

Aerator Monitoring System for Fisheries Using Internet of Things

Himanshu Tyagi¹, Lovink Tyagi¹, Ayush Singh¹, Anjali¹, Arpna Saxena^{2,*}

Abstract

To manage aquaculture effectively, we need to monitor water quality constantly. This helps prevent the depletion of dissolved oxygen, which can lead to fish suffocating. Such monitoring is especially critical in intensive pond systems. If we ignore this and fail to take action quickly, we risk losing all our fish, resulting in high costs that could have been avoided. This paper introduces a low-cost Internet of Things (IoT) based aerator monitoring and management system designed for real-time water quality management in small-scale and rural fisheries. The system uses a NodeMCU ESP8266 microcontroller integrated with sensors for temperature, pH, dissolved oxygen, turbidity, and water level to collect continuous data. The sensor data is sent wirelessly to a cloud platform, where users can visualize it in real time. Alerts can be generated to signal any discrepancies between expected and observed values, and historical analysis can also be conducted. An automated aeration mechanism activates when dissolved oxygen levels fall below preset limits, ensuring stable oxygen availability while minimizing unnecessary energy use. The sensors performed well during testing in freshwater, providing stable wireless communication and measurements that matched laboratory results. This approach streamlines the monitoring of significant changes in water quality, leading to more effective responses. Furthermore, it is affordable, easily expandable, and energy-efficient, making it a smart and eco-friendly option for aquaculture management.

Keywords: IoT, aquaculture, water quality monitoring, dissolved oxygen, automated aeration, NodeMCU ESP8266

INTRODUCTION

Water quality is important not only for fish farming but also for the environment. Fish are often kept in smaller ponds; hence, water quality is a major concern. Pollutants may develop, and high water temperatures may stress fish, resulting in poor immunity and increased disease levels. Sometimes, this results in mass deaths. Therefore, it is important to regularly test the water, and the level of oxygen is a major concern. Sometimes, a lack of food may make the fish sluggish, and hence, if the environment is poor, this may cause mass deaths. Fish are often kept close, and hence, a lack of oxygen may develop quickly. Therefore, it is important to monitor this level regularly [1]. However, the aeration system, if available, may not be able to monitor this level in real time and may require a lot of energy to operate. Therefore, there is a need for smaller, cheaper, and efficient aeration systems, especially for village fish farms. The traditional method of water testing is often time-consuming and expensive. For example, nighttime deficiencies in dissolved oxygen concentrations due to organic decay are rarely noticed until a fish kill event results in

*Author for Correspondence

Arpna Saxena

E-mail: saxenaarpna@akgec.ac.in

¹Research Scholar, Department of Master of Computer Applications, Ajay Kumar Garg Engineering College, Ghaziabad, Uttar Pradesh, India

²Assistant Professor, Department of Master of Computer Applications, Ajay Kumar Garg Engineering College, Ghaziabad, Uttar Pradesh, India

Received Date: July 04, 2026

Accepted Date: August 31, 2026

Published Date: September 20, 2026

Citation: Himanshu Tyagi, Lovink Tyagi, Ayush Singh, Anjali, Arpna Saxena. Aerator Monitoring System for Fisheries Using Internet of Things. Research & Reviews: Journal of Embedded System & Applications. 2026; 14(2): 1–8p.

considerable losses [2]. The Internet of Things (IoT) has been proposed as a cost-effective solution for real-time water quality monitoring using various sensors and wireless technologies [3]. The NodeMCU ESP8266-based IoT system has been shown to be capable of monitoring critical parameters, such as water temperature, pH, and dissolved oxygen concentrations. The proposed automated aerating system, depending on the concentration of dissolved oxygen, has been shown to result in higher survival rates than existing manual aerating systems. The proposed IoT system is energy efficient and provides long-term access to data, thus ensuring better aquaculture management. The proposed IoT system has been shown to be capable of real-time water quality monitoring, thus ensuring better aquaculture management. The proposed IoT system has been shown to be capable of real-time water quality monitoring, thus ensuring better aquaculture management [4]. The proposed IoT system has been shown to be capable of real-time water quality monitoring, thus ensuring better aquaculture management [5].

