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DESIGN AND PERFORMANCE EVALUATION OF LOW-COST IOT-BASED WATER QUALITY MONITORING DEVICE USING WSN

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Abstract

Water is one of the precious factors in human life. But it has been exploited heavily by dumping human, industrial, and chemical waste into the waters, resulting from contaminated water with toxic chemicals. This paper deals with monitoring water quality by mainly considering water's physical and chemical properties. For this purpose, we have designed a Wireless Sensor Network (WSN), which contains several sensors to sense the Physical contents of water. The power for the sensor nodes is obtained from the solar panels connected to the sensor nodes. This project highlights how a real-time monitoring system works using Network Virtualization. Also, new technologies like the Internet of Things (IoT) are incorporated into this system to make it advanced.

Keywords: *Water quality monitoring, Wireless sensor network, Internet of things*

Introduction

Water is the basic need of humans worldwide, but its scarcity has become one of the main hurdles in its attainment. One of the biggest issues is water contamination. Water contamination is due to pollution, industrial wastage, climate change, etc. We have designed a node-based structure that monitors water qualities (i.e., pH, Temperature, Turbidity, TDS) that can alert the authorities about the polluted water before the public utilizes it. Wireless Sensor Networks have been widely used in various aspects of environmental monitoring. This system is low-cost and comprises a low-power wireless sensor node for detecting any change that can occur in the physical quantity of water. The main reason behind this acute water shortage is the low quality of water due to water pollution. We aim to produce an efficient IoT-based smart water quality system that produces real-time analysis in less time. We offer to produce a system that replaces conventional methods for testing the physical qualities of water for domestic, industrial, and drinking purposes. Our system prototype comprises different sensors and internet modules for testing and evaluating results.

Literature Review

Due to the bad water quality, irrigation fields and the growth of crops were highly affected. So, K. Vikranth et al. [1] introduced a system that comprises the latest technology like the Internet of Things (IoT) and Wireless Sensor Networks (WSN) applications to monitor physical water parameters like check soil infertility, check the water level, and environmental changes.

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B. Lalithadevi et al. [2] aimed to produce a water monitoring system that initialized the whole groundwater levels and provided real-time data to the database. The major benefit of the system was to update the people and the concerned government authorities in case of any decrease in water level and water quality below the threshold value

Rapid industrialization and extra groundwater use for activities other than basic needs created water contamination problems. The author emphasized a system comprised of software that evaluated and monitored water quality parameters and activities done by consuming groundwater. C. Oppus et al. [3], showed a hardware setup was initiated to gather water quality parameter data. Then it was sent to a cloud for the result server for better data visualization.

The proposed system designed by G. S. Menon et al. [4] Constitutes three main layers capable of sensing, processing, and transmitting the monitored data and providing necessary alerts to the concerned stakeholders. The challenges faced by the current state in water quality monitoring aided in the detection of pollutants.

WSN was motivated mainly by military applications such as battlefield surveillance. Such networks are used in many applications like industry, and consumer applications. V. Lakshmikantha et al. [5] discussed a few applications such as industrial monitoring and control processes, machine health monitoring, and so on.

A high-configuration intelligent sensing system was developed by A. J. Ramadhan [6] and installed in remote locations to track the water quality of lakes, rivers, reservoirs, and creeks in Australia.

Researchers implemented the smart sensor interface network in industries, collected the water quality parameter data, and updated them in the cloud using IoT. Data was made available to the public through the cloud website and social networking like Facebook by A. A. Fadel et al. [7].

K. M. Simitha et al. [8] showed wireless sensor network nodes were made and installed in security-sensitive areas and unsupervised environments, which made data fusion of wireless sensor networks easy to face various security threats. Under the influence of low energy costs, a complete security mechanism was prioritized to ensure data security.

N. M. Ansari et al. [9] defines IoT devices embedded with sensors, software, and network to exchange and collect data with each other.

S. Pasika et al. [10] proposed a cost-effective and efficient IoT-based smart water quality monitoring system that monitors the quality parameters uninterruptedly. The developed model was tested with three water samples, and the parameters were transmitted to the cloud server for further action.

