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Enhancing IoT Based Aquamonitor Using React.js and Node.js Framework

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Abstract: Aquaculture is essential in addressing the increasing need for fish and other aqua products consumption globally. Nevertheless, maintaining the long-term development of aquaculture needs efficient monitoring of key environmental parameters to maintain optimal conditions for modern freshwater aquaculture health and productivity. This work introduces an IoT-enabled system for aquaculture monitoring (IoT Based AquaMonitor) tailored specifically for the needs of aqua farmers. The system utilizes IoT devices Integrated with sensors to track essential water quality factors likepH level, temperature through continuous monitoring and instant notifications, this system empowers users to enable wellinformed choices and take preventive actions to safeguard aquatic environment that enhances aqua production by developing a react web application which works seamlessly on both mobile phones and PCs and monitors various parameters like pH level, water temperature... etc. continuously through web application. By bridging the gap between technological innovation and traditional aqua practices, this IoT-based solution offers a promising pathway towards sustainable aqua farming.
Keywords: Aquaculture, IoT Based AquaMonitor, sensors, pH level, water temperature, react web application, mobiles, PC, aqua farming.

I. INTRODUCTION

Aquaculture is crucial for global food security and economic growth, but sustainability is key amidst rising fish production demands[1].Traditional monitoring methods in aquaculture lack real-time capabilities, necessitating the integration of IoT technology for continuous and remote monitoring of vital parameters.An IoT-based solution, including a user-friendly react mobile app, empowers aqua farmers with real-time data and actionable insights, driving improved productivity, resource efficiency, and environmental sustainability while fostering socio-economic development.

Aquaculture has emerged to be a major industry for meeting global food needs, supporting economic development, and meeting ever-growing demands of fish and other aquatic products [2]. With overfishing and the environment threatening the natural fish stock, aquaculture is viewed as a renewable alternative. In any case, good condition of water is essential to verify the well-being and productive efficiency of the aquatic organisms involved. Metrices like pH, dissolved oxygen, temperature, and concentration of ammonia need continuous monitoring to limit the likelihood of disease outbreaks, proper growth, and resource usage.

Traditional aquaculture monitoring is mostly based on manual water testing and visual inspections [3], which require much time and labor and are liable to inaccuracies. Since no real-time monitoring occurs, farmers cannot detect unfavorable conditions early; this may bring about financial and environmental costs.

IoT-based monitoring systems provide an advanced solution to such challenges by automating tracking water quality. IoT technology has the capability to enhance decision-making, operational efficiency[4], and sustainability in aquaculture by incorporating sensors, cloud computing, and data analytics. The system can immediately send notifications and predictive insights to the farmers so they can take appropriate corrective actions on time.

This paper presents the AquaMonitor IoT, an IoT-driven aquaculture monitoring system to support aqua farmers in maintaining the optimal conditions for water. The system utilizes IoT sensors that are continuously tracking the key water quality indicators, and the data will be transmitted to a React-based web application to provide access to both mobile phones and PCs. This technology is used by farmers to get better yields, environmental impact reduction, and efficient management of farms that lead to sustainable aquaculture

II. LITERATURE SURVEY

TheIoT has been introduced in aquaculture and it is widely explored for monitoring and automation. Khan et al. [5] proposed an IoTbased fish monitoring system provides real-time data collection for aquaculture. The system improves efficiency by reducing manual monitoring efforts while ensuring optimal environmental conditions for fish growth. Similarly, Tolentino et al.

[6] developed an aquaculture monitoring system which monitors water for the useful of fisheries, highlighting the benefits of IoT in maintaining water quality and reducing human intervention. Another study by Poddar et al. [7] extended IoT applications to urban farming, where sensor-based verification of environmental parameters was implemented. Although not specifically focused on aquaculture, their research demonstrates the effectiveness of IoT in monitoring and maintaining agricultural and aquatic environments' et al. [8] further emphasized the importance of IoT in water quality monitoring using TDS (Total Dissolved Solids) sensors. Their system continuously tracks water quality parameters, ensuring that aquatic conditions remain within ideal thresholds for fish farming. This approach aligns with the broader goal of improving aquaculture sustainability through technology.

With the increasing adoption of IoT in aquaculture, real-time data visualization and remote monitoring are crucial. Hyseni et al. [9] explored the development of a web-based real-time communication system using WebSockets, React, Node.js, and MongoDB. Their findings highlight the efficiency of WebSockets in ensuring seamless real-time updates, which can be beneficial for monitoring fish farming conditions. Additionally, modern web application architectures. ClickITech [10] provided a comprehensive guide on the latest web application architectures, emphasizing microservices and cloud-based solutions. These advancements are instrumental in developing scalable and reliable monitoring systems for aquaculture.