Contribution

The multi-sensor Internet of Things (IoT) water quality monitoring system can collect data from various sensors, including temperature, pH, dissolved oxygen, turbidity, and water level sensors, and display this data in real-time, allowing users to view this data online through the cloud [6]. The proposed solution allows users to aerate their fish tanks by measuring the level of oxygen in the water and adding more oxygen if required, thus reducing stress in fish. The proposed solution is easy to use, cost-effective, and reliable, thus ensuring that data transmission takes place seamlessly in a rural pond environment. The proposed solution is sustainable, thus having a positive impact on operational efficiency, considering that it promotes green technology in fish farming [7].

LITERATURE REVIEW

IoT technology is developing at an incredibly fast rate. One of the advantages of using IoT technology in aquaculture is that it helps in better management of water quality. IoT technology enables the use of fully integrated sensor-based platforms with live monitoring. This helps in tracking the levels of dissolved oxygen, temperature, pH, and turbidity. These are some of the most important factors to be maintained in an aquatic environment. These platforms are more reliable than traditional manual systems, which are time-consuming and labor-intensive [8]. IoT technology also helps with the early detection of fish diseases. Wireless sensor networks are used for monitoring in large-scale aquaculture farms.

However, some problems have been encountered with sensor wear, high power consumption, and reliability. Continuous monitoring techniques have played an important role in the better management of pollution and eutrophication at early stages. In addition, better control techniques have been developed to improve the efficiency of the aeration systems and better manage the water quality using IoT technology [9]. Automated aeration systems are also helpful in maintaining the oxygen levels in smart aquaculture systems. The use of IoT technology along with AI technology is helpful in making the aquaculture industry eco-friendly. However, some problems are being encountered due to the high cost of the technology and complexity of the technology (Table 1). Therefore, there is an urgent need to develop affordable and reliable real-time aerators (Figure 1).

Table 1. Execution goal of the aerator monitoring system.

Design aspect	Target function	Expected outcome
DO sensing accuracy	Continuous measurement	Stable oxygen levels
Automated control	Real-time aerator switching	Reduced fish stress
Wireless communication	Remote monitoring	Reduced manual labor
Low-cost hardware	Affordable components	High rural adoption
Energy efficiency	Optimized aeration cycles	Lower power consumption

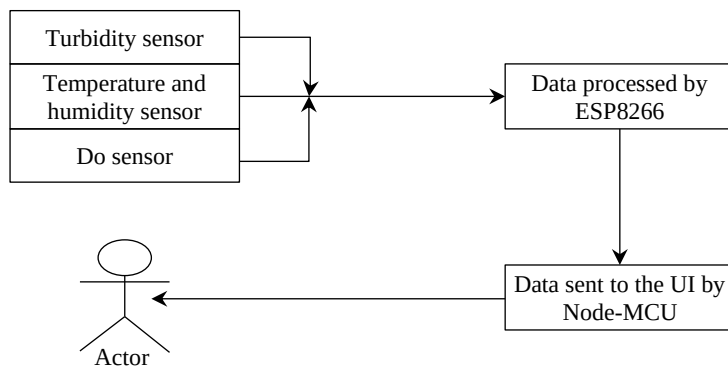


Figure 1. Data flow of sensor input to NodeMCU ESP8266.

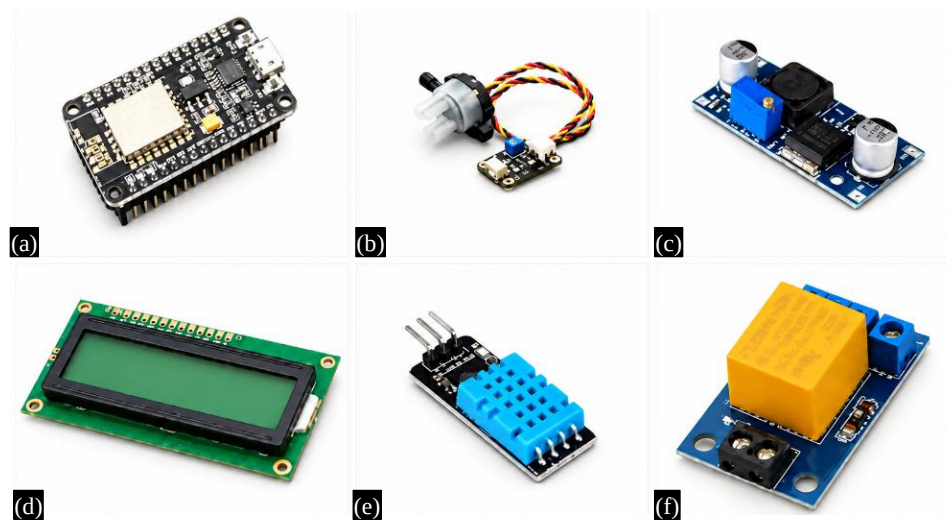


Figure 2. Components used in the proposed water quality monitoring and pond aeration system: (a) NodeMCU ESP8266, (b) Turbidity Sensor, (c) Buck Converter, (d) LCD Display, (e) Humidity Sensor, and (f) Relay Module.

