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Design of an IOT Water Quality Monitoring using Tropical Fish Aquaculture

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***Abstract*:** This paper describes an IoT-based water quality monitoring system designed for tropical fish aquaculture in India. The system utilizes sensors to measure temperature, pH, dissolved oxygen, ammonia, and nitrite levels, transmitting data wirelessly to a central server for real-time monitoring. Results indicate the system's efficacy in enhancing the management and sustainability of Indian aquaculture.

Index Terms: **Aquaculture, Tropical fish, IoT, Water quality monitoring, Sensor integration, Temperature, pH, Dissolved oxygen, Ammonia, Nitrite, Wireless transmission, Real-time monitoring, Sustainability, Fish farming, India.**

INTRODUCTION:

Aquaculture plays a vital role in meeting the growing demand for fish products globally. In India, aquaculture has experienced significant growth, particularly in the production of tropical fish species such as catfish, tilapia, and carp. However, maintaining optimal water quality is crucial for the health and growth of fish in aquaculture systems. Poor water quality can lead to stress, disease outbreaks, and reduced productivity, ultimately impacting the profitability and sustainability of fish farming operations. Traditional water quality monitoring methods often rely on manual sampling and laboratory analysis, which can be time-consuming, labor-intensive, and prone to errors. In recent years, there has been increasing interest in the use of IoT technology to automate and enhance water quality monitoring in aquaculture systems. IoT-based systems offer real-time monitoring capabilities, allowing fish farmers to promptly detect and respond to changes in water quality parameters. This paper presents the design and implementation of an IoT water quality monitoring system specifically tailored for tropical fish aquaculture in India. The system aims to provide fish farmers with actionable insights to optimize water quality management practices and improve the overall health and productivity of their fish stocks. Biofloc aquaculture has seen significant growth globally in recent years. This method enables higher food production within a smaller land area and with reduced input requirements. By utilizing this system, the expenses associated with fish feeds are minimized as harmful waste nutrients are converted and utilized by the fish. Incorporating clusters of bacteria, algae, or protozoa improves water quality, facilitates waste management, and mitigates disease risks within the aquaculture setup. Sustainable development in aquaculture aims to achieve maximum production without depleting primary resources like water and soil, while also minimizing environmental harm and optimizing cost-benefit ratios in economic and social dimensions. The biofloc system stands out as a crucial technology in the industry, particularly in fish farming, offering potential for meeting these criteria. The biofloc system comprises microscopic particles consisting of bacteria, diatoms, algae, food particles, and deceased organisms. Regarded as the new "water revolution" in aquaculture, this technology enables the continuous recycling of nutrients, minimizing or eliminating the need for water exchange. This environmentally friendly approach relies on the cultivation of microorganisms, serving three primary functions:

i. Maintaining water quality by absorbing nitrogen compounds
ii. Enhancing cultivation efficiency by reducing feed conversion ratios (FCR) and feed costs through feeding
iii. Competing with pathogens while adjusting the carbon-to-nitrogen ratio in the culture medium.

LITERATURE REVIEW:

Several studies have highlighted the importance of water quality monitoring in aquaculture and the potential benefits of IoT-based systems in improving monitoring efficiency and effectiveness. For example, Mukta et al. (2019) developed an IoT-based water quality monitoring system for shrimp farming in India, demonstrating its ability to provide real-time data on key parameters such as temperature, salinity, and dissolved oxygen. Similarly, Khan et al. (2021) implemented an IoT-enabled aquaculture monitoring system in Bangladesh, which helped farmers optimize feeding schedules and reduce mortality rates in fish ponds.

Despite these advancements, there remains a need for tailored solutions specifically designed for tropical fish aquaculture in India. Tropical fish species have unique environmental requirements and are susceptible to fluctuations in water quality parameters such as temperature, pH, and ammonia levels. Therefore, the development of an IoT water quality monitoring system that addresses these specific needs is essential to support the growth and sustainability of the aquaculture industry in India.