React has become a preferred framework for building dynamic and interactive user interfaces in web-based IoT applications. DhiWise [11] outlined the advantages of using React for Single Page Applications (SPAs), particularly in real-time systems. Its component-based architecture allows developers to efficiently manage and update UI elements, making it ideal for displaying IoT sensor data in aquaculture monitoring applications.

Saha et al. [12]Designed an IoTenabled automated fish farming monitoring system that employs sensors to assess vital water gradingfactors likepH, temperatureand amount of dissolved oxygen.Theirstudy emphasizes role of wireless sensor networks in improving fish farming efficiency and reducing manual labor. Similarly, Hairol et al. [13] suggested a system based on Arduino Mega monitoring system for selfoperating fish ponds, demonstrating real-time data collection and control mechanisms for optimal fish growth conditions.Murad et al. [14] introduced a water quality monitoring system for aquaponics utilizing an Arduino microcontroller, which integrates hydroponics with fish farming. Their system ensures sustainable water usage by continuously monitoring ammonia, nitrate, and pH levels.

Biofloc Technology and Water Quality Management Crab et al. [15] investigated the benefits of biofloc technology in aquaculture, highlighting its potential to improve water quality by promoting beneficial microbial activity. This method enhances fish health and reduces dependence on water exchange, making aquaculture more sustainable.

Recent Advances in IoT-Based Monitoring Khan et al. [16] integrates IoT sensors, Machine Learning, and QAOA to enhance water quality monitoring, achieving high prediction accuracy and reducing model training time by 50%. The system improves fish survival rates and supports sustainable aquaculture with real-time, cost-effective monitoring.[17] IoT, AI, and machine learning are transforming aquaculture by optimizing efficiency, sustainability, and fish health through real-time monitoring, automation.

Integration of IoT in Agrotechnology Poddar et al. [18] Algerian aquaculture is growing rapidly, and this study presents IoTbased system for realtime water quality monitoring ensure sustainable fish farming. [19]This study develops IoTbased water quality monitoring system, enhancing lowcost sensor using simple linear regression. The system, validated against YSI Professional Pro, achieved accuracy levels of 76% to 97%, ensuring reliable real-time monitoring.the system provides aquafarmers with precise water quality insights, improving productivity and sustainability.

III. IOT SYSTEM IMPLEMENTATION

This is the entire system implementation of this work which I have worked on.

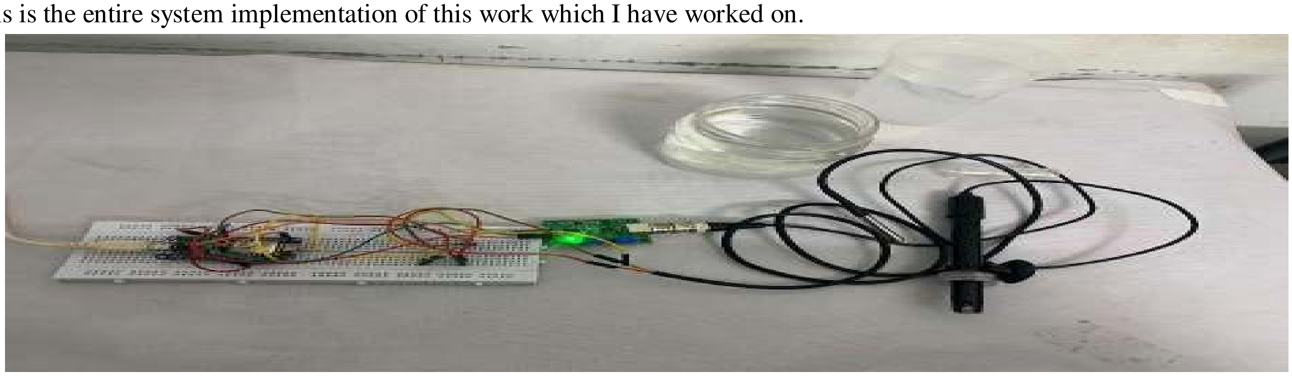

Fig 3.1 system Implementation

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A. NODEMCU

NodeMCU is a microcontroller which is a opensource firmware that provides flexibility and customization for developers that enables easy integration of Wi-Fi connectivity into embedded systems[20]. Built around ESP8266 microcontroller, NodeMCU widely used in Internet of Things applications because its low cost, power efficiency, and ease of programming[21].The NodeMCU module is integrated with web application via built in enabled Wi-Fi to monitor sensor data. The pH sensor is connected to A0 pin and temperature sensor is connected to D0 pin respectively, enabling real-time data transmission to react web application. A 5V adapter powers the setup.