BACKGROUND

This IoT-based monitoring system enables continuous monitoring and data collection of the temperature, pH, dissolved oxygen, turbidity, and water levels in pond water in real time. The system changes the traditional methods of monitoring water quality, as the data are collected at set intervals instead of continuous monitoring using the NodeMCU ESP8266. The electronics section integrates multiple sensors into a single device and uses relay modules to automate the aerators. The voltage regulators ensure that everything is running smoothly, and the LCD enables the user to access the data on site. The traditional methods of aerating the water and checking the sensors are not as efficient as this system [10]. The system enables the regulation of oxygen levels, thereby ensuring the stability and real-time water quality control that every smart aquaculture enthusiast requires (Table 2).

Components

NodeMCU ESP8266 is the main part of the system, which collects real-time data and then sends the data wirelessly, as shown in Figure 2(a). The system uses a turbidity sensor to sense the clarity of the water in the pond, as shown in Figure 2(b). The system uses a buck converter to maintain the required voltage level in the system, as shown in Figure 2(c). The system uses a liquid crystal display to display the important parameters, i.e., temperature, dissolved oxygen level, turbidity level, and water level, as shown in Figure 2(d). The system uses a humidity sensor to sense the vicinity of the pond, as shown in Figure 2(e). The system uses a relay module to switch on the aerating system of the pond, as shown in Figure 2(f).

Table 2. Requirements and job of sensors used in the system.

Parameter	Sensor type/model	Measurement range	Function in system
Temperature	DS18B20 digital sensor	-55 °C to +125 °C	Monitors water temperature affecting fish metabolism
Dissolved oxygen	Galvanic DO sensor	0 – 20 mg/L	Detects low oxygen levels and triggers aerator
Turbidity	Analog turbidity sensor	0 – 1000 NTU	Monitors water clarity and suspended solids

PROPOSED APPROACH

They are using a NodeMCU ESP8266 as their main microcontroller, and the sensors are connected through the GPIO pins, and then the data is sent through the Wi-Fi network. The equipment included a DO sensor to measure the oxygen level, a turbidity sensor to check the clarity of the water, a DS18B20 sensor to measure the temperature, and a DHT11 or DHT22 sensor to measure the humidity level surrounding the fishponds. The aerator was controlled through a relay and was turned on only if the level went below 5 mg/L, saving power and operating only when required [11].

Data Flow and Operation

At regular intervals, the NodeMCU ESP8266 reads the sensor values, performs a bit of processing, and sends the values to Blynk, providing farmers with an instant snapshot of the environment. In the event that any anomalies are detected, such as turbidity levels exceeding the safe limits or a temperature change, the farmers are immediately informed, and at the same time, the system returns the aerator to work mode, ensuring that they are never out of touch with the problem [12]. Moreover, Blynk retains the values for later use, giving farmers the ability to extrapolate possible patterns and hence improving farm management.

Key Benefits

This solution addresses water quality problems immediately, which means that the fish will be healthier and live longer. This is unlike the past, which relied on the traditional manual approach, which required more time and effort. Additionally, it only uses energy when aeration is required, which means that it fits very well with the objectives of sustainable aquaculture set in the 14th SDG [13]. Farmers can receive simple and affordable technology that will enable them to produce more without needing to monitor all the processes.

Algorithm

The algorithm continuously monitors water quality and activates aeration only when required, reducing manual effort, conserving energy, and supporting healthier fish growth in sustainable aquaculture (Figures 3 and 4).

Experimental setup

We created a model using a NodeMCU ESP8266 microcontroller and connected it to temperature, pH, dissolved oxygen, and turbidity sensors. This allowed us to continuously monitor the pond environment. We submerged each sensor individually to the same depth and used shielded cables to prevent electrical interference, hence obtaining accurate sensor readings. Our device updates itself every minute if there is a change, and we are able to detect it instantly. It is much more efficient than manually testing, to say the least.