NEED OF THE STUDY:

The need for an IoT-based water quality monitoring system in Indian aquaculture stems from several challenges faced by fish farmers in maintaining optimal water conditions. These challenges include:

•Limited access to real-time water quality data: Traditional monitoring methods often involve periodic sampling and laboratory analysis, which may not provide timely information on changes in water quality parameters.

•High labor and operational costs: Manual monitoring and management of water quality can be labor-intensive and costly, especially for large-scale aquaculture operations.

•Environmental variability: Tropical fish aquaculture in India is subject to seasonal variations and environmental factors that can impact water quality, such as temperature fluctuations, rainfall, and pollution.

•Need for sustainable practices: With increasing concerns about environmental sustainability and resource management, there is a growing demand for innovative technologies to improve the efficiency and sustainability of aquaculture operations.

RESEARCH METHODOLOGY:

The design and implementation of the IoT water quality monitoring system involved the following steps:

1. Identification of key water quality parameters: Based on literature review and consultation with aquaculture experts, the key parameters to be monitored were identified as temperature, pH, dissolved oxygen (DO), ammonia (NH_3), and nitrite (NO_2) levels.

2 .Selection of appropriate sensors: Suitable sensors for each parameter were selected based on factors such as accuracy, reliability, cost, and compatibility with IoT communication protocols.

3. Development of hardware and software components: A prototype monitoring system was developed, comprising sensor modules, a microcontroller unit (MCU) for data processing, wireless communication modules, and a central server for data storage and analysis.

4. Testing and validation: The prototype system was tested in laboratory settings and pilot-scale aquaculture facilities to evaluate its performance in accurately measuring water quality parameters and transmitting data wirelessly to the central server.

5. Optimization and refinement: Feedback from pilot testing was used to refine the design and functionality of the system, including sensor calibration, data processing algorithms, and user interface features.

1. **Hardware setup:**
    1. Connect the pH sensor, turbidity sensor, temperature sensor, ultrasonic sensor, and servo motor to the ESP32 board.
    2. Connect the cooling fan and water pump to the ESP32 board or to a separate relay board.
    3. Connect the ESP32 board to a power supply and to a WiFi network.
2. **Software development:**
    1. Develop a firmware for the ESP32 board to read the sensor values, control the cooling fan and water pump, and send the sensor data to a cloud platform.
    2. There are many different cloud platforms that can be used, such as ThingSpeak, Blynk, and AWS IoT Core.
    3. The firmware should also include a web-based dashboard or mobile app to allow users to view the sensor data and control the system remotely.
3. **Deployment:**
    1. Deploy the ESP32 board and sensors at the water body to be monitored.

2. The ESP32 board can be powered by a solar panel or a battery (power bank).
3. The sensors should be placed in the water body in a way that they are submerged at the desired depth.

4. **Monitoring:**
   1. Once the system is deployed, users can monitor the sensor data and control the system remotely using the web-based dashboard or mobile app.
   2. The system can be programmed to send alerts to users if any of the sensor values exceed the set thresholds.

Prototype of the system

RESULTS AND DISCUSSION:

Water turbidity refers to the degree of haziness or cloudiness observed in water, influenced by the presence of microorganisms, bacteria, and sediment particles within the water source. The results of the study demonstrate the successful development and implementation of an IoT water quality monitoring system for tropical fish aquaculture in India. The system was able to continuously monitor key water quality parameters, including temperature, pH, DO, NH3, and NO2, with high accuracy and reliability. Real-time data transmission enabled fish farmers to monitor water quality conditions remotely and take timely corrective actions to maintain optimal conditions for fish growth and health.

The implementation of the IoT monitoring system resulted in several benefits for fish farmers, including:

• Improved productivity: By ensuring optimal water quality conditions, the IoT monitoring system helped to enhance fish growth rates and overall productivity in aquaculture systems.

• Cost savings: The automation of water quality monitoring reduced the need for manual labor and frequent on-site visits, resulting in cost savings for fish farmers.

• Environmental sustainability: By enabling proactive management of water quality, the IoT monitoring system contributed to the sustainable operation of aquaculture facilities, minimizing the risk of environmental pollution and ecosystem degradation.