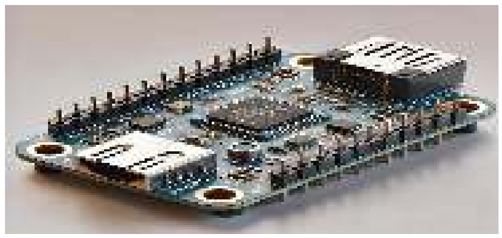

Fig 3.2NodeMCU

B. PH SENSOR

A pH sensor monitors acidity and basicity of water.The probe is present in the pH sensor which gathers the data of concentration of hydrogen ions in the liquid[22], which is then translated into a pH value. When integrated with a NodeMCU, a popular microcontroller with Wi-Fi capabilities, the sensor is used in different type of applications such as environmental, aquaculture, and agricultural projects.Po pin of pH sensor is connected to A0 pin of NodeMCU to measure hydrogen ion concentration, determining water acidity or alkalinity. The V+ pin is linked to the 3.3V to the NodeMCU, while the G pin is connected to the ground (G) of the NodeMCU for proper operation.

Fig 3.2pH sensor

C. TEMPERATURE SENSOR

Waterproof temperature sensor is the most important component in IoT systems that require accurate temperature monitoring in environments exposed to moisture, water, or other harsh conditions[23]. These sensors are designed with rugged, weatherproof enclosures, ensuring reliable data collection even in challenging outdoor environments.The brown wire of the temperature sensor is connected to D0 pin of NodeMCU to measure water temperature. The red wire is linked to the 3.3V pin for power, while the yellow wire is connected to the ground (G) of the NodeMCU for proper functionality

Fig 3.3Waterproof Temperature sensor

D. BREADBOARD

A breadboard, also known as a solderless breadboard, is a versatile tool used for building and testing electronic circuits without the need for permanent soldering. It allows engineers, hobbyists, and students to quickly prototype and experiment with circuit designs, making it an essential component in the early stages of electronics development.

The jumper wires maletofemale and maletomale were used to connect the pH, temperature sensors to NodeMCU via a breadboard. The pH sensor is linked with its Po pin to A0, V+ to 3.3V, and G to G on NodeMCU. Temperature sensor is connected with brown wire to D0, red to 3.3V, and yellow to G on the NodeMCU. The breadboard helps organize the connections for efficient wiring. This setup, shown in Figure 3.1, ensures stable data transmission between the sensors and the NodeMCU

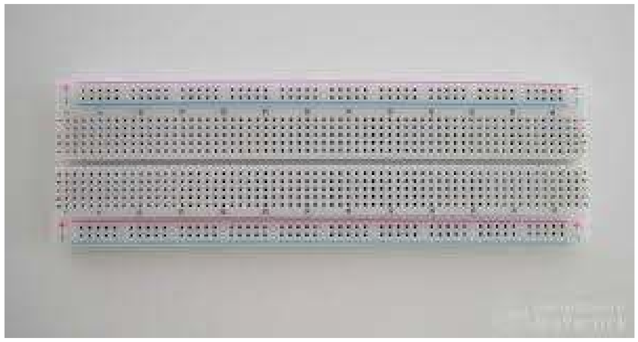

Fig 3.4 Breadboard

IV. IOT BASED AQUAMONITOR

This IoT-based Aquaculture Monitoring System (Aqua Monitor IoT) is used to monitor various IoT devices like pH sensor, waterproof temperature sensor.etc through NodeMCU to our react web application which works seamlessly on both mobile phones and PC's. It can regularly monitor and give instant feedback to our react web application. Our system makes informed decisions and takes proactive actions towards the aquatic environment to safeguard the aquatic life and to enhance the productivity of the aquatic organisms like fish,prawns, green algae..etc. It can be very useful for freshwater aqua farmers so that they don't have to be present on-site regularly unless they receive an alert or notificationfrom the React web application.

