An Intuitive Remote Monitoring Framework for Water Quality in Fish Pond using Cloud Computing

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Abstract. Accuracy in prediction of water quality is a recent research domain gaining popularity in smart aquaculture. In aquaculture, the modifications in water quality parameters possess nonlinearity, dynamicity, unstableness and complexity due to the open environment with its surroundings. Conventional prediction methods have several disadvantages like poor generalization, lower accuracy and high time complexity. By considering these issues, a Novel water quality prediction method interfaced with (IoT)Internet of Things termed as Low-Cost Real-Time Monitoring System (LCRTMS) is proposed to predict water temperature, pH, DO, and Ammonia. Multi-sensors and Blynk private cloud integrated framework are used for collecting data in real-time and enhancing the remote monitoring capabilities. Experimental results indicate that the accuracy in predicting temperature, DO, pH and ammonia can attain 98.56% in 0.257 seconds and 98.97% in 0.301 seconds in the short-term prediction.

1. Introduction
Aquaculture has a significant part in thriving sectors of the food industry. In 2019, worldwide fish production reached its highest point at around 200 million tons while aquaculture contributing 47 percent of the overall production. Due to the stability in outbreak of fishery production through capturing in the previous 1980s, aquaculture is being accountable for the continuous magnificent development in the surplus circulation of fish for human utilization. As per the UNFAO (United Nations Food and Agriculture Organization) report, currently a person intake an average of around 19 to 20 kg of fish products per year. This mean consumption is estimated to grow by 16.7 kg per year in 2030. Aquaculture needs to be upgraded more to provide aquatic eatable products in abundance to fulfill the demands of society. Availability of multiple varieties in fish made aquaculture to provide a profitable yield since fish products are always delicious and healthier to human. An approximation intimates that, fish demands in the country would be around 16 million tons by 2025. Natural habitat of fishing is getting attenuated because of overfishing. It resulted in the arrival of commercial aquaculture that faces several problems because of the uncertainty in climatic conditions causing modifications in water quality parameters. In comparison with animal production and land-based crops, fish are completely affected by the presence of pollutants in water; Hence aquaculture production is prone to water-quality degradation. In addition to this, uncooperative fish farming leads to the outbreak of several viral infections in fish and results in huge loss to aquaculture. The water quality of the fishpond is one of the parameters that should be given significant importance because the mobility of fish is affected when the water quality becomes poor in an environment where the fish is grown inside a pond or in a closed water surface [1]. Water quality has a direct impact in rate of growth, efficiency in feeding and overall progress of the fish. There are certain factors like pH, water level, dissolved oxygen and temperature are required to be monitored to improve the activeness of fish that sequentially enhances profitability and sustainability of fish farming. The present scenario of aqua farmers is that they are entirely relied on manual testing, which results in ineffective, laborious and
irrelevant predictions along with manual field measurement. The major defect in this type is the identification of any abnormality in the water quality untimely causes heavy costs and well framed methodologies to return and preserve the quality of water. With the upgradation in present day’s technology, enhancing the monitoring process, representing a wide variety of problems regarding reachability, insufficient measurements, or even temporal and spatial scaling. Therefore, it increases productiveness and decreases the losses by keen observation of water quality constraints instantaneously. New sensor automations provide remote monitoring, data telemetry, and wireless communication technology in real-time to forward the aquaculture practices to next higher level. LCRTMS Architecture depicted in Figure 1.

Different types of fishpond monitoring systems are in existence nowadays. A remote online monitoring system using artificial neural networks (ANNs) to forecast the constraints for water quality is developed by [1]. An Internet of Things (IoT)-based technological model can track and regulate the essential constraints of a fishpond. The data gathered with the help of IoT system is utilized in long standing computation and to derive certain conclusions for future reference. Therefore, it enhances the usage of resources which in turn increases the profit. In this research article, The LCRTMS: Low-Cost Real-Time Monitoring, which acquires the quality, proper level and temperature of water using the factors such as dissolved oxygen, pH, electrical conductivity, water body turbidity.

2. Related Works
Water quality and fish habitual behaviour are the deciding factors in the improvement of efficiency in aquaculture.[2] developed an embedded system- (Raspberry Pi) for monitoring and regulating aquaculture that regulates quality in water continuously and gathers, sends the corresponding parameter values to the server present in the cloud for further computation. [4] employed wireless sensor network (WSN) in the aquaculture monitoring system that sensed the water-quality constraints like DO content, water level and pH in real-time. Ullah et al. designed an intelligent fish farm system
where an enhancement methodology is used to stabilize the time required for pumping and magnitude of water flow by selecting the proper level in water [3]. It is a hypothesis that continual disclosure to high unionized ammonia concentrations produce disastrous effects in the wellness of fish (Becke et al., 2019). Therefore, proper monitoring of these factors should be carried out to have an effective fisheries management.