This machine always tests the quality of water on its own, and it does so very fast if there is a problem. It has a 5 V battery, and a solar panel serves as a backup, hence self-sustaining outside. If you want a device to continuously monitor and do so without human intervention, then this setup is reliable (Figure 5).

1	Sensor initialization Start the system. Initialize the sensors and Wi-Fi connection.
2	Data acquisition from all nodes Repeatedly read temperature, pH, dissolved oxygen (DO), and turbidity.
3	Signal processing and noise filtering Calibrate the sensor data and apply noise filtering.
4	Alerts and aerator activation If $DO < 5$ mg/L, activate the aerator. If $pH < 6.5$ or > 8.5 , send an alert.
6	Cloud data storage Transmit the data to the cloud for storage.
7	End of loop Return to Step 2 for the next reading.

Figure 3. Sensor-based water quality monitoring workflow.

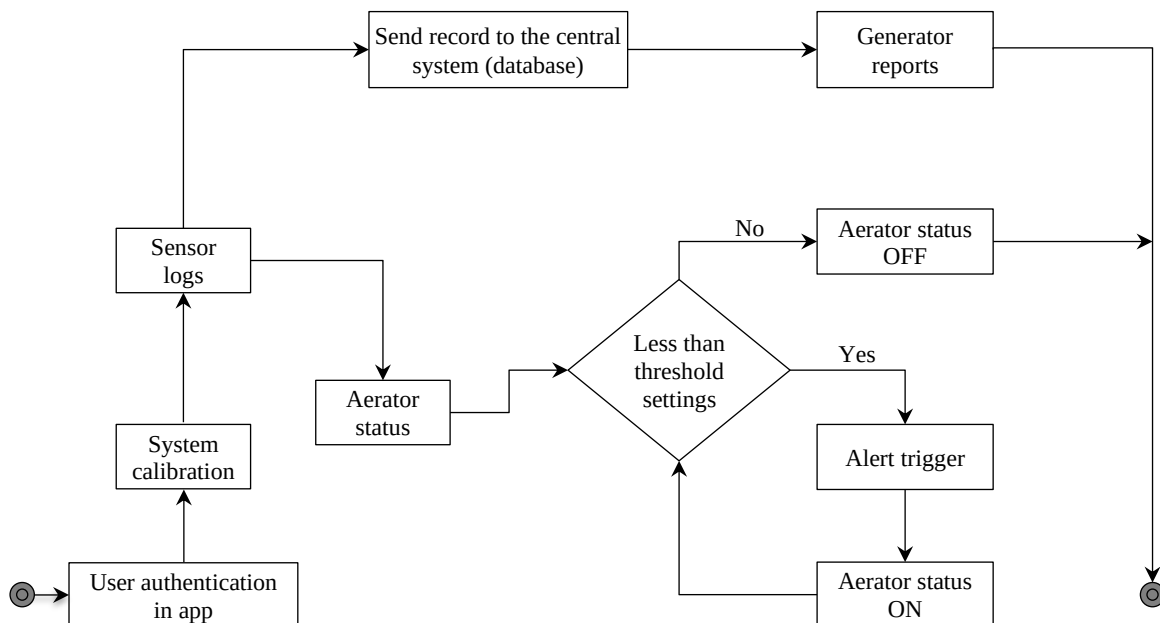


Figure 4. IoT-based aerator control workflow.

Procedure

We tested our prototype for 2 days using it in the water of a freshwater tank. Every day, we took our measurements at 7 a.m., 1 p.m., and 6 p.m. We measured the temperature, pH, turbidity, and dissolved oxygen levels. To check if our sensors were accurate, we compared our sensor readings with those obtained from standard laboratory instruments. The temperature reading was 25 °C in the morning, 30 °C by noon, and then dropped to 26 °C in the evening. The pH reading was relatively constant, fluctuating between 7.1 and 7.4. The reading for dissolved oxygen was also relatively constant, ranging from 5.3 to 6.2 mg/L. The turbidity reading ranged from 12 to 19, indicating that our water was clean and ideal for raising tropical freshwater fish.

