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SMART AQUACULTURE: IOT-BASED WATER QUALITY MONITORING SYSTEM

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ABSTRACT

The Internet of Things (IoT) is rapidly expanding its reach across various industries, emerging as a swiftly growing technology. Its influence is widespread, touching virtually every sector with its transformative capabilities. Aquaculture, a global crucial economic and food source, faces challenges arising from environmental limitations and aquatic diseases, necessitating significant resources and expertise for production enhancement. Water quality management is paramount, especially in pond systems, where multiple parameters influence it. A unified system incorporating water level, temperature and pH sensors connected to an Arduino Uno R3 microcontroller and an ESP8266 Wi-Fi module is proposed to address this. This system enables real-time data transmission to the IoT platform ThingSpeak and automates DC water pump control based on sensed data, accessible through a web interface and mobile application. By providing comprehensive monitoring and management capabilities, this integrated platform empowers aquafarmers to sustain profitability and ensure environmental sustainability.

KEYWORD--Aquaculture, Microcontroller, Sensors, Actuators, Water quality monitoring, IoT ·

I. INTRODUCTION

The growing global population drives up food consumption. However, the area that can be used for agriculture and cattle farming has been steadily declining due to the intensification of the greenhouse effect and the depletion of world resources. Aquatic products are easy to capture rich in protein and can be farmed; therefore, humans are increasingly dependent on fishery resources

Aquaculture water body's critical properties, including pH, dissolved oxygen, temperature, and turbidity, are continually monitored by IoT-based systems through the use of a network of linked sensors and devices. Aquaculture operators may obtain real-time data remotely and respond quickly to changes in water quality parameters by utilizing Internet of Things capabilities. This allows for proactive management. In addition to improving the general well-being and health of aquatic life, this also maximizes productivity and lowers the possibility of adverse environmental effects. Of them, temperature, water level, pH, and salinity are the most crucial factors that need to be watched over and managed.

The techniques used to monitor aquaculture ponds are currently inefficient since they require a lot of effort and time, and they rely on the experience of the farmer. Pond conditions are often measured only after farmers have noticed irregularities in the water.

One of the main factors influencing aquafarms' ability to produce aquatic products is water quality. People and ecosystems may be at risk for health problems due to poor water quality. Water from an aquafarm is manually sampled using traditional ways of assessing water quality, and it is then tested in a laboratory using devices or test papers. These methods, however, take a long time and a great deal of labour.

An Internet of Things (IoT)-based smart aquaculture system (ISAS) for tracking multiple water quality measures in an aquafarm is presented in this research. Three sensors—temperature, pH, and water level—are coupled to an Arduino development platform and wifi module in the Internet of Things-based smart aquaculture system (ISAS). The observed data are sent to a Thingspeak from GSM Module where we receive warnings.

II. LITERATURE REVIEW

A. Related Work

E-Aquaculture Monitoring Using Internet of Things [3]In this system, we use different sensors for measuring the position of the water and soil. The pH sensor, humidity sensor, water level sensor, oxygen sensor and moisture sensor are the sensors which measure the level of the water and soil. The pH sensor measures the acidic or basic nature of the water and soil. The moisture sensor is used to measure the volumetric water content in the soil and just near the pond atmosphere. The humidity sensor measures the amount of water vapour in the air. The water level sensor measures the water level. The analogue signals are directed to the microcontroller and process. The system is not included a Phone app and web interface, which is inefficient for displaying the data.

Aqua monitoring system using aws[8] In this project used Room Temperature, Humidity, Water Level, LED status and Feeder status. Sensor acquisition is performed by ESP-32, it is also used as data processing device as well as local server/controller. User can monitor the conditions of the aquarium locally or remotely from any part of the world as long as he/she has an Internet connection since data is processed through AWS Lambda, stored in DynamoDB and hosted in AWS API. Data is further visualized using AWS IoT Analytics and QuickSight for proper decision making.