2.1 Enhancement of reliability in GPRS communication
Mingfei Zhang et al. presented WSN-based water monitoring system capable of calculating pH, dissolved oxygen, temperature and level of water. The measured data was sent to a database that provides the necessary information to the software for real time monitoring. [6] developed a pond controller using specific sensors to track the quality of pond water which is controlled remotely through closed-circuit television (CCTV). Daudi S. [9] measured water quality parameters like pH, temperature, dissolved oxygen and level of water by deploying ZigBee to pass on the data and for displaying the acquired information, the LabView software (National Instruments Corporation, Austin, TX, USA) was used.).[7] implemented an effective submerged acoustic network appropriate for persistent monitoring of fisheries environment. [5] developed an aquaculture monitoring system with ZigBee and the general packet radio service (GPRS) protocol in real-time for communicating from the sensors to the main server for enhancing dependability in communication.

2.2 IoT Based Aquaculture Monitoring
[10] presented an IoT-interfaced monitoring system for water quality. An analog temperature sensor named Atlas Ph Probe digital sensor (Atlas Scientific, Long Island City, NY, USA) was employed by them to send the acquired information to a MySQL database along with an Arduino node using a ZigBee module. Furthermore, the system used 200 mA/h rechargeable batteries and can operate continuously for 8 hours. A mobile application or desktop can be used to visualize the acquired information. The work in Reference by [8] proposed a method for monitoring quality using aquatic drone enhanced with a Raspberry Pi fixed with an arrangement of water and air quality sensors. The air quality is measured by employing temperature, humidity and gas sensing channels. Water, temperature, and conductivity sensors are employed to assess the water quality. The gathered data is kept inside the drone’s computing platform and connected with a remote server database. Each indicator’s varying trend is forecasted by this model. The functioning of several fishpond farming devices is controlled in relation with the predicted results for maintaining the stability in fish pond’s water parameters. To conserve energy, this model provides an improved control over the equipment [11,12]. Therefore, it is essential to gather, compute, and process the various parameters like water level, dissolved oxygen, pH, electrical conductivity, turbidity, water temperature. [13] focuses at developing a monitoring system for the water quality of aquaculture ponds based on NB-IoT methodology. It is evident that NB-IoT possess quality factors like stability, reliability, comfortability in acquiring the data, speedy responses for commands. These can support the methodology technically in several fields, specifically in agricultural monitoring. It can be inferred from the results that remote control device’s reacting time falls within 100ms. Also the aerator’s intelligence control is realized. In this proposed work, an IoT-based smart fishpond Monitoring system that analyses and predicts several parameters to maintain the water quality effectively.

3. LCRTMS Low-Cost Real-Time Monitoring System
Monitoring the quality of water has a key role in fisheries management. The long-lasting nature of fish diseases has a direct impact on the yield. Poor quality of water tends to delay the fish growth and harvest. At present, water quality monitoring systems are not affordable and lacks in sensitivity. To succeed in aquaculture, maintaining a good quality in water is the most essential factor to be considered. Although the biggest challenge is to refine the water quality specifically in small fish sectors in developing countries. We have developed a LCRTMS equipped with intelligent devices and integration of networks. The LCRTMS enables real-time water monitoring capabilities by reducing the enormous investment in aquaculture. Variations in water quality may occur rapidly irrespective of any
Therefore, monitoring of water with pre-defined alerts intimates the fisher to do the needful immediately. With this intention, the LCRTMS allows the fisher to refine the environmental management and product quality thereby reducing huge loss and expenditures in production. The most crucial parameters like temperature, dissolved oxygen, pH and ammonia need to be intensively monitored and managed in aquaculture. As per the traditional techniques of analysing water quality, water specimen data are extracted and sent to a chemical lab to diagnose the presence of harmful substances. Contrarily, personal experience of an individual impacts in maintaining the measurements and control process. The proposed system can overcome these limitations. Appropriate and specific sensors for temperature, pH, Ammonia, Dissolved oxygen and turbidity are employed to measure the parameters affecting the water quality.

3.1 LCRTMS parameters
Arduino is a non-proprietary microcontroller package that works with adaptable hardware and coding. Arduino reads input data from various sensors and activates an action concerning the input then publishing something online. So, it is employed as a core controller in proposes model.