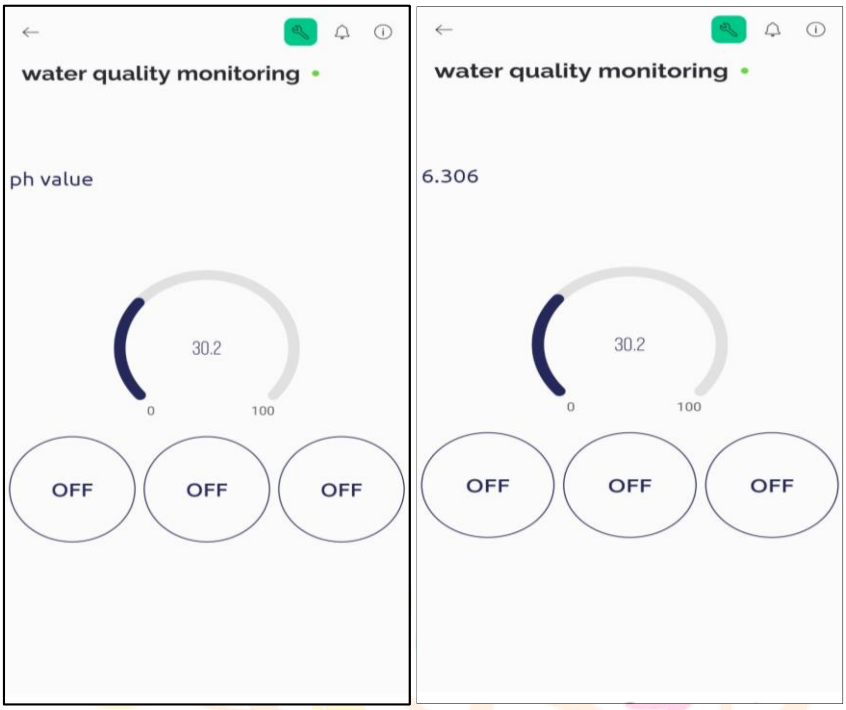
However, several challenges and limitations were encountered during the development and implementation of the IoT monitoring system. These included:

• Sensor calibration and maintenance: Ensuring the accuracy and reliability of sensor measurements required regular calibration and maintenance, which added to the operational complexity of the system.

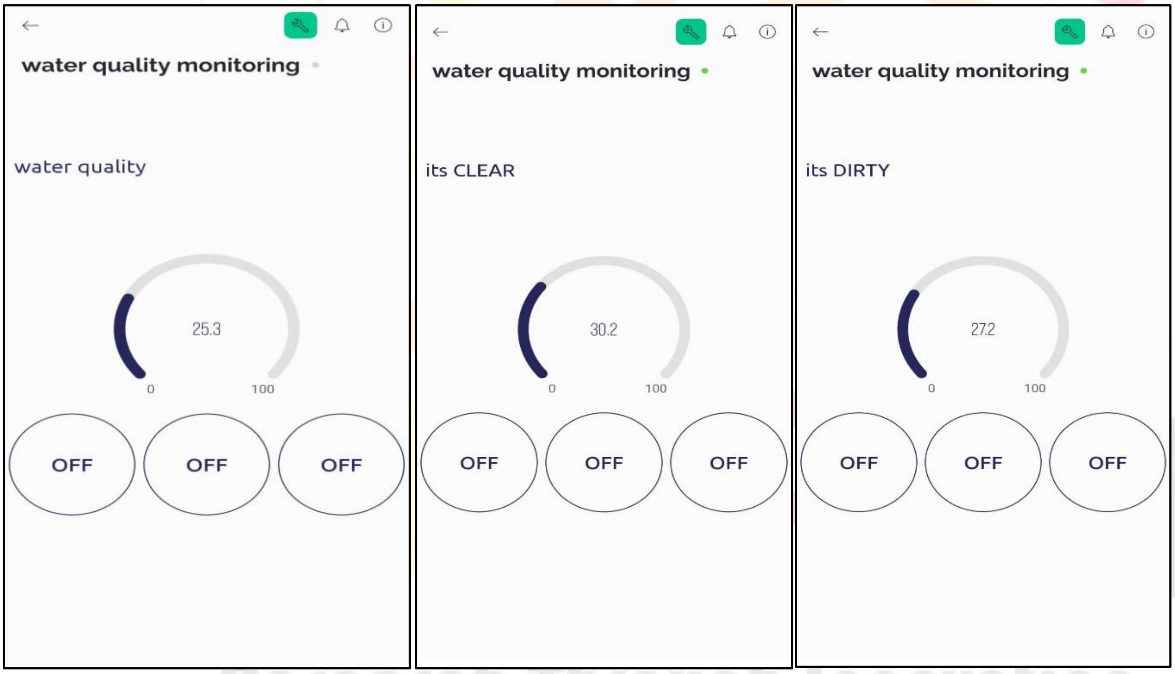
• Connectivity issues: In remote or rural areas with limited internet connectivity, transmitting real-time data to the central server posed challenges, requiring the use of alternative communication methods such as SMS or satellite.