This IoT-based React web application has been developed using Node.js React framework. It integrates a NodeMCU with sensors like pH sensor, temperature sensor..etc. allowing data to be collected from the sensors and transmitted to the NodeMCU. The data is then fetched from the NodeMCU and displayed in React web application.

A. *This is web based application in pc version*

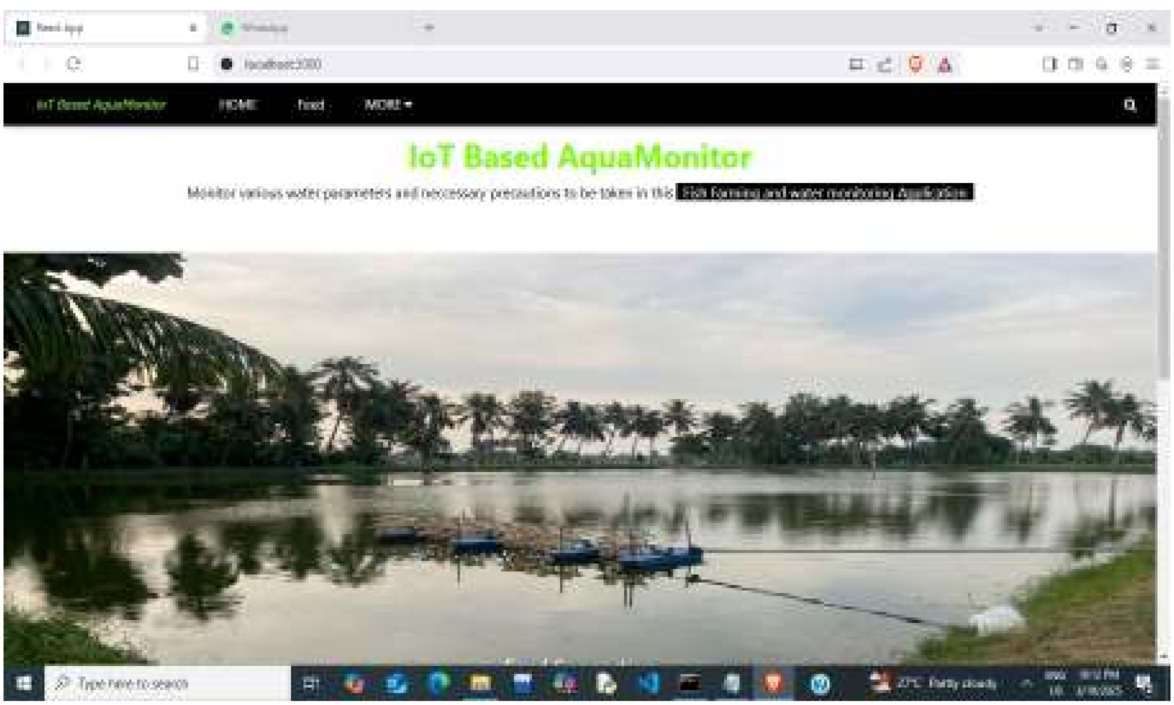

