HydroGuardian: Transformative Water Quality Supervision through IoT Advancements

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***Abstract*—Water contamination has emerged as a widespread issue across the world. To ensure the utilization of pure water, it is indispensable to sustain ambient water quality. Fortunately, smart technology and solutions are available to address this issue. This paper will propose an effective IoT-based water quality measuring device that can detect and measure five parameters, namely pH, turbidity, TDS, conductivity, and salinity. The proposed system can test the required parameter values and provide the best quality value for each. This IoT-based device was developed using a microcontroller and a cloud platform. With this device, we can help address the issue of water pollution and provide people with access to pure water. The proposed system ensures that the water sample does not contain any harmful levels of nitrites/nitrates, chlorine, or hardness, and maintaining appropriate parameters is crucial for good health. In this proposed system, five parameters are to be measured by the system to calculate the quality of the entity like water and migrate the results to a microcontroller and a cloud platform to live monitor.**

Keywords—Water Quality, Internet of Things, pH, Turbidity, Salinity, Conductivity, Total Dissolved Solids.

I. INTRODUCTION

IoT technology has had a significant impact on various industries, including water quality monitoring[7]. With increasing concerns over water pollution and its effects on the environment and human health, there is a growing need for reliable and efficient water quality monitoring systems.[13] Water quality measurement is an environmental issue that affects human health worldwide, as water pollution is the presence of harmful substances in water bodies like rivers, lakes, oceans, and groundwater[9]. It can have adverse effects on the environment and human health, especially on human skin and healthcare. Drinking water safety and quality are critical and can have significant impacts on both human health and the environment.[10] The contamination of drinking water sources by various pollutants is a complex issue with far-reaching consequences. Shockingly, contaminated water is responsible for about 40% of deaths worldwide. Therefore, there is an urgent need to implement effective water quality monitoring systems. It can have deleterious effects on the environment as well as human health. the safety and quality of drinking water, impacting both human health and the environment. The contamination of drinking water sources by various pollutants is a complex issue with far-reaching consequences[11].

Ensuring access to purified drinking water is crucial for both city and village dwellers. In 2014, the city of Flint, Michigan, made a fateful decision to switch its water source from treated Detroit water to the untreated Flint River. This seemingly cost-saving measure led to a catastrophic public health crisis that exposed the vulnerabilities of America's aging infrastructure. Many people were effected on exposing to lead developing neurological damage, and health issues. This crisis due to devastating effects of inadequate water supervision. Love Canal, New York, USA and Aral Sea, Central Asia also devastated by water supervision.

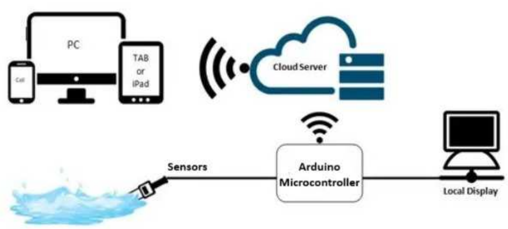

Fig. 1 Representing a blueprint of the system

However, an IoT-based water quality measuring device can provide real-time data on various parameters such as pH levels, turbidity, total dissolved salts, salinity, and conductivity [8] . These sensors are strategically placed in different concentrations of water to measure the quality of water. The widespread contamination impose significant threats: Ecological impact, Health Concerns, Resource Scarcity.

The data abstracted from the sensors will be collected and transmitted at regular time frames and the data will be transfused to a cloud-based platform. This IoT-based water quality monitoring device is a powerful tool for ensuring the safety and sustainability of our water resources. The objectives of the proposed system will be: Early detection and prevention, improved water sustainability and monitors in real time.[14]

II. Literature Survey

[1]In 2016, Jayti Bhatt et al. designed the "IoT Based Water Quality Monitoring System", such that it requires many sensors to calculate different variable factors. The data assembled from these different sensors is handled by a microcontroller and cordlessly transfused to the Raspberry Pi and core controller via a protocol called Zigbee.

[2]"An Efficient Wireless Sensor Network-based Water Quality Monitoring System", Nidal Nasser et al proposed a Network of wireless sensors to supervise the quality of entity with a portal having all the data or knowledge and an alternative mechanism of sleep to extend the duration of network. The system oversees water quality contemporaneously and includes a formidable component that is capable of promptly sending an email alert upon the occurrence of any unusual event.

