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IoT Based Smart Fish Farming Aquaculture Monitoring System

Sohail Karim[1*], Israr Hussain[2], Aamir Hussain[3], Kamran Hassan[4] and Semab Iqbal[5]
[1]Researcher, Department of Computer Science, MNS University of Agriculture, Multan, (Punjab), Pakistan.
[2]Lecturer, Department of Computer Science, MNS University of Agriculture, Multan, (Punjab), Pakistan.
[3]Assistant Professor, Department of Computer Science, MNS University of Agriculture, Multan, (Punjab), Pakistan.
[4]Researcher, Department of Computer Science, MNS University of Agriculture, Multan, (Punjab), Pakistan.
[5]Researcher, Department of Computer Science, MNS University of Agriculture, Multan, (Punjab), Pakistan.

(Corresponding author: Sohail Karim)*
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ABSTRACT: As current human Population is 7.7 billion and growing day by day hence food demand is also increasing accordingly. