CASE STUDY ASSIGNMENT

Team 09

Water quality monitoring in eel aquaculture

Team Member-2

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INTRODUCTION:

Water Quality Monitoring in Eel Aquaculture : Water quality is a critical factor in eel aquaculture. Key parameters that need to be monitored include dissolved oxygen (DO), acidity (pH), and temperature. Other factors such as salinity, alkalinity, turbidity, hardness, ammonia, water level, and nutrient levels also play a significant role. Regular testing and monitoring are essential for maintaining optimal water quality.

Core Hardware Elements

1. Context:

Eel aquaculture, the managed commercial farming of eels, is a rapidly growing industry worldwide. Eels are characterized as having high market value and culinary importance in various dishes. However, successful eel farming is highly dependent on maintaining optimal water quality conditions in aquaculture areas. Changes in water parameters such as pH, dissolved oxygen concentration, temperature and ammonia concentration can negatively impact eel health, growth and survival.

2. Importance of water quality management:

Traditional aquaculture practices typically rely on manual sampling and periodic measurements to monitor water quality. However, this approach has limitations, such as bureaucracy, late detection, and insufficient spatial coverage. In contrast, IOT (Internet of Things) In the actual monitoring of water crops, continuous sensory analysis and analytical analysis of water analysis, and the situation. The timing can be blocked.

3. Project objectives:

- The main objective of this IoT-based project is to develop and implement a comprehensive water quality management system designed for eel aquaculture. The main objectives are:
- Development of sensors capable of measuring important water parameters such as pH, dissolved oxygen, temperature, ammonia, and turbidity.
- Combining sensor data with a centralized monitoring platform to enable real-time data collection, analysis and visualization.
- Implementing an algorithm for anomaly detection and predictive analytics to identify potential water quality issues before they affect eel health.
- Develop an easy-to-use framework for aquaculture farmers to access monitoring data, receive alerts, and make informed aquaculture management decisions.
- Evaluate the effectiveness of an IoT-based monitoring system to improve eel production, including growth rates, survival and overall profitability.

4. Profit Expectations:

By using IoT technology for water quality management in eel aquaculture, this project aims to deliver several important benefits:

- Improved eel health and welfare: Ongoing monitoring and timely intervention can help improve water quality, thus reducing stress and improving overall eel health and welfare.
- Increased productivity and efficiency: By reducing the risk of water quality issues, aquaculture can achieve higher yields and efficiencies
- Sustainability and environmental management: Changing water quality management can reduce the impact of eel farming on the environment, as well as responsible aquaculture practices to promote sustainable development.
- Data-Driven Decision Making: Having access to real-time monitoring data and operational insights enables aquariums to make informed decisions and proactively address challenges, ultimately delivering better outcomes eel production and environmental management.

5.Sensor Technology:

- pH sensors: These sensors measure the acidity or alkalinity of the water, which is important for optimal conditions for eel health and growth
- Total Dissolved Solids (TDS): It is a measure of the combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form. Temperature signals: Fluctuating temperatures can dramatically affect eel behaviour, growth rate and metabolism, making temperature sensors critical for sustaining harsh conditions
- Ammonia sensors: Ammonia is a metabolic waste excreted by eels and decomposers. Controlling ammonia levels helps prevent toxicity and maintain a healthy aquatic environment.
- Turbidity sensors: Turbidity sensors measure the cloudiness or clarity of water caused by suspended particles. High turbidity levels can indicate sedimentation or pollution, which can adversely affect eel health.