[3]The paper titled 'Monitoring System using IoT' was authored by Ashwini Donie et al. in 2018. Their primary objective was to address the issue of industrial pollution in water and its impact on the environment. They developed a real-time data collection system that monitors various water parameters like temperature, pH, and turbidity. This data is then transmitted to a remote station where it is compared with threshold values. The system uses GPRS to send the comparison results and store them for further analysis.

[4] Another paper was published in 2018 by Raheel Shaikh et al. Their proposal presents a comprehensive method of monitoring water quality and collecting data in a remote region. The system evaluates the water environment and discovers disasters that occur naturally and water accidents.

[5] The paper by Mithila Barabde et al. published in 2015, discusses the expansion of a sensor networks 'WSN' for the supervision of quality of the entity to test. The authors emphasize the importance of the system for various purposes, including irrigation, domestic use, and industries. In their proposal, the authors suggest the use of a high-power Zigbee that consumes low power for water quality monitoring.

[6] In 2020, Sathish Pasika et al. published a paper - the device or the system they evolved utilizes NodeMCU target boards and Arduino boards, which are connected to multiple sensors to monitor or supervise the quality of the entity.

[12] A paper by Dharon Joseph Edison et al. published in the year 2013 monitors the water quality using a graphical user interface(GUI). The proposed system uses sensor nodes to continually assess the water and transmit data to a station via RF technology.

[15]A reference paper by S Gupta, et al. has proposed a concurrent supervising system Using an IP address to access the sensor data that is stored on the cloud platform used in the system. Lastly, artificial intelligence uses image or video processing techniques (deep learning) to detect contaminants and determine the results.

III. Methodology

A proposed IoT-based system will be used to test the quality of water in a given location. The system will compare approximately five parameters to check the water quality. The system will use sensors like Turbidity, pH, Total Dissolved Solids, Electric Conductivity and Salinity.

After comparing the values recorded by the system with the IS: 10500-2012 and IS: 3025-1964 water quality guidelines, the system will determine whether the water is drinkable or not.

The system shown in Figure 2 uses a microcontroller to evaluate water quality upon contact with the system. The parameters are then updated to the cloud, where the query is processed and the results are provided to the user. The results are displayed on the screen, indicating whether the water is drinkable or not.

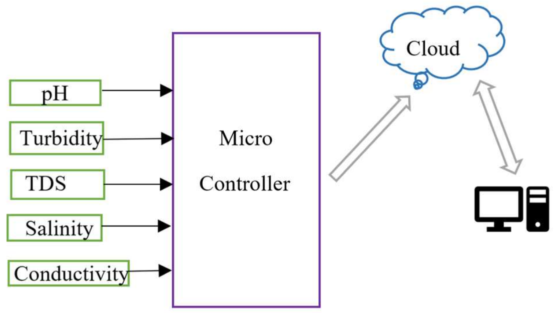

Fig. 2 Operation of the proposed system

A. *Calculating pH:*

pH is a fundamental measure to calculate a solution's acidity. It represents the negative logarithm of the ionic Hydrogen concentration ($-\log_{10}[H^+]$) present in the solution. This means that pH can be in a range [0, 14] with a pH in [0, 7) interval range being acidic, with a pH in (7, 14] interval range referred to as basic and pH 7 being neutral. Understanding pH is crucial in various fields, such as chemistry and biology, as it helps to determine the properties and behavior of substances in different environments.

The Fig 3 shows the pH sensor used by the proposed system. When working with a pH sensor, it is necessary to calibrate the sensor to 2.5 V. To calculate voltage from the sensor, use the following formula:

$$Voltage = pH \times (5.0 \div 1023.0) \tag{1}$$

To obtain pH readings from a sensor, the system requires an input voltage of 2.535 V. The system will take several analog readings from the sensor, arrange them from smallest to largest, and calculate their average value. Even without calibration, the system can determine the pH value using the following formula:

$$pH = (avgAnalogRead) \div CalibrationValue \quad (2)$$

Fig. 3 pH sensor

The calibration equation can be normalized by making the default pH 7. As per the limitations of IS: 3025-1964, the pH of drinking ranges from 6.5 to 8.5 would be best for drinking.

B. *Calculating Turbidity:*

What is turbidity and how can it be measured? Turbidity is the cloudiness, opacity or thickness caused by suspended solids in water, and it is a crucial marker for calculating the quality of an entity used. The IoT system will calculate the turbidity in the NTU or FNU. The acceptable limit as per IS: 10500-2012 for turbidity is at most 1 Nephelometric Turbidity Unit. The measurements in this system rely on:

- Frequency or the wavelength of an entity
- Scattered angle of the entity

Fig 4 shows the turbidity sensor used by the system. The measuring method used by the system is uniquely represented by the units of NTU.

This indicates that the reading was captured using white light at a detection angle of 90° and that the sensors used in this system comply with EPA method 180.1. To calculate turbidity, the system requires a reference voltage of 5.0V and a turbidity constant of 'k' equal to 0.1. The sensor will then read an analog input, and the system will calculate the resistance and voltage as shown below:

$$Voltage = analogInput \times ReferenceVoltage \quad (3)$$

The system will use Ohm's law to determine resistance (Resistance = V/I, where V is voltage and I is current, assuming I = 10mA). The sensor resistance is given by:

$$Resistance = (Voltage) \div 0.01 \quad (4)$$

The calibration equation for turbidity is given by:

$$Turbidity = k \times (Resistance \div R) \quad (5)$$

Fig. 4 Turbidity Sensor

For 0 NTU turbidity, the resistance R of 1000.0, is taken by the system.

C. *Calculating Total Dissolved Salts:*

TDS is the amount of non biological substances and biological substances that are dissolved in a liquid like water. Water can contain a variety of dissolved substances. The TDS, a key parameter is calculated in mg/l. The concentration of TDS in water can affect its taste. The formula for calculating TDS from a sensor is given as follows:

$$Total\ Dissolved\ solids = K_e \times EC \quad (6)$$

Typically the constant is taken as 0.5. The system will calculate the TDS at a temperature of 25°C. The Total Dissolved Solids is given by:

$$TDS = 0.5 \times EC \quad (7)$$

In this formula, the K_e is the proportionality constant that ranges from 0.5 to 0.8

Fig 5 below represents the TDS sensor used by this system.

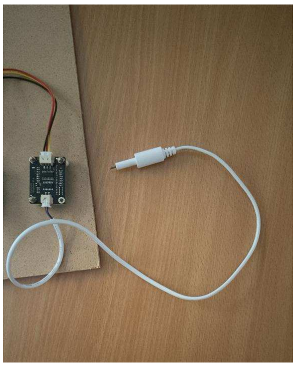

Fig. 5 Total Dissolved Solids

For calculating the Total Dissolved Solids, the offset is set to 0.0.

D. *Calculating Salinity:*

Salinity is referred to as the amount of salt that is dissolved in a liquid, say water. Typically, it is measured in grams of salt per kilogram or liter of liquid. The salinity is given by:

$$Salinity = (\, salt\ in\ mg) \div (amt\ of\ water\ in\ kg) \qquad (8)$$

The system measures salinity in ppt (parts per thousand) as the degree of saltiness. The proposed system will calculate the salinity from the Total Dissolved Solids as one-thousandth part of the TDS value (likely 0.001) and it is given by:

$$Salinity = tdsValue \ \div 1000 \qquad (9)$$

E. *Calculating Conductivity:*

Water's ability to conduct electricity is measured by its conductivity. Conductivity is directly influenced by the conductive ionic concentration that is present in water. These ions come from non biological compounds(inorganic) or ions, such as chloride, carbonate, alkalis, sulfide compounds, and dissolved salts. Water conductivity refers to its ability to transmit heat, sound, and electricity, and is represented by s or k. The units to calculate the conductivity parameter are Siemens per meter (S/m) and Millimhos per centimetre (mmho/cm). The system will calculate the Conductivity from the TDS value as the conductivity is twice as TDS value. The formula to calculate Conductivity is given by:

$$Conductivity = tdsValue \ \times K_c \qquad (10)$$

In the formula proposed above, K_c is the constant of proportionality, typically evaluated to 2. In fig 6, it depicts the proposed system with all the sensors integrated with it.