Internet-of-things (IoT) establishes connections between billions of smart devices, performing a diverse range of purposes. Connected devices will grow to almost 31 billion in the world of IoT defined by N.M Ansari et al. [11].

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Proposed System

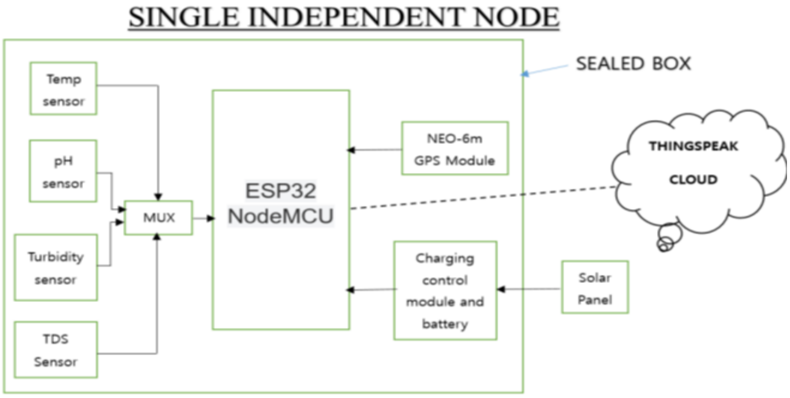

Fig: 1 Wireless Sensor Network

Methodology

Table: 1 Parameters and their ranges

Parameters	Safe-Water	Unsafe Water
pH	6.5 – 8.5	< 6.5 and > 8.5
Temperature	5 – 25	< 5 and > 25
Turbidity	Less than 5	Above 5
TDS	Less than 900	Above 900
Action	No Action	Send Alert to Control Room

We have designed a node that is enclosed in a sealed box which is placed above the surface of water and left for floating on water. Node is basically composed of different sensors like: Temperature sensor, Turbidity sensor, pH sensor and TDS sensor. These sensor computes all water parameters collectively, compute and evaluate readings through core controller (multiplexer). The core controller forms the heart of the system. All the sensors are connected to a core controller and this controller controls the node's operation and achieve data from sensors then inform the concerned authorities about the results along with the geographical location of water through wireless modules installed in the system indicating if water is safe for drinking or not.

The whole system is powered by the battery which is charged by the solar panels. Those solar panels energy (i.e., charging capacity) will be managed by the charging control system.

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Fig. 2. Flow chart of the system