An IOT-Based Real-Time Aquaculture Health Monitoring System. The IoT method in [1] used technologies in water quality management system. In this system, four sensors are used to measure the essential water parameters. The most essential water parameters needed to be monitored by the average users are water pH level, water level sensor, oxygen and water temperature which is a measurement of the amount of water in a container. This system doesn't contain the GSM module for alert messages.

B. Problem Statement

The literature analysis shows that one of the sectors in emerging nations with the fastest growth is aquaculture. Aquaculture is the practice of raising marine fisheries in artificial environments like tanks and ponds. Many elements are taken into consideration when producing these fisheries in habitats that are intentionally built. Food production and financial development are essential to this activity and face significant worldwide obstacles. The most important ones are caused by fungi, bacteria, and viruses. Water quality led to the discovery of each of them. Variations in water quality can put fisheries under stress and threaten their sustainability. The majority of aquacultures use manual techniques to calculate water quality measurements. Because of the parameters and the time it takes, manual testing yields unreliable findings. however, there aren't enough facilities around their aquaculture. Water measurement parameters are unreliable and vary repeatedly.

III PROPOSED MODEL AND DESIGN

There are two categories in this system design. The hardware configuration comes first, followed by the software implementation. First, the Arduino UNO R3 microcontroller must be connected, and sensors must be assembled Gsm module dc motor and calibrated. The second step is programming the Arduino and setting up a Wi-Fi connection to transfer data to the server and get alert messages.

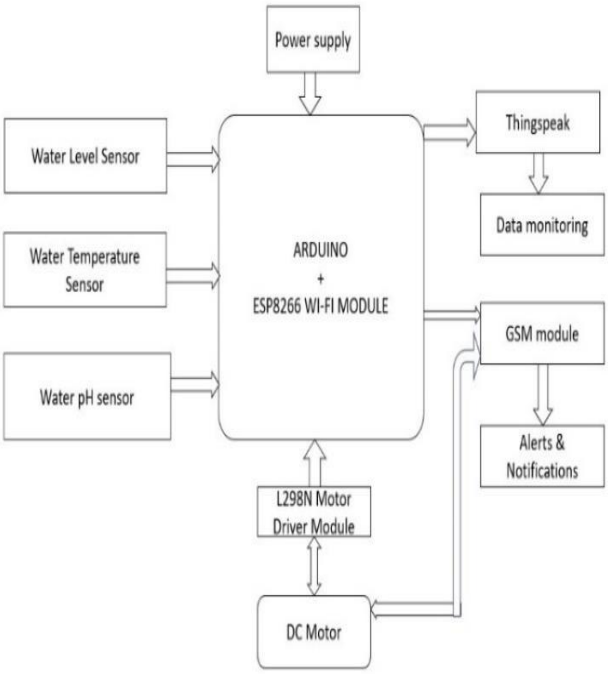

Fig. 1. Block diagram of the proposed System.

The system depends on three primary sensors and is connected to the microcontroller. Based on the data collected the dc motor will on and off automatically Wi-Fi module ESP8266 used with Arduino UNO R3 for communication with server ThingSpeak and GSM module for alert messages.

