A Review on Fish Farm Aquaculture Monitoring & Controlling System

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***Abstract*—**This paper is a review on aquaculture monitoring and controlling system using various approaches. Water is getting polluted due to use of pesticides & fertilizers, industrialization, urban development, etc. Aquaculture is the farming of fish, aquatic plants, molluscs, algae & other organisms. It involves cultivating fresh and salt water population under controlled condition. Farming involves rearing process to enhance production, like feeding, protection from predators, regular stocking and so on. Due to the under development of economy in wild fisheries & over exploitation of marine species with the demand for high quality protein, encouraged aqua culturist to domesticate marine species. As the over fishing at oceans and other natural resources is increasing continuously every year, the oceans provide the demand for sea food naturally. To fill the gap of this sea food supply, aquaculture is the main tool.

***Index Terms*—Aquaculture monitoring, Fish farming, Temperature, Turbidity, conductivity.**

1. INTRODUCTION

AQUACULTURE is one of the most emerging field because the demand for sea food is increasing all over the world. Of the several sea foods the most wanted food is fish because of its health benefits. Fish farming has a huge impact on any country's economy as the demand for fish is increasing. However, many countries need to import fish, as the production does not meet the total consumption. For example, in Ghana, half of the countries demand does not meet though there is combination of annual supply of fish from aquaculture and capture. Aquaculture has become of crucial importance in relation to the development of fisheries sector in many of the countries in the world today because of the shortage in supply as it is expected to increase with limited prospects. Management of fisheries relies on the monitoring of water quality as fish diseases are very common and have a direct impact on the harvesting yield [6]. Protected location for farming could be suitable for reducing environmental effects and production. More stable water flow can be featured by such areas which leads to stable culture condition & dispersal of waste [15]. Since water is a prerequisite for fish, quality of water must be monitored and controlled continuously. One of the mistakes made by the aqua farmers is over feeding, as the uneaten food which remains can pollute the water. The significant parameters such as pH level dissolved oxygen, water level, ammonia content & temperature in the tank should be continuously monitored in order to avoid undesirable condition for farming [2]. Since fish are cold blooded animals, optimum temperature should be maintained and controlled in proper range. Enough oxygen is required for the fish for proper metabolism else they reside at the surface to catch up oxygen resulting in slower metabolism and eventually die due to lack of oxygen. The dissolved oxygen should be more than 5ppm always, pH value should be between 7 and 8.5 for their biological productivity ideally.

In India, aquaculture has become one of the growing sectors. It contributes about 1.07% of the GDP. According to a estimation, the fish requirement by 2025 would be in order of 16 million tons. Natural fisheries have exhausted by over fishing due to which commercial aquaculture came into existence. Because of the sudden climatic changes, fluctuations in water quality parameters occur posing problem for commercial aquaculture.

2. LITERATURE SURVEY

[1]. In this paper an outline for monitoring of water quality for aquaculture is used using Arduino, Raspberry pi and various sensors, android application and smartphone camera. The parameters for water quality used in this paper are pH, color, temperature and electrical conductivity. The sensor acquisition is performed by Raspberry pi and Arduino which is used as server and data processing device. To detect the color of the water photo acquisition is conducted using Raspberry pi with the help of smartphone camera. Any user can check the water condition using an android application through Wi-Fi within Wi-Fi threshold range and internet from anywhere in the world. To check the water condition some analysis is performed with these four parameters and necessary action can also be taken.

[2]. An IoT based smart water quality monitoring system is implemented that helps in continuous water condition monitoring based on four physical parameters: temperature, turbidity, electric conductivity & pH properties. Arduino Uno is connected with four sensors separately to find the water parameters. The acquired data is transmitted to a application developed using .NET platform and it is compared with the standard values of WHO (World Health Organization). The water parameters can be analyzed based on the measured parameters to determine if the water sample is fir for drinking.