Work done in past researches:

1. Improving water quality following the death of Asian swamp eel (Monopterus albus) in cage culture through monitoring of ammonia nitrogen levels

This is by Yuan Q, Lv W, Huang W, Sun X, Bai N, Zhou W. Improving water quality following the death of Asian swamp eel (Monopterus albus) in cage culture through monitoring of ammonia nitrogen levels. Aquac Res. 2020;51:696–706. https://doi.org/10.1111/are.14419

This study investigated water quality management in Asian swamp eel cage culture, focusing on temperature and eel weight effects post-eel mortality. Results revealed similar water quality deterioration patterns across temperatures and eel weights, with distinct microbial shifts during decomposition stages. Recommendations include timely removal of dead eels and use of detoxifying substances based on ammonia nitrogen levels and water temperatures, optimizing water quality management in eel production. However, the study acknowledges limitations due to the absence of water exchange, potentially affecting observed water quality changes.

2. Water quality monitoring in recirculating aquaculture systems

LindholmLehto,P.(2023)Waterqualitymonitoringinrecirculatingaquaculturesystems.Aquaculture,FishandFisheries,3,113–131.https://doi.org/10.1002/aff2.102

This review discusses the importance of water quality in recirculating aquaculture systems (RAS) and the lack of standardized regulations for parameter measurement. It highlights the transition from traditional handheld sensors to IoT-based systems for real-time monitoring, emphasizing the need for competent users and regular maintenance. Changes in water quality affect fish behavior, prompting the exploration of alternative monitoring methods based on fish activity. The review provides an overview of water quality parameters, sensor technologies, and analytical methods, indicating the need for further development in real-time measurement of advanced parameters.

3. Effects of different stocking densities on growth performance of Asian swamp eel Monopterus albus, water quality and plant growth of watercress Nasturtium officinale in an aquaponic recirculating system

Hua Thai Nhan , Nguyen Tan Tai , Pham Thanh Liem , Vu Ngoc Ut , Harry Ako(2019) Effects of different stocking densities on growth performance of Asian swamp eel Monopterus albus, water quality and plant growth of watercress Nasturtium officinale in an aquaponic recirculating system,https://doi.org/10.1016/j.aquaculture.2018.12.067

This study investigated the impact of different stocking densities on the growth of Asian swamp eel and watercress in a floating-draft aquaponic recirculating system. Results showed no significant difference in eel growth between systems with and without watercress, but weight gain varied significantly among watercress treatments. Survival rates were high across all densities. The most effective eel stocking density for growth and nutrient accumulation was 180 individuals/m2 in the system with watercress. This suggests a feasible approach for swamp eel aquaculture in the Mekong Delta, minimizing environmental impact.

4. Application of Biofloc Technology in Indonesian Eel Anguilla bicolor bicolor Fish Culture: Water Quality Profile

NH Sadi et al 2022 IOP Conf. Ser.: Earth Environ. Sci. 1062 012006 by NH Sadi, D Agustiyani, F Ali, M Badjoeri and Triyanto

This study investigated the feasibility of applying biofloc technology in eel farming, a practice not previously utilized in this sector. Two pond systems, with and without water recirculation, were employed, both maintaining dissolved oxygen levels at 7-8 mg/L and achieving a C/N ratio of 20:1 using molasses and activated charcoal. Results demonstrated that both biofloc systems effectively maintained water quality for up to eleven weeks without water replacement, indicating the suitability of biofloc technology for eel aquaculture.

5. Water and land efficiency in eel (Anguilla bicolor bicolor) rearing in development of urban aquaculture through vertical aquaculture system

This study evaluates the water and land requirements for Vertical Aquaculture in RAS for eel production. It tested different water volumes for rearing elver eels over 60 days. Results showed no significant difference in production performance across treatments. Treatment A had the highest water efficiency, requiring 0.77 L/kg eel/day and 10.66 L/kg eel/year of new water. Business analysis suggests VAR technology is viable, with a R/C ratio of 3.4, net profit of Rp. 2,730,000/year, and a payback period of 1.3 years.