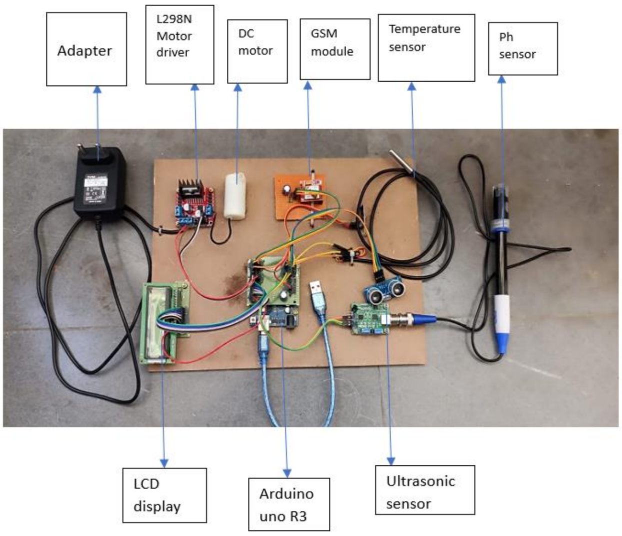

Fig. 2. Proposed water quality Monitoring System

The hardware-assembled proposed system is illustrated in Fig. 2. The micro-controller Arduino Uno R3 is used with the ESP6288 Wi-Fi module. The system is designed for the three crucial water metrics measurements, and these values are taken by using water level, temperature and water pH sensors. The container is used for system testing. Sensors are calibrated before installation and precisely checked using standard techniques such as pH sensor in buffer solution, dipping the dissolved oxygen sensor in zero dissolved solution, temperature sensor, and ultrasonic sensor reading using a physical scale.

1) Arduino Uno R3

Based on the ATmega328P, the Arduino UNO microcontroller board is depicted in Figure 3. It contains six analog inputs, a 16 MHz ceramic resonator, a reset button, a power jack, an ICSP header, a USB port, and fourteen digital input/output pins.
merely has to use a USB cable to connect to the computer.
This microcontroller can be easily acquired at a reasonable price.

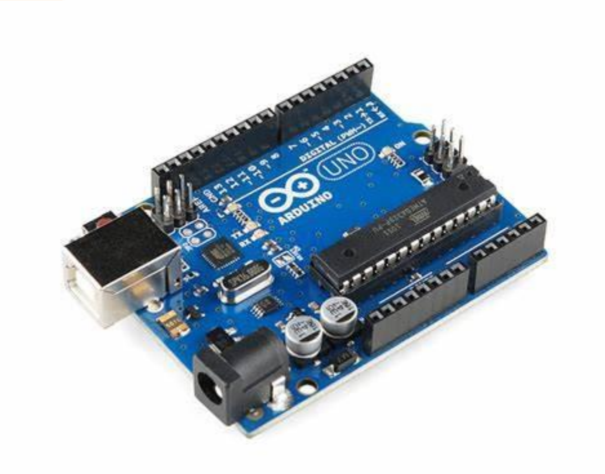

Fig. 3. Arduino Uno R3.

2) pH sensor

pH electrode probe has reliable reading accuracy and can provide almost instantaneous reading of pHvalue, thus it can be used in water purification processes. This pH sensor probe is depicted in Figure 4 is refillable, which mean its KCl (potassium chloride) salt solution can be refilled to extend pH, quantitative measure of the acidity or basicity of aqueous or other liquid solutions. The term,widely used in chemistry , biology, and agronomy, translates the values of the concentration of thehydrogen ion —which ordinarily ranges between about 1 and 10 −14 gram-equivalents per litre into numbers between 0 and 14

Fig. 4. pH sensor

3) Ultrasonic sensor:

Ultrasonic sensors is depicted in Figure 5 are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. The speed of emitted ultrasonic waves travelling speed is faster than the audible sound.

Fig. 5. Ultrasonic Sensor

4) Temperature sensor

A temperature sensor is depicted in Figure 6 that is single-wire programmable in nature. It is widely used to measure the temperature of chemical solutions and substances which are present in a hard environment. One of the advantages of using this sensor is that we only require a single pin of our Arduino board to get temperature samples. Therefore, it is extremely convenient to use with the microcontroller as we can use multiple DS18B20 temperature sensors by using only one pin on Arduino.

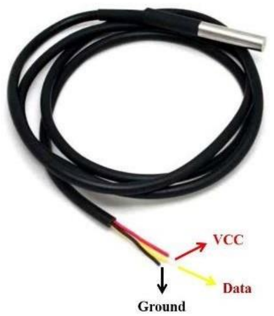

Fig. 6. Temperature sensor

5) L298N MOTOR DRIVER MODULE

This L298N Motor Driver Module is a high-power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.