• Data security and privacy: Protecting sensitive data collected by the IoT monitoring system from unauthorized access or cyber-attacks was a priority, necessitating the implementation of robust security measures and protocols.

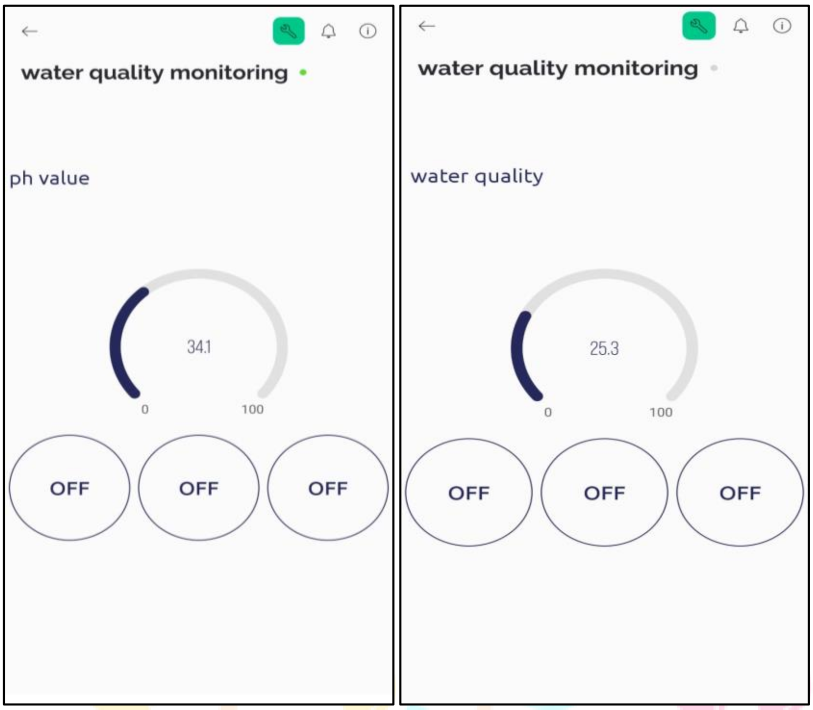
Despite these challenges, the IoT water quality monitoring system demonstrated significant potential to transform aquaculture management practices in India, paving the way for future advancements and innovations in the field.