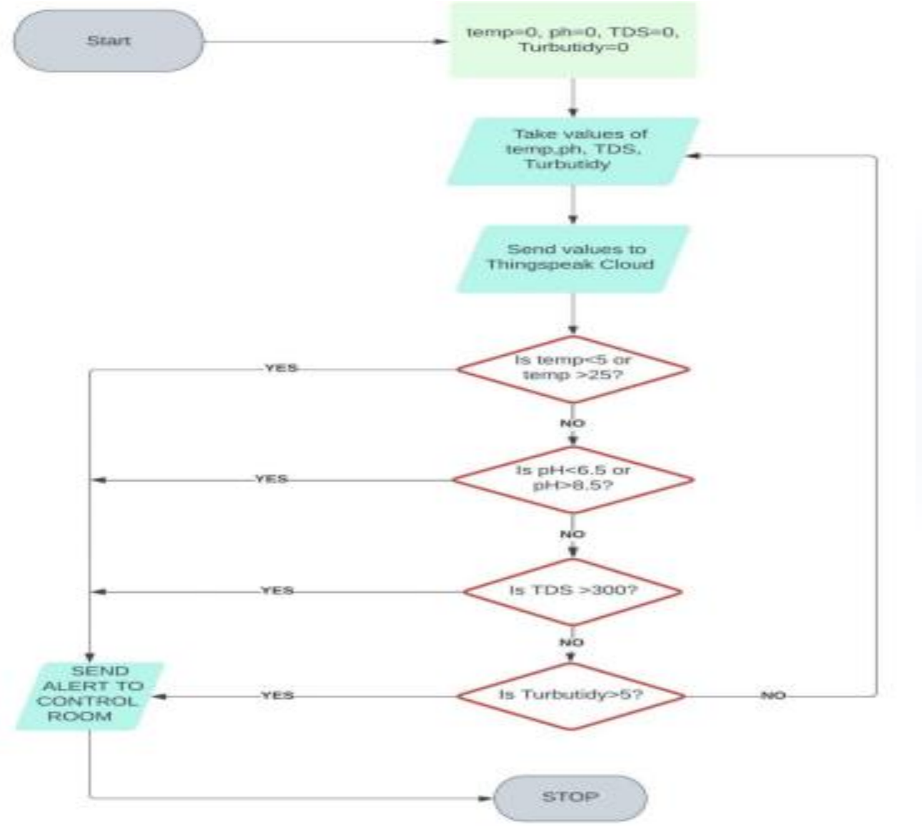
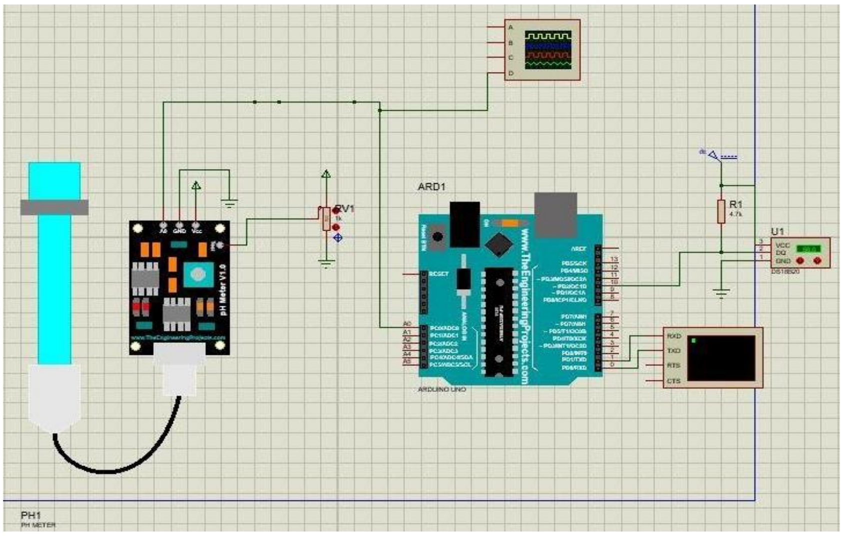


Fig. 3. Simulation Model of the system



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A. System Hardware

1. SEN0161 pH Sensor

pH Sensor is one of the essential electric devices used to determine the amount of acidity and alkalinity of any solution and water. In our project, we used this sensor to measure the pH of the water samples for our system.

2. DS18B20 Temperature Sensor

We have used DS18B20, a waterproof temperature sensing device consisting of a 1 m long probe, sealed and pre-wired, used to measure the temperatures of water and other fluids. This waterproof sensor can be easily connected to a microcontroller and gives digital inputs of the measured temperature. Its usable temperature range is 55^{0}C to 125^{0}C.

3. SENO0244 TSD-10 Turbidity Sensor

The turbidity sensor determines the amount of light that passes through the water and declares its results. We have used this sensor in our project to evaluate the clarity of water samples.

4. Analog TDS Sensor Module

Analog TDS Sensor stands for Total Dissolved Solids, used to measure the total concentration of dissolved particles/substances/solids such as salts and minerals in the water. We have used a TDS sensor that can measure up to a suitable range of 50-150 human consumption.

5. ESP32 Node MCU

ESP32 is an integrated microprocessor widely used for electronics and IoT programming. We have used Node MCU to send real-time data (water samples results) to the cloud through Wi-Fi.

6. NEO-6m GPS Module

NEO-6M GPS Module can track up to 22 satellites and identifies locations anywhere. They are low-power (suitable for battery-powered devices), inexpensive, and easy to interface with. In our project, this module is used to analyze the location of the nodes.

7. Solar Panel

Solar Panels are also PV Panels that convert light from the sun. A solar panel is used in our project to charge the system's battery to keep it running properly and without any shutdown.

8. Charging Control Module

The charging module with protection keeps the battery safe from over and undercharging. A charging module is added to our project because of solar panels. Its main function is to regulate the voltage and current from the solar panel, prevent overcharging, and keep the battery charged in the absence of solar light so that the system keeps working.

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Fig. 4. Hardware structure of the system

Result and Discussion

Fig. 5. Simulation based results

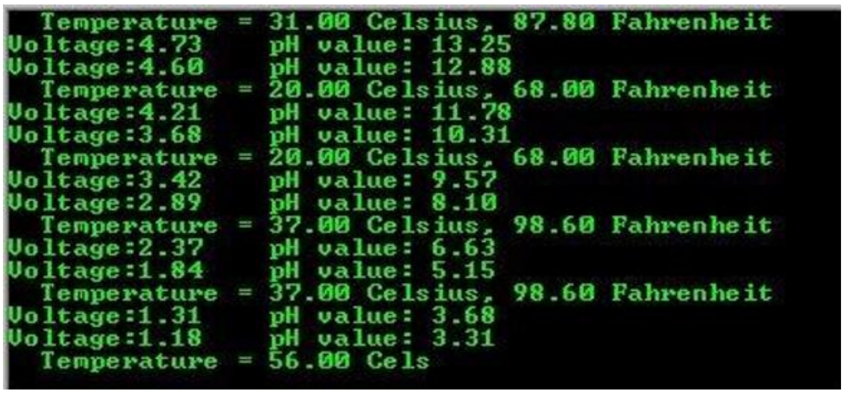

Fig. 6. Graph of the results

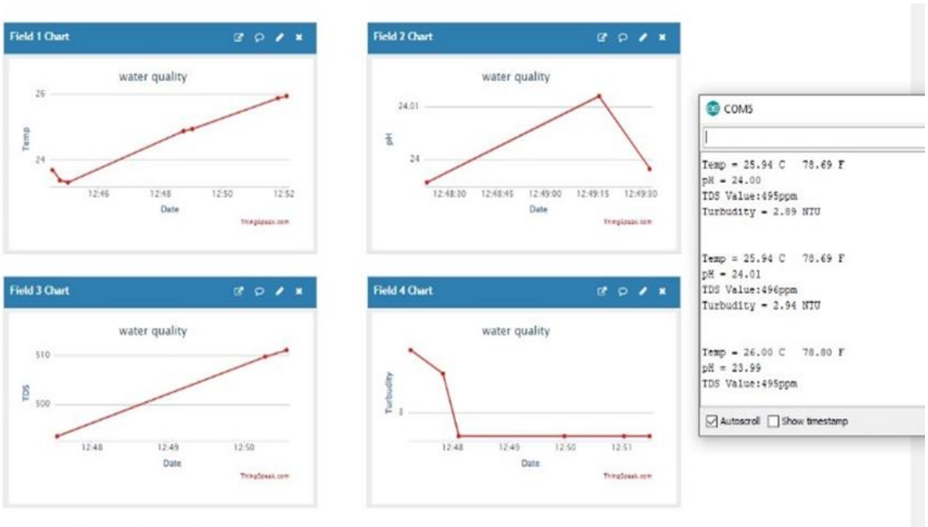

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Fig. 6 shows the output curves generated by the cloud for monitoring water quality parameters. Graphs represent different parameters of the water condition, such as TDS and turbidity, for comparison of data from various places and multiple days. We have used cage meters to view the current water parameter value. Graphs show the visualization of real-time data on water qualities that are also easy to understand. These are the final obtained results that will be sent to concerned authorities as proof.

Conclusion

Water best evaluation and purity testing for huge-scale industries is a hectic task. Real-time monitoring of water quality by using IoT integrated Real-time Data Analytics can immensely help people become conscious against using contaminated water and stop water pollution. Our research focuses on monitoring water parameters having any physical location using IoT and generating needful actions timely using data analytics techniques. It can be helpful in aspects of reliability, scalability, speed, and persistence. During the project development phase, an intense comparative analysis was conducted, and generated results were sent to the cloud for data logging.

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