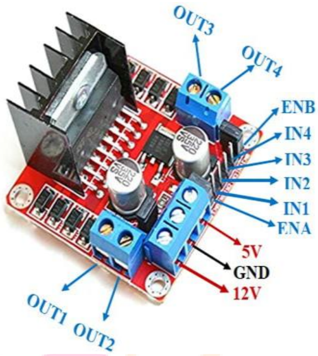

Fig. 7.L298N Motor Driver

6) ESP8266 WI-FI Module

The ESP8266 is a low-cost Wi-Fi microcontroller chip manufactured by Espressif Systems. It became popular for its ability to provide Wi-Fi connectivity to embedded systems at a low cost. The ESP8266 chip is used in various IoT projects and products. It comes in different versions, with varying amounts of flash memory and features

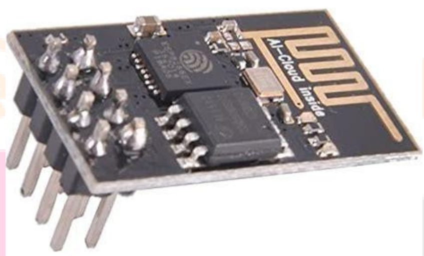

Fig. 8 WI-FI Module

7) DC motor:

DC motor is defined as a class of electrical motors that convert direct current electrical energy into mechanical energy. A DC water pump is an electric pump with low voltage. They are quiet and use little power. They are used for many applications, including automotive, household, and water wells.

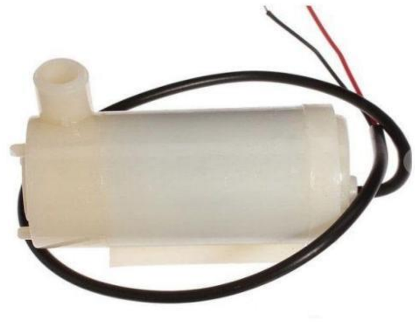

Fig. 9 DC motor

8) SIM800L GSM Module

The SIM800L is a GSM module from Simcom that gives any microcontroller GSM functionality, meaningit can connect to the mobile network to receive calls and send and receive text messages, and also connectto the internet using GPRS, TCP, or IP. Another advantage is that the board makes use of existing mobilefrequencies, which means it can be used anywhere in the world.

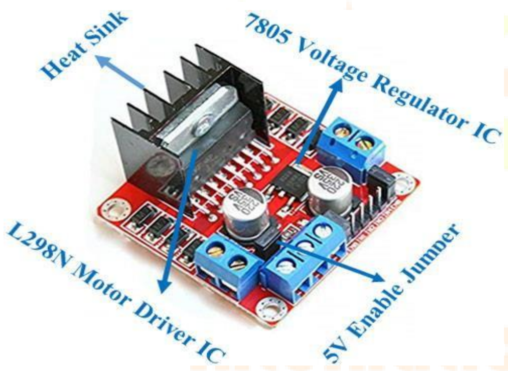

Fig.10. GSM Module

C. Software Implementation

The second step, which is necessary for system setups, is software implementation after hardware setup. Conversely, let's say that the system's core is its hardware. Then, the system's outer layer is the software implementation. The software facilitates communication between the various parts, acquires data from the hardware, and presents the outcome together with a time series on the web server and phone.

Three sub-sections define the software part implications below:

i. IDE for Arduino Programming.
ii. Writing Data to the Cloud server.
iii. Reading Data on website and Phone App.
iv. IDE for Arduino Programming.

IDE Stands for (Interpreter Developed Environment) designed by Arduino.cc. IDE is available open-source online and compatible with all Arduino modules microcontrollers, ESP32, MKR1000, Arduino Uno, Arduino Mega, and Arduino Nano. IDE could use online and install in all windows operating systems. IDE provides two main parts an editor and a compiler. The compiler is used for compiling and uploading code to the Arduino module by using codes in the editor. C and C++ languages can use to write the code in IDE . After installing the IDE in the Operating system, Editor prompts up while opening the IDE and using Tools from the tab bar to install the required libraries according to the microcontroller module and sensors. After installing the required libraries, the editor is ready to write the code.