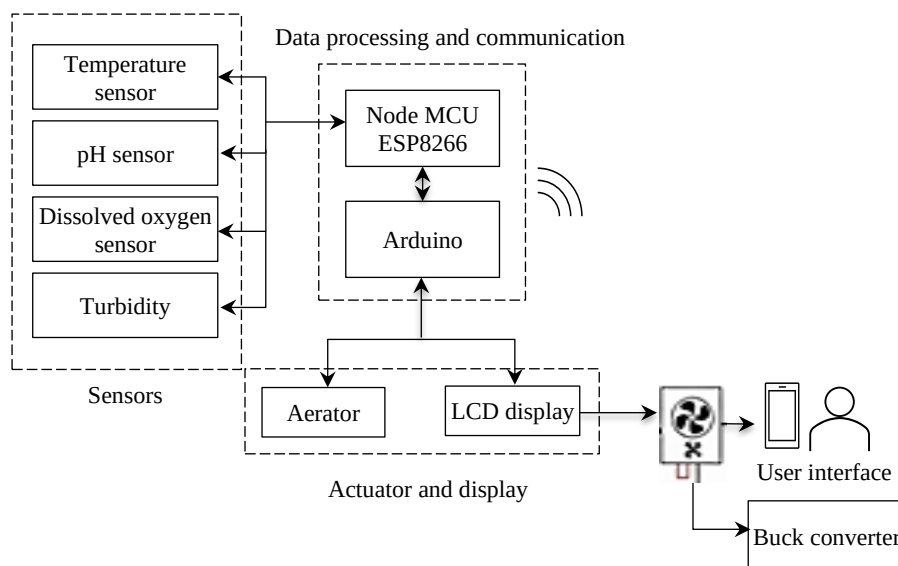


Figure 5. System setup.

RESULTS AND DISCUSSION

As shown in Figure 6, the system remained stable; there was almost no signal interference, and the wireless connection did not move, even when the environment changed. As we tested the above system in the environment, the cheap IoT components worked well, and the accuracy of the system, in the case of the above components, remained the same as in the lab environment. Moreover, owing to automation, it is possible to monitor the environment from a distance. The above-mentioned traditional method of collecting water samples is no longer needed, as the new method has reduced the labor needed by more than 80%, and the time needed to solve the problem of water quality has been reduced from hours to just a few seconds. Of course, some studies have obtained the same results using fuzzy logic or artificial intelligence [4, 9], but in the above case, the difference is that the above results were obtained while maintaining the simplicity of the system and low costs; therefore, the results can be obtained even by small farmers. In conclusion, the above-mentioned system of monitoring the environment, which uses IoT, is a significant help in keeping the environment eco-friendly, as you will receive updates in an instant, you will be able to use the resources in a better way, and the fish will survive in greater numbers.



Figure 6. User dashboard.

In the field, its advantages were obvious to everyone. As soon as the levels of oxygen were close to the maximum, the system jumped into action, first turning on the aeration system almost instantly. This ensured that the fish were always safe and sound, and there was never a chance for a problem to occur. It was much simpler, and alerts were reduced by over 80% through automated alerts, which is in line with the productivity benefits from such a system. And, to top it all off, the numbers were accurate. False alerts were filtered out when multiple sensors intersected and compared what each one was reading. Then, averages were used to keep everything steady and stable. But what is perhaps most amazing? The whole thing operates on solar energy! This, of course, is fully in line with our ecological and resource-saving principles, and no outside electricity source is needed. This makes the use of IoT and automation in our fisheries a true reality, and one that is not just talk, but one that does indeed help the economy and our ecology, even if it does have a few flaws. For instance, sometimes the Wi-Fi just stops working or turns off during bad weather. In addition, sensors also need to be cleaned and checked regularly, or else weird results are obtained, and this messes up the whole system. In addition, there is a problem with security if one decides to put one's data on other platforms. So, what do we do? Therefore, we implement predictive analytics, improve security, and improve communication over long distances, and everything begins to run much more smoothly; we can even watch our growth accelerate, and problems are caught early on before they become huge problems.

