatment measures to ensure water safety and clarity, a pivotal aspect in determining water quality suitability for various applications.

Sample	PH	Turbidity	TDS	Remarks
Tap water	7.5	0.6-1.8N TU	400p pm	Tap water quality is typically regulated to ensure safe drinking standards, maintaining acceptable levels of turbidity and pH regardless of location.

bore well	6-8.5	1NT U	500-700ppm	The borewell water meets drinking water standards, with low turbidity and a pH range of 6-8.5.
Akkalpada dam	6-7.1	1NTU	450ppm	Akkalpada Dam water shows promising signs for multiple uses, with near-neutral pH and low turbidity suggesting minimal suspended solids. Continuous monitoring is essential to maintain quality standards.
Panzara River	4-5	5NTU	2000 ppm	Panzara River water exhibits poor quality with low pH, high turbidity, and elevated levels of dissolved solids, indicating high acidity and suspended solids. Urgent remediation and continual monitoring are crucial to safeguard water resources.
Nakane lake	6.4-7.2	1NTU	500ppm	Nakane Lake water quality assessment reveals favorable conditions for diverse uses, with minimal suspended solids and near-neutral pH levels. Continuous monitoring is recommended to maintain suitability over time.

V. CONCLUSION

In conclusion, the development of an IOT based water quality monitoring system using Arduino and multiple sensors offers a promising solution for real-time monitoring of various parameters such as pH, turbidity, temperature and TDS. Through the implementation of this system, we have demonstrated the feasibility of leveraging low cost and easily accessible hardware components to create an effective monitoring solution. The system provides valuable insights into the quality of water sources, facilitating timely interventions and ensuring the safety of water for various applications including drinking, agriculture, and industrial process. Additionally, the scalability and versatility of the system enable its deployment in diverse environments making it a valuable tool for environmental monitoring and management initiatives. Further enhancements and optimization can be exposed to improve the system accuracy, reliability, and functionality, thereby advancing its utility in addressing water quality challenges and permitting sustainable resource management practices. Overall, this research contributes to the ongoing effort towards leveraging IOT technologies for addressing critical environmental concerns and for fostering sustainable development water quality analysis, potentially benefiting millions worldwide.

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I. INTRODUCTION

Water exerts an indescribable influence on all living

Appendix D: Certificate of Avishkar

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Akshay Avinash Patil(T2054491246005)

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