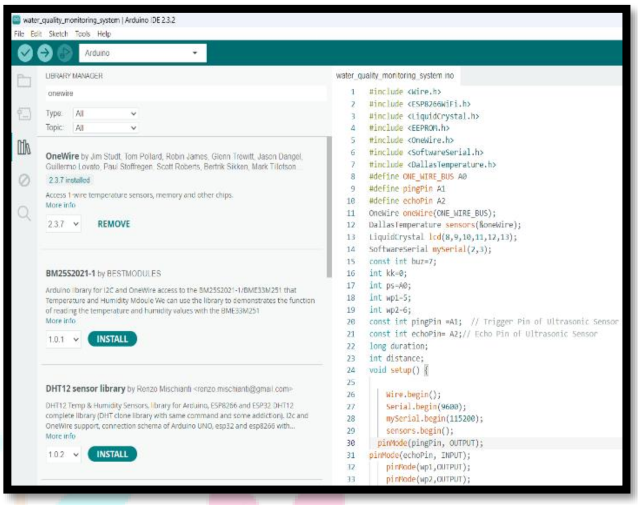

Fig. 11. IDE Editor and Library Manager

The microcontroller Arduino Uno was selected for the suggested system. In order to link the microcontroller from the library manager, an Arduino Uno was installed. Additionally, an ESP8266 Library was loaded in order to transmit data over wifi. In addition, sensor libraries were needed for the pH, temperature onewire library has seen in FIG.11 , and ultrasonic sensors.

The ThingSpeak server is utilized for data transfer and wireless display, enabling ThingSpeak library. Once the necessary libraries have been installed, begin writing and compiling the code. The errors are displayed in the black console if there is a code button issue. After fixing the problem, uploading the corrected code to the microcontroller allows you to view the system's data on the serial port by clicking the system's values via the serial port by using the Toolbar. Fig. 12 displays the system flow chart that is shown below.

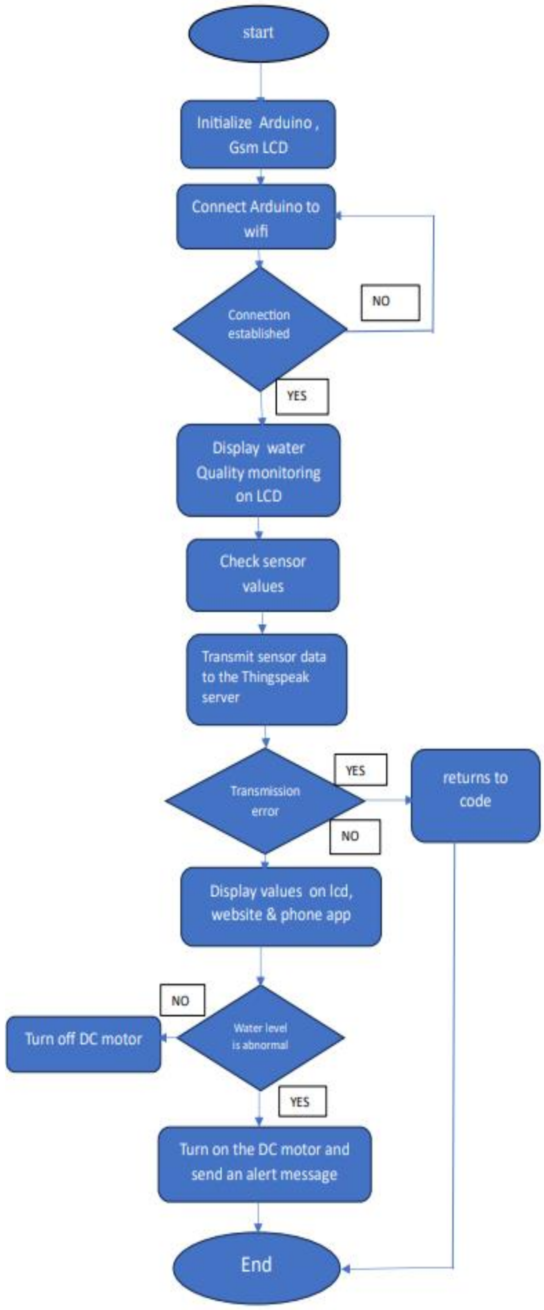

Fig. 12. Flow Chart of the proposed system represents the functions.