3.1.1 Temperature
By using the DS18B20 temperature sensor, the system finds whether the water is hot or cold. The value received by DS18B20 is forwarded to a controller for further action. However, the major constraint to take into consideration is that the various phases in fish growth like incubation of eggs, development of larval fish and production of a food-sized fish involve distinctive temperatures. LCRTMS gives better performance to collect temperature whenever a change happens in water.

3.1.2 Dissolved Oxygen (DO)
Oxygen plays the foremost role in limiting the development and wellbeing of fish. Oxygen is the principal gas used for respiration and denoted in milligram (mg) of oxygen absorbed per kilogram (kg) of fish per hour (mg O2/kg/h) framed by the physiologists. Inflowing water distributes the oxygen in tanks and raceways having the necessity of saturation value closer to altitude and temperature. When the range exceeds the limits, the LCRTMS notify the user to replace the water.

3.1.3 pH
pH value is collected by considering the below guideline: The proportion of pH is indicated by the accumulation of hydrogen ion (H+) in water. The pH scale becomes logarithmic when it ranges between 0 to 14 with base 10. It is highly important to consider since a drop in 1 pH unit leads to 10 times doubling up of hydrogen ions (H+) in water. A pH value tends to drop at any value on a scale from 0 indicating the strongly acidic nature to 14 indicating strongly basic or alkaline nature, and the value 7 indicating neutral nature (= 10^-7 moles/litre of H+ ions).

The Fertile natural waters free from pollution has the pH value in the range of 6.5 to 8.5 at sunrise, usually closer to 7 than 8. Photosynthesis plays a role in deciding the diurnal variations.

\[ \text{PH is calculated as } \text{pH} = - \log [\text{H}^+] \]  
(1)

3.1.4 Ammonia
The concentration of ammonia has a significant role in assessing the water quality. An extremely stocked culture pond or the discharge of a raceway possess fish excretions through the gills in most cases forms the principal source of ammonia. Generally, the animals produce ammonia as a by-product of protein metabolic process. Nessler method is adopted for chemical analysis and measurement of ammonia and the resulting component is termed as total ammonia nitrogen (TAN) since it possesses two ionic concentrations of Ammonia: the unionized form - Ammonia (NH3), and the ionized form- ammonium ion (NH4 +). The UIA - unionized Ammonia has poisonous reactivity towards fish. As per the following expression given the ammonia level is collected for analysis.
\[ \text{NH}_3 + \text{H}_2\text{O} = \text{NH}_4^+ + \text{OH}^- \] \hspace{1cm} (2)

\[ \text{NH}_3 + \text{H}_2\text{O} \text{ at low temperature and pH} \]

\[ \text{NH}_4^+ + \text{OH}^- \text{ at high temperature and pH} \]

The parameters collected from the water source is analyzed with the normal range, then the same is notified to the fishers to take the needful action. The LCRTMS takes a significant role in monitoring the ponds at round the clock with minimum cost.

4. Experimental results

4.1. The data and environment for experimentation

Nochikadu (Cuddalore Dist, Tamilnadu, India longitude 11.6515N latitude 79.7540E) is the site chosen for data collection in the proposed study. The fish pond occupies an area of 70ft long, 35ft width, and 4-5 depth along with inlet and outlet for water. The various sensor nodes such as pH sensor (Shanghai Leici, Model E-201-C), temperature sensor (DS18B20), water turbidity sensor (Water WT-RCOT) and dissolved oxygen sensor (YHT-8402) were installed in the fish pond for evaluation. The sensors are attached to Arduino which is then interconnected with the Blynk app for monitoring through Wi-Fi. The Blynk app is used to inform the fish farming environmental parameters, etc.) the prototype of LCRTMS shown in Figure 2.

![Figure 2. LCRTMS Prototype Model](image)

4.2 Data cleaning for reliability
The experiment was conducted from March 04, 2020, to April 22, 2020. The data of pH, temperature, ammonia, and dissolved oxygen of fishpond are collected periodically on the time points of 6:00, 9:00, 15:00 and 21:00. These time points are chosen to find the lower and higher values of temperature and oxygen within a day. Initially, the time was fixed at 6:00 for first data collection during which the measurements of temperature and dissolved oxygen were in lowest values on a daily basis. In order to find the start of feeding secondly, the data collection time begun at 9:00. Then, the third data collection time was fixed at 15:00 during which the values of pH, temperature and dissolved oxygen were in highest form. The final data collection time was fixed at 21:00 for determining whether the aerators should be turned on. Nochikadu is an area having acceptable water quality, medium temperature, high level of dissolved oxygen, and surplus flow of water. In accordance with these features of nochikadu, the fishpond water-quality constraints and parameters must be regulated instantly. Few changes and irrelevant data are encountered in the testing phase due to the disruptions in sensor. It might lead to considerable variations in the range and consistency of the data which in turn affects data analysis results. The outliers are eliminated using an appropriate method to ensure data reliability. If the water level drops below than the sensor’s position, the lower level of water is sensed and intimated to the fisher for starting the process of water pumping, which refills the water up to the extent of pre-set sensor position automatically. Hence the level of water is always monitored and made to remain stable. Therefore, the water level sensor data are not considered for further computation and analysis.