6. Application of Biofloc Technology in Indonesian Eel Anguilla bicolor bicolor Fish Culture: Water Quality Profile

This study assessed the feasibility of applying biofloc technology in eel farming, a method commonly used in other aquaculture practices. Two pond systems, with and without water recirculation, were compared. Both systems maintained good water quality for 11 weeks without water replacement. The addition of molasses and activated charcoal achieved a C/N ratio of 20:1, effectively controlling nitrogen levels. Overall, biofloc technology proved suitable for eel aquaculture, offering a promising approach to maintain water quality.

7. The Growth Performance and Nutrient Quality of Asian Swamp Eel Monopterus albus in Central Java Indonesia in a Freshwater Aquaculture System with Different Feeds

This study in Central Java, Indonesia, evaluated the growth performance and nutrient quality of Asian swamp eels in freshwater aquaculture. Different feeding treatments, including golden snails, snails, silkworms, and earthworms, were tested at 5% of total body weight. Results showed significant effects on relative growth rate (RGR), feed intake, and survival rate (SR), with silkworms yielding the best outcomes. Silkworm-fed eels achieved a final weight of 11.80 g, RGR of 2.64%, and SR of 80.95% after a 60-day culture. The nutrient composition of eels fed silkworms revealed high protein content (76.90%) and significant levels of essential amino acids.

8. Internet of Things (IoT)-based aquaculture: An overview of IoT application on water quality monitoring

This article summarizes research on IoT-based aquaculture focusing on water quality monitoring in fishponds. It analyzed 30 published papers from May to December 2020, covering recent research trends, aquaculture environments, research approaches, common water quality parameters, and solution forms. Most studies (81%) focused on inland aquaculture, with the framework and architecture approach (48%) being most common. Temperature, dissolved oxygen, and pH were the top-prioritized water quality parameters. Real-time monitoring (50%) was the most common solution offered. The findings aim to support the aquaculture industry, researchers, practitioners, and decision-makers.

9. Design of water quality monitoring system for aquaculture ponds based on NB-IoT

This article introduces a water quality monitoring system for aquaculture ponds using NB-IoT technology. It enables remote collection, storage, and management of environmental parameters like temperature, pH, and dissolved oxygen. The system utilizes an STM32L151C8 microcontroller for real-time data acquisition and transmission over long distances to an IoT telecom cloud platform. Software tools like Keil and Java are employed for data format design, wireless communication, and background monitoring applications. Tested in ChangZhou, China, the system demonstrated accurate temperature control (±0.12℃), dissolved oxygen control (±0.55mg/L), and pH control (±0.09), providing reliable real-time data transmission for aquaculture production management.

10. An Integrated Wireless Multi-Sensor System for Monitoring the Water Quality of Aquaculture

This paper presents a wireless multi-sensor system for monitoring critical water quality factors in freshwater aquaculture. It integrates temperature, pH, dissolved oxygen (DO), and electrical conductivity (EC) sensors with an ESP32 Wi-Fi module. Salinity information is derived from the EC level. Data from these sensors are transmitted via Wi-Fi to an on-site access point and then to the ThingSpeak IoT platform. The information is visualized through the ThingView APP, providing user-friendly access to real-time water quality data. Through calibration processes, the system demonstrates sufficient accuracy and reliability for freshwater aquaculture monitoring.

HARDWARE COMPONENTS:

Temperature Sensor:

Monitoring Water Temperature:

- Temperature sensors measure the temperature of the water in eel tanks or ponds.
- Eels are ectothermic organisms, meaning their body temperature is regulated by the surrounding environment. Monitoring water temperature is essential for ensuring that it remains within the optimal range for eel health and metabolic functions.

Detecting Thermal Fluctuations:

- Temperature fluctuations can occur due to various factors such as weather changes, equipment malfunctions, or water flow disruptions.

- Temperature sensors detect deviations from the desired temperature range, allowing aquaculturists to identify potential issues and take corrective actions promptly.

Preventing Stress and Disease:

- Rapid or extreme changes in water temperature can induce stress in eels, compromising their immune system and making them more susceptible to diseases.
- Continuous monitoring of water temperature helps prevent temperature-related stress and reduces the risk of disease outbreaks among eel populations.