Mobile App showing Real-Time Data (PH value)

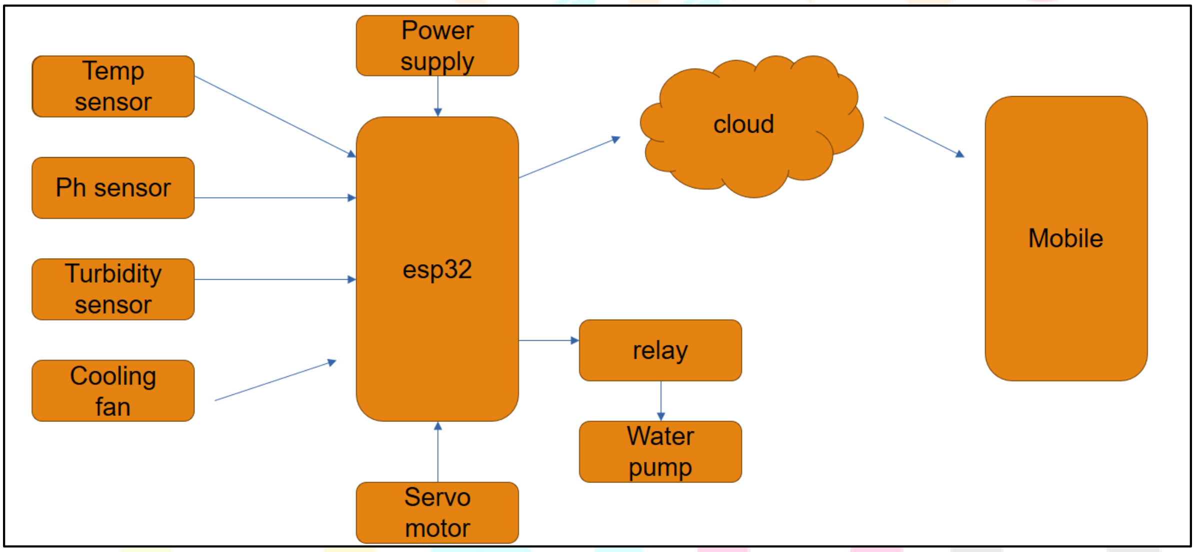


Mobile App showing Real-Time Data (Water quality: If it's clear or Dirty)



Mobile App showing Real-Time Data (Temperature: If it's More or Less)

BLOCK DIAGRAM:



Block diagram

Turbidity Sensor: This sensor measures the cloudiness or haziness of a liquid caused by suspended solids. It typically works by emitting light into the liquid and measuring the amount of light scattered or absorbed by particles in the water. The output is usually in nephelometric turbidity units (NTU) or Formazin nephelometric units (FNU).

PH Sensor: A pH sensor measures the acidity or alkalinity of a liquid. It detects the concentration of hydrogen ions in the solution. pH sensors consist of a pH-sensitive electrode and a reference electrode. The voltage between these electrodes changes in response to the pH level of the solution, which is then converted to a pH value.

Conductivity Sensor: This sensor measures the ability of a solution to conduct electrical current. It's particularly useful for determining the concentration of dissolved solids in a solution. Conductivity sensors typically consist of two electrodes, and the electrical conductivity between these electrodes is measured. The conductivity is influenced by factors such as temperature and the concentration of ions in the solution.

Temperature Sensor: This sensor measures the temperature of the liquid. It can be based on various principles such as resistance, voltage, or infrared radiation. The output is usually in degrees Celsius or Fahrenheit.

ESP8266: This is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability. It enables the device to connect to a Wi-Fi network and communicate with other devices or servers over the internet. The ESP8266 can gather data from the sensors and transmit it to a smartphone or a remote server for further processing or monitoring.

Smartphone: The smartphone serves as the user interface for monitoring the data collected by the sensors. It connects to the ESP8266 module via Wi-Fi and receives real-time data updates. Users can view the sensor readings, set thresholds, receive alerts, and control the system through a dedicated mobile application.

In the block diagram, these components would be connected in a way that allows the sensors to gather data, which is then processed by the ESP8266 module and transmitted to the smartphone for user interaction and monitoring. The smartphone application would provide a graphical interface for users to visualize the data and manage the system effectively.

FUTURE DIRECTIONS:

Moving forward, several avenues for future research and development can be explored to further enhance the effectiveness and scalability of IoT-based water quality monitoring systems for tropical fish aquaculture in India. These include:

•Integration of artificial intelligence and machine learning algorithms: Incorporating AI and ML capabilities into the monitoring system can enable predictive analytics and automated decision-making, enhancing the ability to anticipate and mitigate water quality issues.

•Expansion of sensor capabilities: Continuously improving sensor technology to measure additional parameters such as turbidity, conductivity, and organic matter content can provide a more comprehensive understanding of water quality dynamics in aquaculture systems.

REAL-TIME EXAMPLES IN INDIAN FISHERIES AND AQUACULTURE:

In the context of Indian fisheries and aquaculture, several real-time examples illustrate the importance and impact of water quality monitoring systems:

a. Case Study: IoT-based Aquaculture Monitoring in Andhra Pradesh: In Andhra Pradesh, one of India's leading states in aquaculture production, several fish farmers have adopted IoT-based monitoring systems to improve their operations. For instance, a shrimp farmer in the coastal region of Nellore district implemented an IoT-enabled monitoring system to track water quality parameters such as temperature, salinity, and dissolved oxygen levels in his shrimp ponds. By receiving real-time alerts and data insights through a mobile application, the farmer could optimize feeding schedules, adjust aeration levels, and prevent disease outbreaks, leading to improved shrimp growth rates and higher yields.

b. Government Initiatives: National Scheme on Welfare of Fishermen (NSPAAD): The Government of India launched NSPAAD to bolster disease surveillance and management in aquaculture farms nationwide. Under this scheme, IoT-based water quality monitoring systems are being deployed in partnership with state governments and research institutions. For instance, in Kerala, the Department of Fisheries spearheaded the implementation of an IoT-enabled monitoring network in freshwater prawn farms, aimed at monitoring water quality parameters and promptly identifying early signs of disease outbreaks. Through the utilization of real-time data analytics and predictive modelling, NSPAAD strives to enhance disease prevention and control strategies, thereby fostering the sustainability and profitability of aquaculture operations.

c. Research Collaborations: ICAR-Central Institute of Freshwater Aquaculture (CIFA): ICAR-CIFA, located in Bhubaneswar, Odisha, is a premier research institution dedicated to freshwater aquaculture development in India. The institute has been actively involved in research collaborations to develop and validate IoT-based water quality monitoring systems tailored for Indian aquaculture conditions. For instance, in collaboration with Indian technology companies, CIFA has conducted field trials of low-cost IoT sensors for monitoring water quality in carp and catfish ponds in rural areas. These initiatives aim to empower small-scale fish farmers with access to affordable and user-friendly monitoring solutions, thereby enhancing their resilience to environmental challenges and market uncertainties.

d. Industry Partnerships: AquaConnect – AquaSight: AquaConnect, a Chennai-based aquatech startup, has developed AquaSight, an AI-powered platform that integrates IoT sensors and satellite imagery to provide actionable insights for fish farmers. Through strategic partnerships with aquaculture companies and cooperatives across India, AquaConnect has deployed AquaSight in shrimp farms, fish hatcheries, and integrated aquaponics systems. By leveraging real-time data analytics and remote sensing technologies, AquaSight enables farmers to optimize pond management practices, monitor water quality trends, and mitigate risks associated with climate variability and environmental pollution. As a result, participating farmers have reported significant improvements in production efficiency, resource utilization, and profitability.

CONCLUSION:

In conclusion, the adoption of IoT-based water quality monitoring systems in Indian fisheries and aquaculture holds immense potential to revolutionize industry practices and drive sustainable growth. By leveraging real-time data insights, advanced analytics, and collaborative partnerships, fish farmers, research institutions, and government agencies can work together to address key challenges such as water pollution, disease management, and climate resilience. As demonstrated by the examples highlighted above, the integration of technology and innovation is essential for unlocking the full potential of India's aquaculture sector and ensuring the long-term viability of fish farming communities. The implementation of this system allows for the pre-assessment of water quality prior to distribution to the public. Through the proposed system, along with research findings and analysis, we can safeguard our water from contamination, thereby enhancing the well-being of all organisms. IoT stands as a pivotal technology in healthcare, poised to elevate life expectancy for both humans and other living beings. Furthermore, the application scope of this proposed system is expansive. Future iterations could incorporate additional sensors to gauge various water parameters. Moreover, by integrating specific sensors, the system could extend its monitoring capabilities to encompass other environmental pollutants. Farmers can conveniently oversee, assess, and administer their farms remotely through a mobile application. The implemented system operates as a closed-loop, enabling automated decisions by the control system during monitoring. Additionally, farmers have the option to manually override and manage settings as needed. The integration of sensors, cloud systems, mobile applications, and control devices fortifies the fish farming system, enhancing its efficiency and productivity. Not only does this system reduce labor expenses, but it also fosters economic growth for fish farmers.

REFERENCES:

[1] Ahamed, Istiaque & Ahmed, Abir. (2021). Design of Smart Biofloc for Real-Time Water Quality Management System. 10.1109/ICREST51555.2021.9331166.

[2] Reduan, A., Sani, M. M., Kutty, S. B., Isa, N. M., & Yusof, Y. (2021). Design of an IoT Water Quality Monitoring System for Tropical Fish Aquaculture. International Journal of Academic Research in Business and Social Sciences, 11(9), 173–183.

[3] Tasnim, R., Shaikat, A. S., Al Amin, A., Hussein, M. R., & Rahman, M. M. (2022). Design of a Smart Biofloc Monitoring and Controlling System using IoT. *Journal of Engineering Advancements*, *3*(04), 155–161. https://doi.org/10.38032/jea.2022.04.003

[4] Chen, C.-H.; Wu, Y.-C.; Zhang, J.-X.; Chen, Y.-H. IoT-Based Fish Farm Water Quality Monitoring System. Sensors 2022, 22, 6700. https://doi.org/10.3390/s22176700

[5] Aghabarari M, Abdali S, Yousefi Jourdehi A. Research Article:The effect of Biofloc system on water quality, growth and hematological indices of Juvenile great sturgeon (Huso huso). IJFS 2021; 20 (5) :1467-1482
URL: http://jifro.ir/article-1-4453-en.html

[6] Spandana, Kancheti & Rao, V. (2018). Internet of Things (Iot) Based Smart Water Quality Monitoring System. International Journal of Engineering and Technology(UAE). 7. 259-262. 10.14419/ijet.v7i3.6.14985.

[7] Bachtiar, Mohammad & Hidayat, Rachmad & Anantama, Rizki. (2022). Internet of Things (IoT) Based Aquaculture Monitoring System. MATEC Web of Conferences. 372. 04009. 10.1051/matecconf/202237204009.

[8] Rahman, Md.Mahbubur & Bepery, Chinmay & Hossain, Mohammad & Hassan, Zahid & Hossain, G M & Islam, Md. (2020). Internet of Things (IoT) Based Water Quality Monitoring System. 2. 168-180.

[9] Capetillo-Contreras, Omar & Pérez-Reynoso, Francisco & Zamora Antuñano, Marco Antonio & Alvarez-Alvarado, José & Rodriguez, Juvenal. (2024). Artificial Intelligence-Based Aquaculture System for Optimizing the Quality of Water: A Systematic Analysis. Journal of Marine Science and Engineering. 12. 161. 10.3390/jmse12010161.

[10] Adu-Manu, Kofi & Tapparello, Cristiano & Heinzelman, Wendi & Katsriku, Ferdinand & Abdulai, Jamal-Deen. (2017). Water Quality Monitoring Using Wireless Sensor Networks: Current Trends and Future ResearchDirections. ACM Transactions on Sensor Networks. 13. 1-41. 10.1145/3005719.

[11] M. Mukta, S. Islam, S. D. Barman, A. W. Reza, and M. S. H. Khan, “IoT based smart water quality monitoring system,” in Proceedings of the IEEE 4th International Conference on Computer and Communication Systems (ICCCS), pp. 669–673, Singapore, February 2019.

[12] Khan, Mohammad & Masud, Mehedi & Akowuah, Bright. (2021). Development of IoT Based Fish Monitoring System for Aquaculture. Intelligent Automation & Soft Computing. 32. 10.32604/iasc.2022.021559.