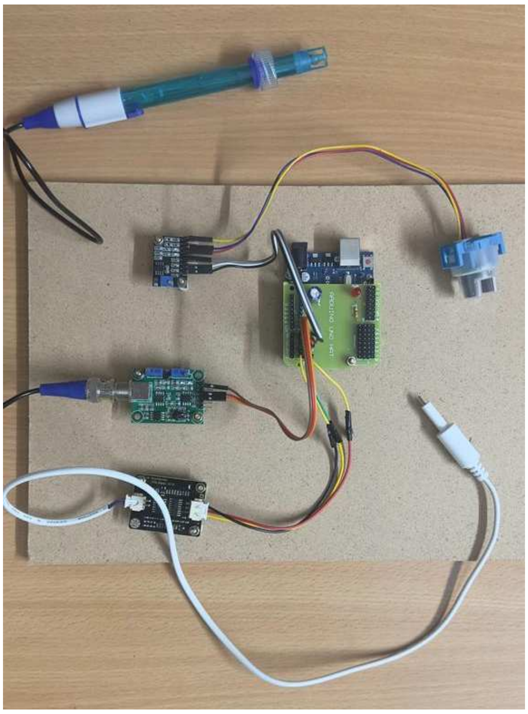

Fig 6. The Proposed System

F. *Limitations for parameters as per IS:10500-2012:*

TABLE I.

S.No	Limitations of Water	
	Test Parameters	***Acceptable limit as per Specifications***
1	pH	Range of 6.5 and 8.5
2	Conductivity as mS/cm	1500
3	TDS as mg/l	500
4	Salinity as mg/l	1200
5	Turbidity as NTU	1

The limitations mentioned above are provided based on a standard temperature of 25°C.

G. *Integrating with ThingSpeak Cloud Server:*

The proposed system will collect water quality parameters and integrate them with the cloud. The five fields include pH, TDS, Turbidity, Salinity, and Conductivity. Fig 5 depicts the integration of the cloud with the proposed system. The cloud will use wireless communication with the ESP8266 installed. In Fig 6, it depicts that cloud integration comprises of five fields. The micro-controller readings are transmitted through a component, identified as ESP8266.

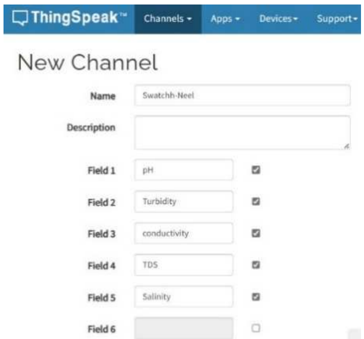

Fig. 7 The fields in the cloud

This component acts as a bridge between the cloud and the proposed system, facilitating the data transfer between the microcontroller and the cloud. As the connection is established, the cloud generates an output that visualizes the recent readings for each field.

RESULT

As a part of the setup process, the proposed system has been connected to the ThingSpeak Cloud. The cloud will showcase the accuracy of the water testing and display the corresponding values. Once the channels have been saved as per the methodology, the suggested cloud will exhibit all five parametric widgets, as depicted in Fig 7 and Fig 8.

Fig 8 presents a group of widgets that aid in representing the values they contain. In this proposed system, the GAUGE widget was chosen, as it resembles a speedometer

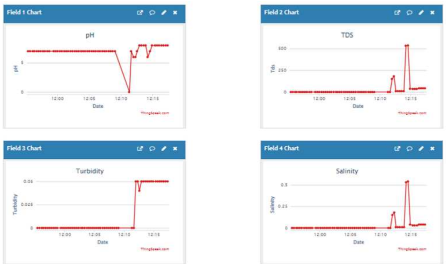

Fig. 8 Widget for all parameters

Once all the widgets are added, the representation is completed and the results are shown the Fig 8. In the figure, all parameters have the Gauge widget and that widget will show the values.

Once all the widgets are set up, the proposed system can present all parameters in a graph, which can be easily done using the ThingSpeak cloud platform. The user needs to connect a device to the ThingSpeak cloud platform using a cable. After completing the setup, the system displays the results with the values represented both in the widgets and graphically.

So, the user needs an API key, and the API key is provided to the cloud by the user. By committing all the necessary actions, the proposed system and the cloud that is being integrated are ready for testing the water sample.

Fig 9. Website widget depicting the results

SUMMARY AND FUTURE WORKS

With the current situation, the quality and safety of drinking water has become a significant concern. To address this issue, a proposed system has been developed to consider various problems and complexities in order to provide better solutions. The system uses accurate calculations to measure five parameters namely– pH, turbidity, TDS, conductivity, and salinity. These parameters are decisive in determining the quality of entity like water and ensuring that users receive the best possible values.

In the future, the proposed system will be integrated with a mobile application with all parametric values. The proposed system includes an application for live monitoring, quick water quality checks, and fast response to display values. The mobile application can also give measures to alter the quality of the entity being tested so that the water will be used for household and for drinking as well, like decreasing the pH and so on.

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