Optimizing Feeding and Growth:

- Water temperature influences eel metabolism, feeding behavior, and growth rates.
- By maintaining stable water temperatures within the appropriate range, aquaculturists can optimize feeding schedules and promote healthy growth and development of eels.

Ensuring Reproductive Success:

- Water temperature plays a critical role in the reproductive success of eels, particularly during spawning seasons.
- Monitoring temperature variations helps create optimal breeding conditions, facilitating natural spawning or induced breeding techniques in aquaculture facilities.

Integrating with Control Systems:

- Temperature sensor data can be integrated into control systems to automate temperature regulation in eel tanks or ponds.
- Automated systems adjust heating or cooling equipment based on real-time temperature measurements, maintaining stable conditions and reducing manual intervention.

Data Analysis and Trend Monitoring:

- Temperature sensor data, along with data from other sensors, are analyzed to identify trends and patterns in water temperature fluctuations.
- Historical temperature data can be used for trend analysis, helping aquaculturists make informed decisions regarding water management strategies and system optimizations.

pH Sensor:

Monitoring Water Acidity/Alkalinity:

- pH sensors measure the acidity or alkalinity of the water by detecting the concentration of hydrogen ions (H+) in the solution.
- Maintaining the pH of the water within the optimal range is essential for eel health, as extreme pH levels can stress or harm eels and disrupt biological processes.

Preventing pH Fluctuations:

- pH fluctuations can occur due to various factors such as organic waste accumulation, chemical additions, or changes in water source quality.
- pH sensors continuously monitor pH levels and detect deviations from the desired range, allowing aquaculturists to identify and address potential issues promptly.

Optimizing Water Quality Conditions:

- Eels have specific pH requirements depending on their species and life stage. For example, freshwater eels typically thrive in slightly acidic to neutral pH conditions.
- Monitoring pH levels helps aquaculturists maintain water quality conditions that are conducive to eel health, growth, and physiological functions.

Preventing Ammonia Toxicity:

- pH levels influence the toxicity of ammonia (NH_3/NH_4^+) in water. Ammonia toxicity increases at higher pH levels, posing a risk to eel health.
- By monitoring pH levels, aquaculturists can assess the potential risk of ammonia toxicity and take corrective actions, such as adjusting pH or implementing water treatment measures to mitigate ammonia accumulation.

Turbidity sensor:

Assessing Water Clarity:

- Turbidity sensors measure the cloudiness or clarity of the water by detecting the scattering and absorption of light caused by suspended particles.
- Clear water with low turbidity levels is essential for eel health and well-being, as high turbidity can hinder visibility, disrupt feeding behavior, and compromise water quality.Detecting Suspended Solids:
- Turbidity sensors provide insights into the concentration of suspended solids in the water, including organic matter, algae, sediment, and other particulate pollutants.
- Monitoring turbidity levels helps aquaculturists identify sources of water pollution and assess the effectiveness of filtration and water treatment processes in removing suspended solids.

Preventing Organic Waste Accumulation:

- Excessive turbidity levels can indicate the accumulation of organic waste and uneaten feed in eel tanks or ponds, leading to deteriorating water quality and increased ammonia levels.
- By monitoring turbidity levels, aquaculturists can implement timely waste removal strategies and optimize feeding practices to prevent organic waste buildup and maintain water clarity.