[3]. The author has proposed usage of an IoT system for monitoring and controlling the water parameters. The system detects and controls ammonia, water level, pH value, foul smell, temperature, dissolved oxygen in the water. The real time data is collected from the sensor nodes and sent to Arduino for processing. The processor activates the corresponding controller to take necessary action when the parameters exceed the threshold. These values are also sent to the cloud using Wi-Fi and can be accessed in the control room. These values in the form of short messages are sent through GSM modem to the concerned person. This system is compatible and can be used for any type of aquaculture system.

[4]. This system gives a low range, low cost, low power and scalable approach for water quality monitoring using LoRa module with the help of LoRaWAN protocol which uses Low Power Wide Area Network technology (LPWAN). The system has wireless LoRa module for sending and receiving sensor values, adding sensors to the microcontroller and ThingSpeak IoT platform for testing and visualizing water quality sensor values.

[5]. Water quality is monitored using IoT based design is proposed in this paper. The power required by the sensors is provided using solar energy. This system is designed using Arduino Mega 2560 to measure turbidity and pH level using sensors. Data gathered from these sensors are sent to the cloud by means of Wi-Fi module. The collected information is analyzed further and is shown in visual format on LCD & displayed using Thingspeak which is a cloud server. This system can be monitored from anywhere in the World using internet and also implemented to the overhead and roof top tank.

[6]. The system consists of electrical, mechanical and communication components which are integrated with IoT (Internet of Things). The electrical part consists of a pi camera, which provides real time video data collection of the fish and interface with a Raspberry Pi B+ module. A stepper motor is controlled using Raspberry Pi, B+ via web interface are the mechanical parts used for food dispensing purpose. The two modes that can be used for feeding are: (1) Pre-scheduled feeding by the care taker, (2) manual feeding by the web interface. In scheduled feeding, the schedule must be fixed in the webpage while in manual feeding, fish must be fed by the user using web interface.

[7]. This paper explains the development of a prototype which is located in Kumah farms in Kumasi, Ghana. The main aim here was to give access to water quality measurements at low cost as fish farmers may not have enough budget to invest into commercial water measurement sensors as such farmers are only aware of actions to be taken on their ponds using traditional methods.

[8]. A smart fish farm of a remote control and monitoring system is developed by using IoT technology. The system senses and monitors several sensors such as temperature, water level, pH, oxygen level. Also, a closed loop water control of the aquarium is controlled by a microcontroller and supported by Message Queue Telemetry Transport (MQTT) protocol on the website application or mobile application.

[9]. The author has used machine learning, IoT and cloud computing technologies to monitor water quality at low cost which also replaces the traditional way of water quality monitoring. The model is capable of controlling the temperature of water and modify itself to adjust to the temperature of environment.

[10]. A design is proposed for water quality monitoring system for crab farming based on IoT which gives awareness to farmers for maintaining threshold levels of water quality in the pond. The system makes use of light weight Message Queuing Telemetry Transport (MQTT) protocol and LoRa based wireless sensor network for exchanging messages between mobile devices, sensors & embedded devices. The system mainly includes Raspberry Pi MQTT broker, sensor node as publisher and mobile client devices as subscribers. Sensor nodes are built using LoRa wireless interface, small embedded devices and water quality sensors like pH sensor, temperature sensor and salinity sensor. Also, a web based monitoring application using node-red dashboard for acquiring water quality parameters remotely is built.

[11]. In this paper fish talk system uses sensors to drive actuators in real time for aquarium. The relationship between actuators and sensors are described, the solid examples above threshold settings are given. The system allows the designer to adapt smart control for various conditions of water. An intelligent fish feeding mechanism is implemented for the fish as they may be either under fed or over fed. Also, an simulated analytic model and measurement experiments are developed to investigate the causes of loss on water control condition and IoT message delays.