1) Data uploaded to the cloud server

These days, cloud technologies are well-known for having revolutionized the globe by offering IoT and data storage services. Online cloud resources include ThingSpeak, AWS, Azure, and many more. ThingSpeak's free and open-source IoT analytics platform and data storage made it the preferred choice for this suggested solution. However, alternative sources come at a higher cost. Because the ThingSpeak library is available on the IDE, users may easily set it. ThingSpeak has eight channel fields for data reading. It implies that ThingSpeak might be used to set up 8 sensors concurrently.

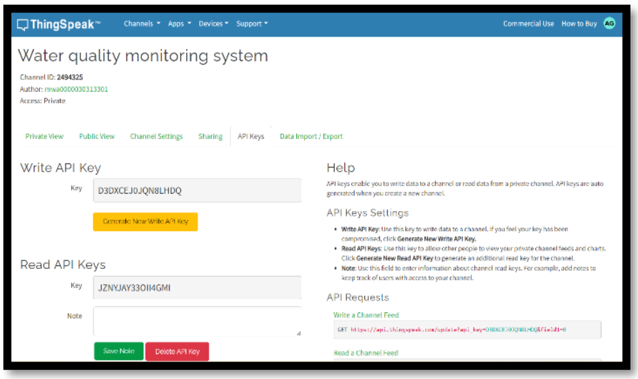

Fig. 13. ThinkSpeak Channel ID and API keys.

Following the proper code writing, the microcontroller used the ESP8266 to connect to the WiFi. Using the name of our suggested system in Figure 13, the ThingSpeak Channel was established. Next, the system generates its own API keys and unique channel ID. The code uses these API keys to send data from Arduino to the ThingSpeak channel. Writing the final code and uploading it to the Arduino Uno microcontroller required the use of ThingSpeak Channel ID, API keys, and local Wi-Fi credentials. Insert the data into the selected field channel of each individual sensor on the dashboard by writing the API key that is used for data transmission and reading the API key allows the data from every sensor individually to be displayed on the dashboard in its allocated field channel.

2) Monitoring Data on Mobile Apps and Websites

All sensor data was shown on the ThingSpeak Channel on their website once data transmission from Arduino to ThingSpeak was accomplished. ThingSpeak provides private internet channel access, and time series data visualization is available.
Figure 14 shows the data presentation on the ThingSpeak channel dashboard. Three fields were set up for the three sensors, and in each field, data transmission was precisely observed.
Data that are shown with the measuring unit and time series shown on the y-axis. Temperature is recorded in field 1, pH is recorded in field 2, and water level is recorded in field 4.