4.3 LCRTMS visualization and indication

The proposed low-cost real-time monitoring of fish and pond system facilitates the fish farmers by giving several sensors collected data that act as the indicators for maintaining the water quality parameters. Data visualization is also performed to intimate the functional report of water quality parameters. It delivers valuable suggestions by using information and communication system with the help of functional report. The LCRTMS analyses the water quality as per the instructions embedded in the board. Further, it refers to the average ranges from Table 1 for abnormal notification. All the correspondence between the sensor and Blynk is automated.

4.4 Optimal requirements of water quality in a fish pond

In accordance with (ICAR) Indian Council of Aquaculture Research and Central Institute of Fisheries Technology guidelines, the LCRTMS refers to the water quality parameters presented in Table 1.

### Table 1. Water Quality Parameter Range

| S.No | Evaluation of Water Quality Parameters | Range(units) |
|------|----------------------------------------|--------------|
| 1    | pH                                     | (6.5-8.5) ppm|
| 2    | Ammonia                                | (0-0.1) ppm  |
| 3    | Dissolved Oxygen (DO)                  | (4-10) ppm   |
| 4    | Salt                                   | (0-2) ppt    |
| 5    | Temperature                            | 21°C-33°C    |
| 6    | Carbonates (CO$_3^{2-}$)               | (20-40) ppm  |
| 7    | Bicarbonates (HCO$_3^{-}$)             | (150-500) ppm|
| 8    | Sour gas (H$_2$S)                      | (0-0.4) ppm  |
| 9    | Nitrates (NO$_2$)                      | (0-0.3) ppm  |

4.5 Blynk Application Scenario

Blynk app is designed for the Internet of Things to control and monitor the hardware in cloud and visualize it. The major components working the cloud platform is App, Server and libraries to enable cloud communications. Here the figure 3 shows the application platform, figure 4 shows the water level indication, figure 5 shows the temperature indication, figure 6 shows the oxygen level indication, figure 7 & figure shows the ammonia and pH level. Every data is been stored in the Blynk cloud.
Figure 3. Blynk mobile application

Figure 4. Blynk Low level water Notification

Figure 5. Blynk High Temperature Notification

Figure 6. Blynk Low Oxygen level Notification

Figure 7. Blynk High Ammonia Notification

Figure 8. Blynk Low pH level Notification
4.6 Results of the LCRTMS

The sample data was gathered from the aquaculture ponds by using sensor devices and sent to the private cloud in a wireless manner. The sampling frequency of the data was taken once in every 5 mins for instant predictions. The LCRTMS attain 98% of accuracy within earlier of 0.032 secs, which means the system initialization time is very minimal while comparing to conventional method however, the LCRTMS begins the sensing with the above mentioned time span (start-up time). The data associated with water quality of about 610 groups (about 45d), including pH, temperature, DO, and ammonia parameters were used for the prediction. figure 9., shows the graph of Average Temperature in between 6h to 00h at all the days. figure 10., shows the average graph of Dissolved Oxygen Level in between 6h to 00h at all the days. figure 11., shows the average graph of pH Level in between 6h to 00h at all the days. Figure 12, shows the graph of average Ammonia Level in between 6h to 00h at all the days.

5. Conclusion

The quality of water has a significant importance in aquaculture as it is one of the deciding factors in the growth and well-being of fish. Therefore, it is necessary to measure and monitor the water quality using a finest and exclusive water testing kit. In this paper, a low-cost real-time monitoring system (LCRTMS) is developed to monitor the quality of water in aquaculture. The proposed model can monitor the variations in water parameters like pH, temperature, ammonia and dissolved oxygen by the deployment of affordable sensors. The proposed system gives highly reliable and accurate data with minimal human intervention for immediate action. It is evident that the accuracy is nearing to 98% in short term prediction of LCRTMS. Proactive steps are taken further to avoid any harmful occurrence. Although the initial set up cost is higher, there will not be any added expenses for maintenance after it is installed. Thus, the proposed implementation could reach the farmers by
alleviating the harm related to climatic changes and assures growth and wellbeing of aquatic life. As a future direction, this proposal can be used at a higher level in various sites.

6. References

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