Fig 5.1 React web application interface desktop version

B. This is web based application in mobile version

Fig 5.2 Mobile edition interface of home page

Fig 5.3

Mobile editioninterface of user interface

C. This is the view of web applications on both devices mobile and PC.

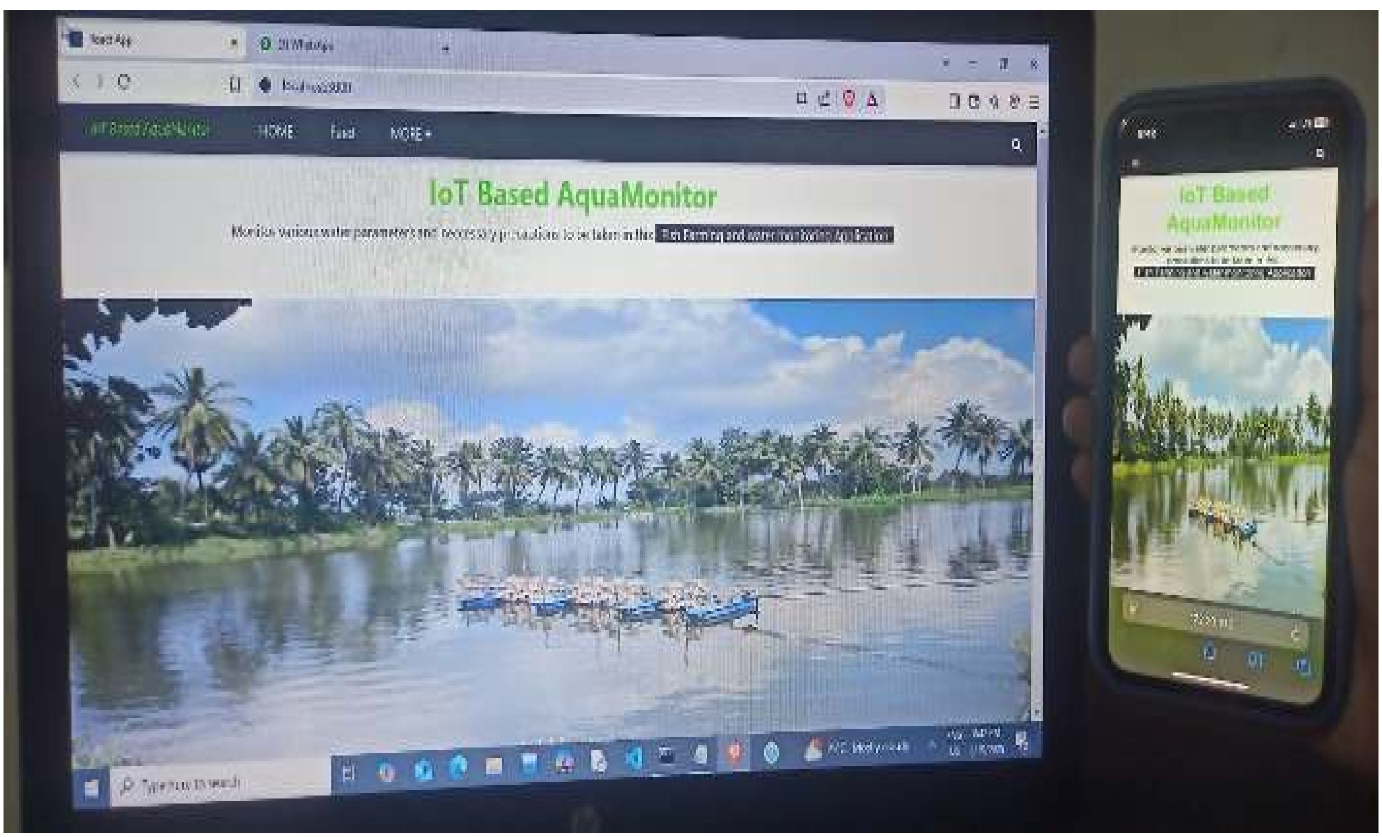

Fig 5.4 Simultaneous working on both web and mobile interface

D. Test Scenario -1: If the temperature is high and the pH is optimal, we can achieve this.