ESP32:

The ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities, making it well-suited for IoT-based water quality monitoring systems in eel aquaculture. Here's how the ESP32 can be utilized in such projects:

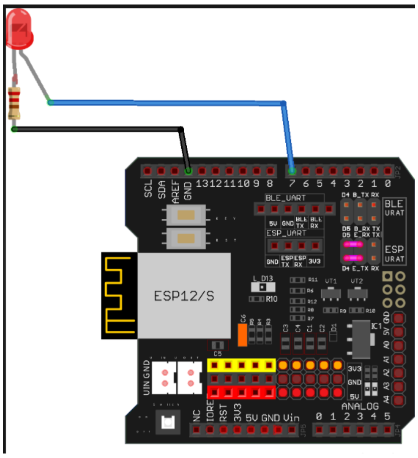
Wireless Data Transmission:

- The ESP32's integrated Wi-Fi module enables wireless data transmission from sensors to a central monitoring station or cloud server.
- Aquaculturists can receive real-time updates on water quality parameters without the need for physical connections, facilitating remote monitoring and management of eel aquaculture facilities.

Remote Monitoring and Control:

- ESP32-based systems allow aquaculturists to remotely monitor water quality parameters and control system components such as pumps, heaters, or aerators via Wi-Fi or Bluetooth connectivity.
- Remote control capabilities enable quick response to changing conditions and implementation of corrective actions, improving overall system efficiency and eel welfare.

Blynk Server:



Blynk Server can enhance IoT-based water quality monitoring systems in eel aquaculture by providing a centralized platform for data visualization, remote monitoring, and control. Here's how Blynk Server can be utilized in such projects:

Real-time Data Visualization:

Blynk Server allows aquaculturists to visualize real-time sensor data from eel aquaculture facilities through customizable dashboards on mobile devices or web browsers.

Aquaculturists can monitor water quality parameters such as pH, dissolved oxygen, temperature, ammonia, turbidity, and more, enabling timely detection of anomalies or deviations from desired levels.

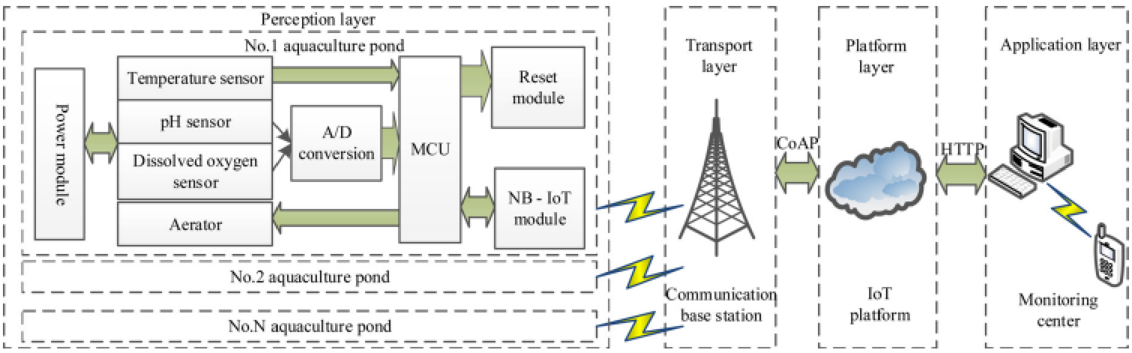
Customizable Dashboards:

Blynk's user-friendly interface enables aquaculturists to create custom dashboards with interactive widgets such as gauges, graphs, sliders, and buttons.

Customizable dashboards allow aquaculturists to tailor the visualization of sensor data to their specific monitoring needs and preferences, improving usability and decision-making efficiency.

Architectural diagrams used in past researches:

1. Design of water quality monitoring system for aquaculture ponds based on NB-IoT



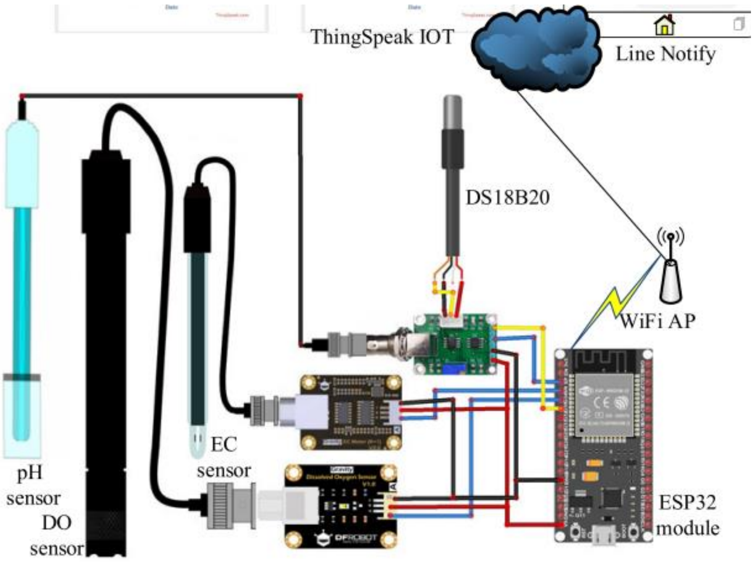
Sensors placed in the aquaculture ponds collect various data related to water quality. This could include parameters like temperature, pH, dissolved oxygen, turbidity, and more.

The collected data is transmitted using NB-IoT technology. NB-IoT is a low power wide area network technology that allows devices to wirelessly connect and communicate over long distances with minimal power consumption.

The transmitted data is received and analyzed in real-time. This could be done on a cloud platform or a local server. The analysis helps in understanding the water quality and making necessary adjustments to ensure optimal conditions for the aquatic life in the pond.

This system allows for efficient and real-time water quality management, which is crucial for the success of aquaculture operations. It reduces manual labor, increases precision, and enables quick response to any changes in water quality.

2. An Integrated Wireless Multi-Sensor System for Monitoring the Water Quality of Aquaculture



The system integrates multiple sensors that are capable of measuring various parameters related to water quality. This could include temperature, pH, dissolved oxygen, turbidity, and more.

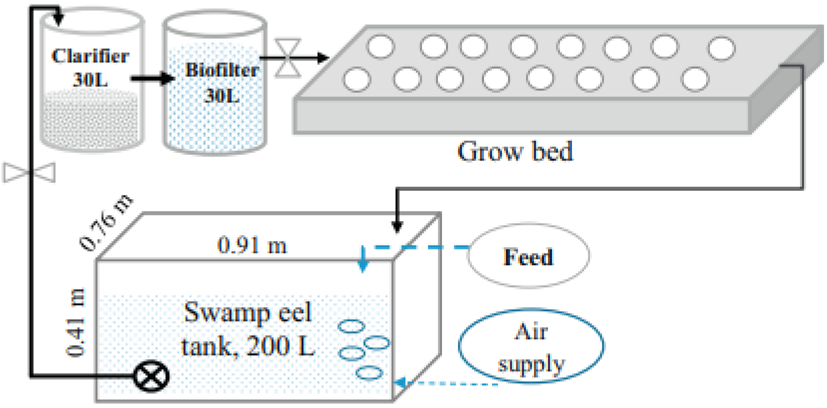
The data collected by the sensors is transmitted wirelessly. This could be done using various wireless communication technologies, including Wi-Fi, Bluetooth, Zigbee, or even cellular networks.

The transmitted data is monitored in real-time. This allows for immediate response to any changes in water quality, ensuring the health and well-being of the aquatic life in the aquaculture.

The data is also analyzed to understand trends and patterns in water quality. This can help in predicting potential issues and taking preventive measures.

IoT Integration: The system leverages Internet of Things (IoT) technology for seamless connectivity and data management. This allows for remote monitoring and control, making the system highly efficient and user-friendly.