[12]. A big data platform and open IoT is presented here to accelerate changes in rural Africa. The technology is not limited only for the rural cases. It is designed for any application of IoT. This platform allows applications of IoT to be coupled with big data capacities. Besides, the platform can adapt to the constraints and specific requirements of African users. This paper gives an overview of big data platform and IoT, details its technical aspects and finally introduce three cases to prove the platform architecture validity.

[13]. The proposed paper focuses mainly on monitoring of water quality parameters constantly from time to time, in order to take preventive measures. The architecture consists of four modules (1). Power module which comprises of

charge controller, DC-DC converter, battery and solar panel. (2). Sensor module consists of sensors like ammonia, temperature, nitrate, dissolved oxygen, pH and carbonates. (3). Microcontroller module has a processor. Raspberry Pi3 is used as a computer due to its low cost application. (4). Output module requires the mobile of an aquafarmer which is taken as an output module in which an application has been installed that mainly consists of two buttons i.e., get data and history buttons.

[14]. The system implements an embedded system for monitoring and controlling environmental parameters with the help of sensors and actuators. Different types of sensors are integrated in the cultivation field all of which are connected to a common microcontroller board which is built on a Arduino Uno board. The real time sensor values which are monitored using microcontroller are shared to a data logging system which is implemented on a Raspberry Pi. The SD card of Raspberry Pi are logged with real time sensor values. Actuators like aerator and pump will be turned off and on automatically with the threshold value of different parameters by the Raspberry Pi. Using IoT the farmers can also control aerators and pumps. Information can be collected from a weather forecasting website based on real time temperature and humidity and if any abnormality is observed in environmental parameters the system will notify an alert SMS through a web service app called Twilio to the farmer. The development of such system will increase the yield in paddy field which helps the farmer to harvest in a better environmental condition.

[15]. The monitoring of water quality is designed and implemented using Raspberry pi3 and this device monitors the quality of water for aquaculture which uses oxygenation in the form of micro bubble. Some water quality parameters that are used in the monitoring are temperature, acidity (pH) and dissolved oxygen (DO). Data processing device use python program and Raspberry Pi3 to create the program viewer and acquisition program of a sensor. The test is performed in two stages: (1). Device monitoring performance (2). Sensors reading stability. The testing device monitoring is conducted in aquariums using microbubble aeration and testing sensor ability is conducted in the laboratory. Micro bubble aeration is used to implement eel aquaculture. The features used in this device monitoring can function smoothly and properly.

[16]. The farming of Atlantic salmon in open area throws unique challenge to structures, equipment and operation due to severe wave, irregular wind, sheer remoteness and current conditions. Six target areas of technological innovations will enable reliable and safe exposed operations of aquaculture. (1). Monitoring and operational decision support. (2). Vessel design for exposed operations. (3). Fish behaviour and welfare. (4). Autonomous systems and technologies for remote operations. (5). Structures for locations exposed. (6). Risk and safety management.

[17]. In this paper artificial neural network is used to develop a model for the growing status of aquaculture. Many water quality parameters are affected by growing state model, which is developed in this work and by using artificial neural network technology that can solve congestion problem in an expert system. This method is proven effective from the experimental results obtained.

3. HARDWARE

Temperature Sensor

The most important physical analysis of water quality is measurement of temperature. It effects the quantity of oxygen dissolved in the water, the chemical and biological properties of water. It can be easily interfaced with Arduino using one-wire protocol. Probe type sensor is perfect for sensing temperature of water in wet conditions. The temperature range is in between -55°C to 125°C.