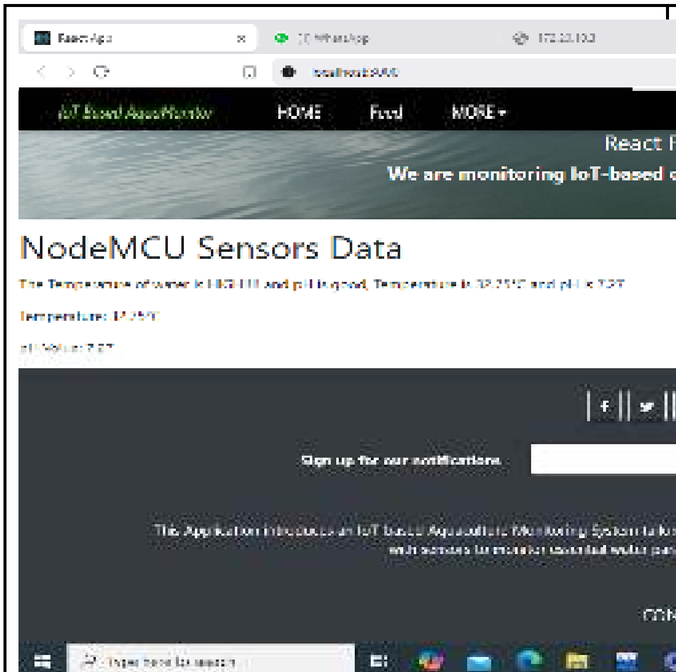

Fig 5.5 Web version for Test Scenario -1

Fig 5.6 Mobile version for Test Scenario -1

E. Test Scenario -2: If the temperature and pH is optimal, we can achieve this.

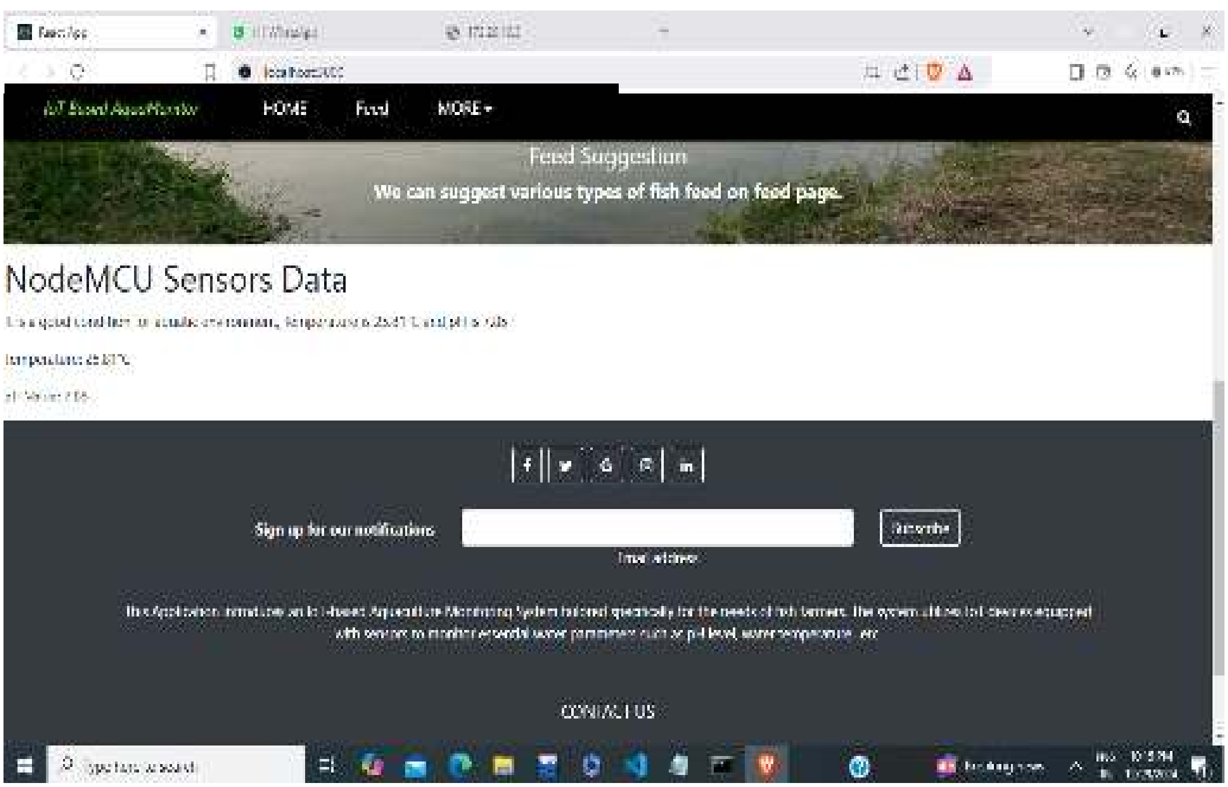

Fig 5.7 Web version for Test Scenario -2

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F. Test Scenario -3: If the temperature is optimal and pH is high, we can achieve this.