3. Effects of different stocking densities on growth performance of Asian swamp eel Monopterus albus, water quality and plant growth of watercress Nasturtium officinale in an aquaponic recirculating system



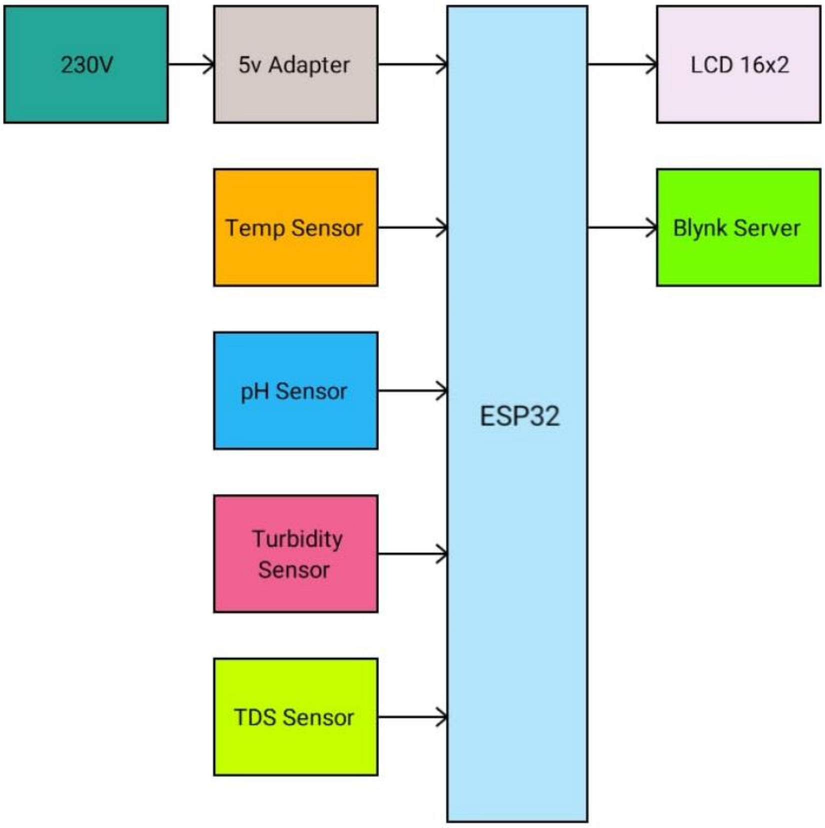
These eels are stocked in the fish tanks. The stocking density (number of eels per unit volume of water) can affect their growth performance. Too high a density can lead to competition for resources and stress, affecting the eels' health and growth.The water in the fish tanks is rich in nutrients from the eels' waste. However, the waste also produces ammonia, which can be harmful to the eels in high concentrations. Therefore, maintaining water quality is crucial.

The nutrient-rich water is circulated to the plant grow beds, where watercress is grown. Watercress can absorb the nutrients from the water, aiding its growth. At the same time, it helps purify the water by absorbing the harmful ammonia.

Recirculation: After the plants absorb the nutrients, the water is recirculated back to the fish tanks. This not only conserves water but also ensures a continuous supply of clean water for the eels.These are used to convert the harmful ammonia from the eels' waste into nitrites and then nitrates, which are less toxic and can be absorbed by the plants.

This system allows for the sustainable and efficient co-cultivation of eels and watercress, with each component benefiting the other. The eels provide nutrients for the plants, and the plants help maintain water quality for the eels. The stocking density of the eels would need to be carefully managed to balance the nutrient production with the plants' absorption capacity and maintain optimal water quality.

Architectural diagram of our problem:



For water quality monitoring in eel aquaculture, a refined architectural diagram and hardware requirements would involve several key components. Here's a breakdown:

Refined Architectural Diagram:

Sensor Nodes:

- pH Sensor
- Temperature Sensor
- Ammonia Sensor
- Turbidity Sensor
- Water Level Sensor

Microcontroller Unit (MCU):

- Arduino or ESP32 for data acquisition and processing.
- MQTT protocol for communication.

Internet Connectivity:

- Ethernet, Wi-Fi, or GSM module for connecting the gateway to the internet.
- Cloud Server:
- Cloud-based storage (e.g., AWS, Azure) for storing sensor data.
- Database for historical data analysis.