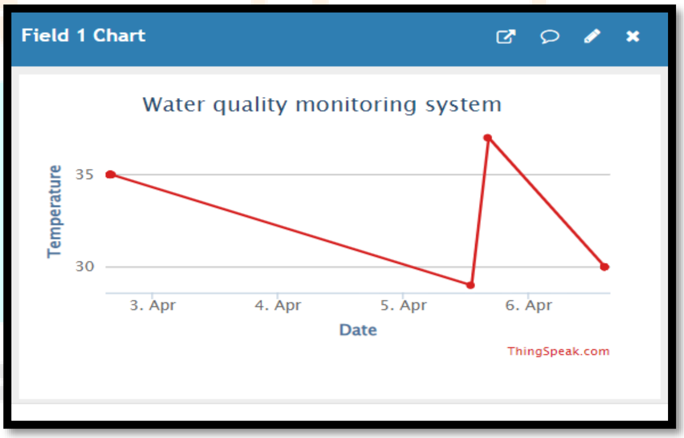

Fig.1 Field -1

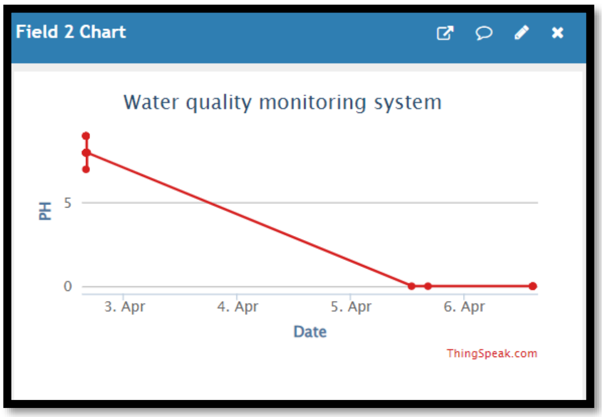

Fig.2 Field -2

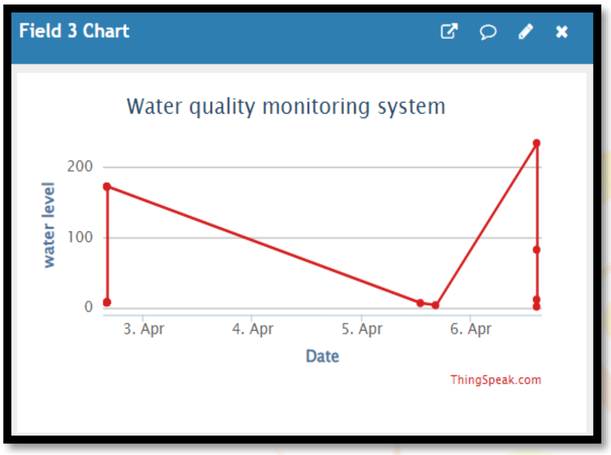

Fig.3 Field -3

Fig. 14. Data display dashboard on ThingSpeak.

2) Alert messages generated by the GSM module

Alerts generated by a GSM module typically involve signaling or notifications triggered by certain conditions detected by the module. Here conditions are given when the ph value is greater than 7.5 or the temperature sensor is greater than 30.
The module can be programmed to send SMS alerts to predefined numbers or contacts when certain events occur. For example, if a sensor connected to the GSM module detects a change, the module can send an SMS alert to notify the user.

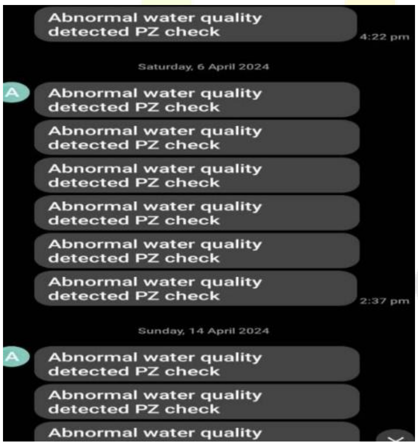

Fig. 15. Generating alerts on a mobile phone

The proposed system could successfully access the Phone App provided using the API key and channel ID by ThingSpeak. And also by assigning a phone number to the GSM module, aquafarmers can receive alerts

IV CONCLUSION

The designed proposed system concluded that ,"Smart Aquaculture IoT-Based Water Quality Monitoring System," underscores the significance of harnessing IoT technology to address the challenges faced by the aquaculture industry. By developing a comprehensive monitoring solution that integrates sensors, microcontrollers, and IoT platforms, we have demonstrated the potential to enhance water quality management in aquaculture environments. The system's ability to provide real-time data monitoring, remote access, and automation features offers aquaculture practitioners a powerful tool for optimizing production efficiency, minimizing risks, and promoting sustainability.

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