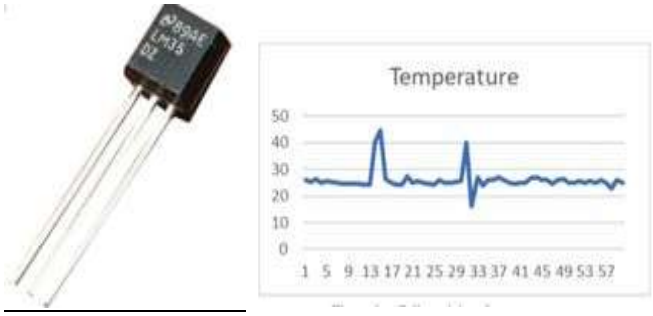

Figure 1. Temperature sensor and its collected data

pH sensor

pH measures the acidity or alkalinity of any solution. It ranges between 0-14 where the pH for pure water is 7. A pH meter consists of hydrogen ion activity of solutions which shows whether it is acidic or alkaline.

$$pH = - \log(H+)$$

A pH sensor is called a pH probe which combines plastic shell rechargeable acidity meter electrode. It is round surfaced, refillable and appropriate for labs, schools where periodic pH calculation is done.

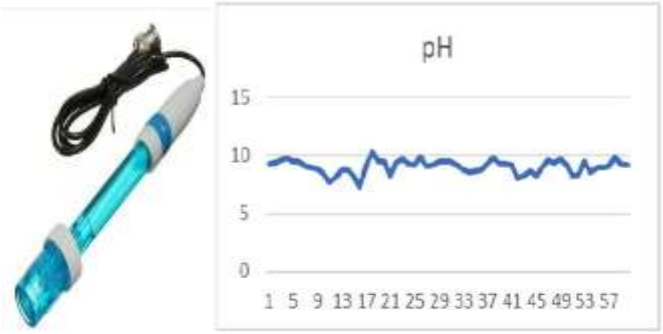

Figure 2. pH sensor and its collected data

Turbidity sensor

A turbidity is the measure of quality of water which is based on total suspended solids (TSS) and clarity. It also indicates the presence of pathogens and bacteria levels. Monitoring of water quality is done constantly to ensure that it does not exceed safe levels. The light scattered by sold particles which are small in water is measured by turbidity sensor. With the increase in solid particles turbidity level of water is increased.

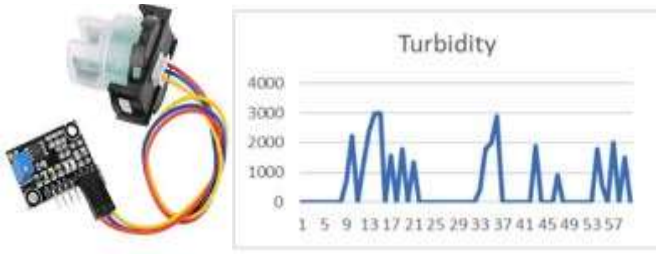

Figure 3. Turbidity sensor and its collected data

Conductivity sensor

The important aspect f water chemistry is carbonate hardness (KH) which represents the pH buffering capacity. Buffering capacity is higher for harder water. The ideal KH medium is 4– 6KH. The accuracy of water is more with the KH range 4(4 KH) which is suggested to monitor the carbon di oxide level. Electrical conductivity is related roughly to general

SL. No	AUTHOR	YEAR	TECHNIQUE	ADVANTAGES
1.	SAJAL SAHA, RAKI BUL HASAN RAJIB, SUMAIYA KABIR	2018	It uses Raspberry pi, Arduino, various sensors, android application and smartphone camera for water quality monitoring.	It finds a way to give a better result for low cost than any other available systems.
2.	MONIRA MUKTA, SAMIA ISLAM, SURAJIT DAS BARMAN, AHMED WASIF REZA	2019	The proposed system can analyze successfully water parameters using fast forest binary classifier to classify whether the test water samples is fit for drinking.	Fast forest binary classifier shows better performance to validate systems effectiveness and accuracy in predicting the quality of water.
3.	T ABINAYA, J ISHWARYA, M MAHESHWARI,	2019	This system is used for monitoring and controlling the parameters of water for aquaculture. It can also detect and control the parameters such as foul smell, dissolved oxygen, pH value, ammonia and water level.	The values measured are sent to aqua farmer through short messages to inform the present situation in the farm.
4.	SIMITHA K M, SUBODH RAJ M S	2019	It uses IoT and wireless sensor networks which gives real time data of the quality of water so that water resources can be used effectively.	The system was successful in monitoring turbidity, DO, pH, and temperature. Using LoRa receiver the water quality parameter values could be sent from LoRa sender from several kilometers away.
5.	FAHIM REDWAN, SHADMAN RAFID, AHANAF HOSSAIN ABRAR, BISHWAJIT BANIK PATHIK	2019	The system is designed using Arduino Mega 2560 and different water qualitative parameters namely	It is comparatively faster in continuous transmission of results