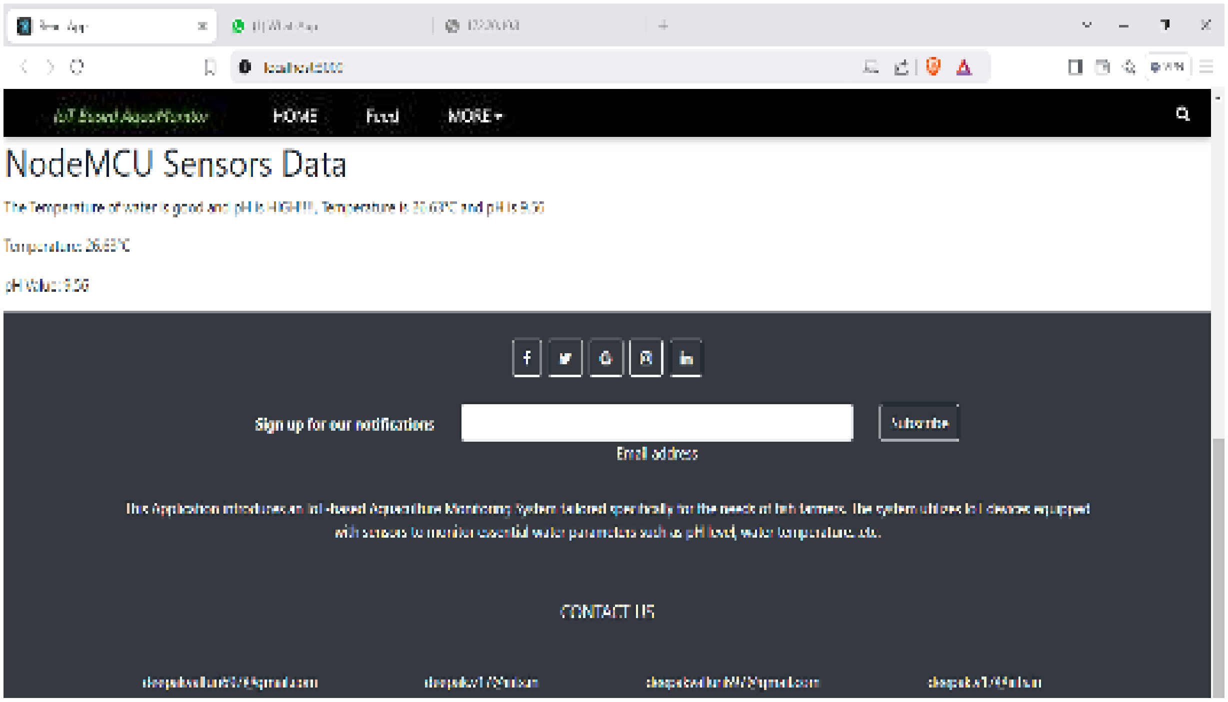

Fig 5.8 Web version for Test Scenario-3

G. Test scenario -4: If there is a power outage to nodemcu, we can achieve this.

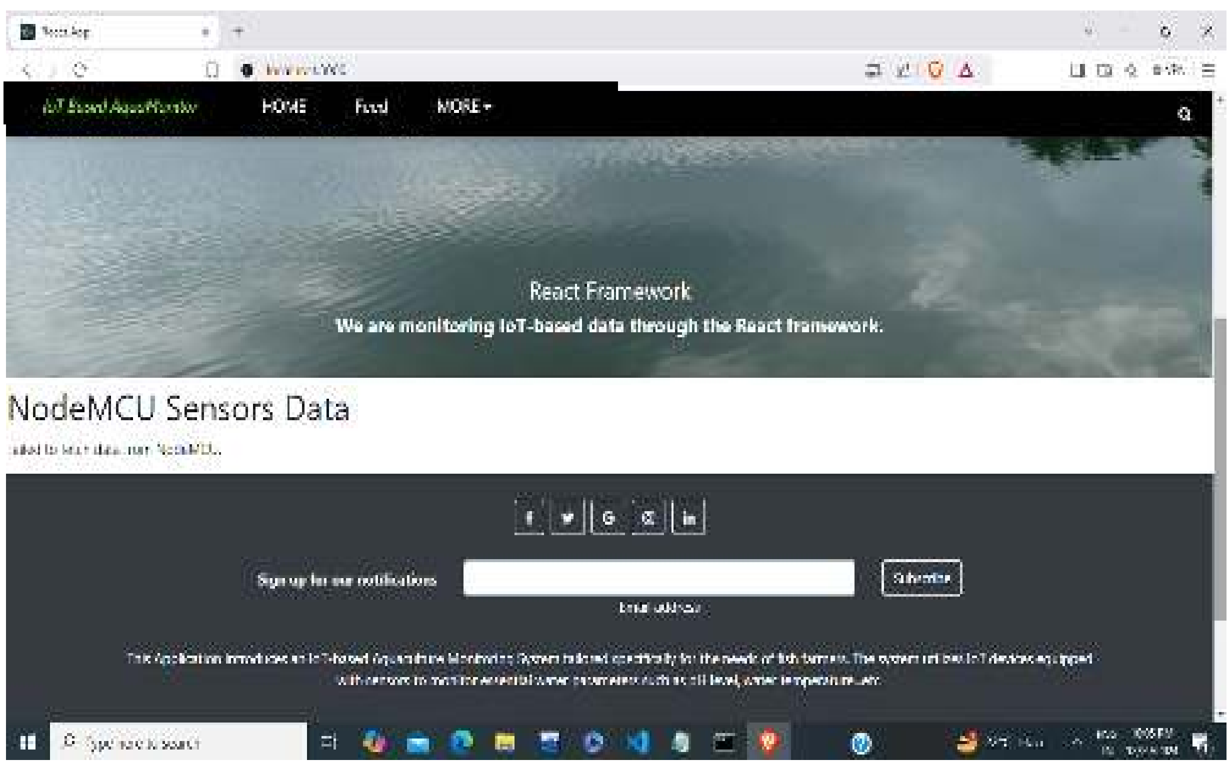

Fig 5.9 Web version for Test Scenario-4

H. Test Scenario-5:If the temperature is optimal and pH is low, we can achieve this.

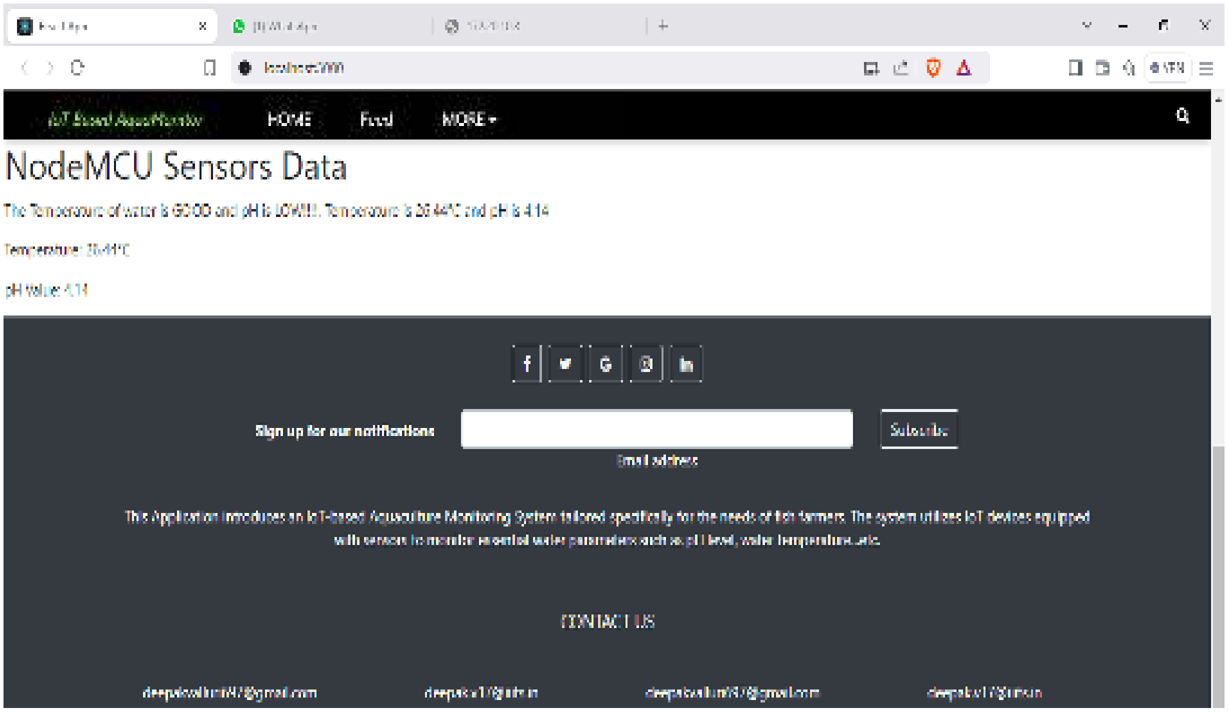

Fig 5.10 Web version for Test Scenario -5

V. CONCLUSION AND FUTURESCOPE

The AquaMonitor IoT system presents a sustainable solution for modern aquaculture by leveraging IoT technology, real-time monitoring, and intelligent automation. By integrating Node.js and the React framework, the system ensures efficient data processing, visualization, and remote accessibility, enabling farmers to maintain optimal water conditions with minimal manual intervention. This research highlights the significance of IoT-driven aquaculture in promoting environmental sustainability, improving resource efficiency, and reducing operational costs. The implementation of automated control mechanisms enhances water grade level management, contributing to healthier aquatic ecosystems and increased productivity. Future advancements in AI-driven analytics, predictive maintenance, and cloud-based data management can further optimize the system’s capabilities, making AquaMonitor IoT a scalable and adaptable solution for global aquaculture industries. This study serves as a foundation for future research in aquaculture, aiming to achieve a balance between technology, sustainability, and food security.

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