CONCLUSION AND FUTURE SCOPE

With all this in place, IoT, as well as automation in the fishery industry, is a reality, not just mere talk, which can provide economic benefits while being environmentally friendly. As far as the development of the project is concerned, we made use of NodeMCU ESP8266 along with several multi-parameter sensors to create a water quality system for aquaculture water quality monitoring system using Internet of Things (IoT) technology. This system will be able to monitor the water level, turbidity, temperature, pH, as well as the amount of dissolved oxygen in the water at the time of measuring it. Auto aeration? It is awesome, indeed, as it requires less human intervention; the water becomes clean, and the fish remain healthy too. Nonetheless, it has certain limitations too, which are: Actually, the Wi-Fi range is a bit disappointing, and the sensors need to be recalibrated most of the time. But if we make the transition to cellular IoT technology, we can improve the range while, at the same time, making the operations easier. We are developing sensors that will be able to clean themselves, and the sensors will be able to get calibrated through the use of AI technology, so there is

no need to monitor them all the time. As far as the plan is concerned, it should be quite reliable, but the predictive analytics feature of the system will be able to help us in identifying the problems, if they are going to occur, before they are further worsened.

REFERENCES

1. Ya'acob N, Dzulkefli NNSN, Yusof AL, Kassim M, Naim NF, Aris SSM. Water quality monitoring system for fisheries using Internet of Things (IoT). IOP Conf Ser Mater Sci Eng. 2021;1176:012016. doi:10.1088/1757-899X/1176/1/012016.
2. Akhter F, Siddiquei HR, Alahi MEE, Mukhopadhyay SC. Recent advancement of the sensors for monitoring water quality parameters in smart fisheries farming. Computers. 2021;10(3):26. doi:10.3390/computers10030026.
3. Manoj M, Dhillip Kumar V, Arif M, Bulai ER, Bulai P, Geman O. State of the art techniques for water quality monitoring systems for fish ponds using IoT and underwater sensors: a review. Sensors (Basel). 2022;22(6):2088. doi:10.3390/s22062088. PMID:35336256.
4. Tsai KL, Chen LW, Yang LJ, Shiu HJ, Chen HW. IoT based smart aquaculture system with automatic aerating and water quality monitoring. J Internet Technol. 2022;23(1):177–184.
5. Garcia M, Trambulo EM, Pajarillo J, Apsay MRB, Tenorio JE, Chua MG. Development of dissolved oxygen monitoring system for fish ponds. In: IEEE 3rd International Conference on System Engineering and Technology; 2013. p. 83–88. doi:10.1109/ICSEngT.2013.6650148.
6. Chislock MF, Doster E, Zitomer RA, Wilson AE. Eutrophication: causes, consequences, and controls in aquatic ecosystems. Nat Educ Knowl. 2013;4(4):10.
7. Khan PW, Byun YC. Optimized dissolved oxygen prediction using genetic algorithm and bagging ensemble learning for smart fish farm. IEEE Sens J. 2023;23(13):15153–15164. doi:10.1109/JSEN.2023.3278719.
8. Huang YP, Khabusi SP. Artificial intelligence of things (AIoT) advances in aquaculture: a review. Processes. 2025;13(1):73. doi:10.3390/pr13010073.
9. Li W, Wu H, Zhu N, Jiang Y, Tan J, Guo Y. Prediction of dissolved oxygen in a fishery pond based on gated recurrent unit (GRU). Inf Process Agric. 2021;8(1):185–193. doi:10.1016/j.inpa.2020.02.002.
10. Enehizena ON, Ogbeide KO, Farhaoui Y, Imoize AL. ZigBee wireless sensor network design for environmental monitoring. In: The International Conference on Artificial Intelligence and Smart Environment. Cham: Springer Nature Switzerland; 2024. p. 498–505.
11. Lambrou TP, Anastasiou CC, Panayiotou CG, Polycarpou MM. A low-cost sensor network for real-time monitoring and contamination detection in drinking water distribution systems. IEEE Sens J. 2014;14(8):2765–2772. doi:10.1109/JSEN.2014.2316414.
12. Sheela MS, Chand SR, Gopalakrishnan S, Choubey SB, Gopianand M, Hephzipah JJ. Empowering aquarists: a comprehensive study on IoT-enabled smart aquarium systems for remote monitoring and control. Babylon J Internet Things. 2024;2024:33–43. doi:10.58496/BJIoT/2024/005.
13. Abinaya T, Ishwarya J, Maheswari M. A novel methodology for monitoring and controlling of water quality in aquaculture using Internet of Things (IoT). 2019 International Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India. 2019. p. 1–4. doi:10.1109/ICCCI.2019.8821988.