			arsenic level, pH level, salinity, turbidity, etc. can be measured. The collected data from sensors is visualized and displayed on LCD and demonstrated using Thingspeak which is a cloud server.	so that the monitoring gets simpler.
6.	I S AKILA, KARTHIKEYAN P, HARIHARAN M V, HARIKRISHNAN J	2018	It consists of electrical, mechanical and communication components which are integrated with IoT.	The prototype designed is well functioned with all features without any malfunction or disorder.
7.	CHARLOTTE DUPONT, AMOS WUSSAH, SADOUANOUAN MALO, OUSMANE THIARE, FAROKH NIASS, CONGDUC PHAM, SAMUEL DUPONT	2018	A low-cost and connected water monitoring system measuring DO, temperature and pH in a fish farm is developed	The improvements made from the corresponding collected data leads to a significant development in the business
8.	YUHWAN KIM, NAMGU LEE, BYEONGJUN KIM, KYOOJAE SHIN	2018	Water quality parameters such as oxygen , pH and so on are controlled by microcontroller which is supported by MQTT communication protocol on the website application or mobile app.	It reduces human effort for the fish farming and unmanned and it is applied to smart fish farm aquariums for future purpose.
9.	NIKHIL KUMAR KODITALA, PURNENDU SHEKAR PANDEY	2018	This system uses technologies emerging such as cloud computing, IoT and machine learning.	It developed economical and practical solution to monitor water quality especially in rural areas without any human mediation.
10.	MUHAMMAD NISWAR, SONNY WAINALANG, AMIL A IILAM, ZAHIR ZAINUDDIN, YUSHINTA FUJAYA, ZAENAB MUSLIMIN, ADY WAHYUDI PAUNDU, SHIGERU KASHIHARA, DOUDOU FALL	2018	It uses LoRa based wireless sensor network and a MQTT lightweight protocol. It also comprises of raspberry pi, sensor node and mobile client.	In this system low cost sensors, small embedded systems and LoRa wireless interface is developed.
11.	YI-BING LIN, HUNG-CHUN TSENG	2018	Analytic model, simulation and measurement experiments to check the effects of message delays and loss on water condition using IoT is developed.	For monitoring and controlling a web based application is used which is free.
12.	CORENTIN DUPONT, MEHDI SHEIKHALISHAHI, ABDUR RAHIM BISWAS, TOMAS BURES	2017	An open IoT and big data platform and its architecture is used.	Open IoT platform were used to get all services needed for simulation and implementation.
13.	K RAGHU SITA RAMA RAJU, G HARISH KUMAR VARMA	2017	Water quality is a crucial factor for cultivating aquatic organisms which mainly depends on dissolved oxygen, temperature, salt, nitrates, etc. and the quality must be monitored continuously. So the data sensed is transferred mobile of aqua farmer through cloud.	It helps to increase the GDP of the nation and foreign trade. The collected data can be analyzed using big data and the measures can be taken before the quality of water reaches the maximum range.