User Interface:

- Web-based dashboard or mobile application for real-time monitoring and control.
- Data visualization tools for analyzing trends and patterns.
- Hardware Requirements:

This refined architectural diagram and hardware requirements outline a comprehensive solution for water quality monitoring in eel aquaculture, incorporating sensors, microcontrollers, gateways, internet connectivity, cloud storage, and user interfaces to ensure efficient monitoring and management of water quality parameters.

REFERENCES:

1) T. I. Salim, T. Haiyunnisa and H. S. Alam, "Design and implementation of water quality monitoring for eel fish aquaculture," 2016 International Symposium on Electronics and Smart Devices (ISESD), Bandung, Indonesia, 2016, pp. 208-213, doi: 10.1109/ISESD.2016.7886720.

2)B´orquez L´opez RA, Martinez Cordova LR, Gil Nun˜ez JC, Gonzalez Galaviz JR, Ibarra Gamez JC,Casillas Hernandez R (2020) Im- plementation and evaluation of open-source hardware to monitor water quality in precision aquaculture. Sensors 20(21):6112

3)Mulyani et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 934 012080

4)Eko Harianto et al 2022 IOP Conf. Ser.: Earth Environ. Sci. 1033 012013

5)NH Sadi et al 2022 IOP Conf. Ser.: Earth Environ. Sci. 1062 01200

6)Abbaszadeh, A., Keyvanshokooh, S., Yavari, V. & Naderi, M. (2019) Proteome modifications of Pacific white shrimp (Litopenaeusvannamei) muscle under biofloc system. Aquaculture Nutrition, 25, 358366.

7)Becke, C., Schumann, M., Steinhagen, D., Rojas-Tirado, P., Geist, J. & Brinker, A. (2019) Effects of unionized ammonia and suspended solids on rainbow trout (Oncorhynchus mykiss) in recirculating aquaculture systems. Aquaculture, 499, 348357.

8)Harianto, E., Supriyono, E., Budiardi, T. et al. The effect of water level in vertical aquaculture systems on production performance, biochemistry, hematology, and histology of Anguilla bicolor bicolor. Sci Rep 11, 11318 (2021). https://doi.org/10.1038/s41598-021-90912-1

9)Goddek, S., Joyce, A., Kotzen, B. & Burnell, G. M. Aquaponics food production systems-combined aquaculture and hydroponic production technologies for the future. (Springer, 2019).

10)Z. K. Xu, J. Cao, X. M. Qin, W. Q. Qiu, J. Mei, and J. Xie, “Toxic effects on bioaccumulation, hematological parameters, oxidative stress, immune responses and tissue structure in fish exposed to ammonia nitrogen: a review,” Animals, vol. 11, 2021.

11)M. B. Timmons and S. M. Zhu, Recirculating Aquaculture Systems, Zhejiang University Press, Zhejiang, China, 2021.

12)Salah Uddin M, Fatin Istiaq M, Rasadin M, Ruhel TM. Freshwater shrimp farm monitoring system for Bangladesh based on internet of things. Eng Rep. 2020; 2(7): 1-14.

13)Prapti DR, Shariff ARB, Man HC, Ramli NM, Perumal T, Shariff M. An overview of water quality monitoring in IoT based aquaculture. In: ASABE 2021 Annual International Meeting; 2021: 2-10.

14)Manoharan H, Teekaraman Y, Kshirsagar PR, Sundaramurthy S, Manoharan A. Examining the effect of aquaculture using sensor-based technology with machine learning algorithm. Aquac Res. 2020

15)Kun-Lin Tsai, Li-Woei Chen, Li-Jun Yang, Hung-Jr Shiu, Han-Wei Chen, "IoT based Smart Aquaculture System with Automatic Aerating and Water Quality Monitoring," Journal of Internet Technology, vol. 23, no. 1 , pp. 177-184, Jan. 2022.