14.	SNEHA P S, RAKESH V S	2017	Different sensors are connected to a common microcontroller board which is built on Arduino Uno. The real time data are shared to a logging system which is implemented on a Raspberry Pi based on single board computer.	Monitoring controlling the parameters of environment of a fish farm using IoT and embedded system is a low cost flexible to implement and ease to use electronic system.
15.	TAUFIK IBNU SALIM, TRIYA HAIYUNNISA, HILMAN SYAEFUL ALM	2016	The quality of water is monitored using Raspberry pi3. Some water quality parameters that are used to monitor are temperature, pH and DO. Data processing is done using Raspberry pi3 and python program.	The program viewer can run manually to see the historical and real time data. It also monitors the effect of micro bubble aeration.
16.	HANS V BJELLAND, MARTIN FORE, PAL LADER, DAVID KRISTIANSEN	2015	An autonomous system for monitoring remote locations is proposed in this paper.	The solutions that enable the use of exposed and remote sites will contribute to Norwegian salmon industry and global production of aquaculture by improving proper safety and cost efficiency.
17.	CHANGHUI DENG, YANPING GAO, JUN GU, XINYING MIAO, SONGSONG LI	2010	Artificial neural technology is used for aquaculture organisms in this project.	The experiment shows the method proposed is very effective and important instructive significance in practice.

hardness (GH) and TDS. The correct EC value is required to keep the fish healthy. Pollutants in the water increases the EC value which indicates changes in condition of water. The EC value can be maintained by reducing pollutants in water. If the EC value is too high osmotic water can be used to dilute it. If EC value is too low water must be hardened by using calcium carbonate solutions or commercial salt mixes.

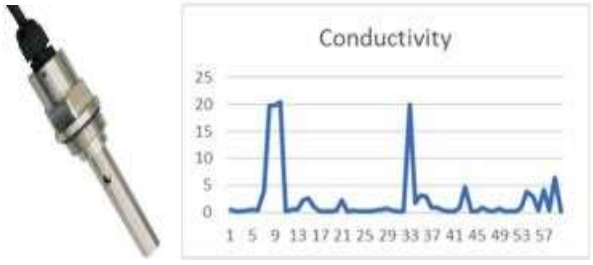

Figure 4. Conductivity sensor and its collected data

4. SOFTWARE

Arduino

Arduino is a open source platform which designs and manufactures single board microcontrollers and microcontroller kits for developing digital devices. Arduino board designs various types of controllers and microprocessors. The boards are integrated with digital and analog input or output pins that may be interfaced on bread boards and other circuits. The boards uses serial communications interface which includes universal serial bus (USB) on some models. It can be programmed using C and C++ languages. Based on processing language project integrated development environment (IDE) is used. It aims to provide low cost and easy way for novices

Raspberry Pi

Raspberry pi is a series of single board computers which are compact. It does not include cases or peripherals. The speed ranges from 700MHz to 1.4GHz. the onboard memory ranges from 256mb to 1gb. SD cards in microSDHC is used to store program memory and operating system. It consists of five

USB ports. The common protocols such as I²C is supported using lower GPIO pins.

5. CONCLUSION

Maintaining a sustained water quality is necessary, polluted water is unfit for usage and it directly affects habitat. The design and implementation part can be done using various methods.. Internet and Wi-Fi can be combined for convenience to give a better result for low cost than any other system. Neural network based system can be developed for aquaculture organisms. Using Raspberry Pi3 design and implementation can be carried out, in which monitoring can be done on a laboratory scale. The temperature sensor is dipped in a shrimp farm were the readings of temperature and dissolved oxygen is acquired. When compared with the atmospheric temperature, the temperature level during day time is decreased and vice versa. Fish feeding can be done through automate and manual control mechanism.

6. FUTURE SCOPE

With the advancement in IoT technology chemical parameters of water can be detected and real time monitoring and controlling can be done. Using IoT and WSN Smart City project can be done which includes street light energy saving system and air quality monitoring. Purification and filtering of contaminated water can be done, soil quality can be determined. A base station can be established in order to monitor the quality in multiple areas. The counting of fishes can be done along with its health monitoring. With addition of some more sensors the physical and chemical parameters can be determined, that effects the quality of water. Energy consumption of IoT devices can be determined. The labor cost and energy consumption can be reduced by designing automatic aqua system

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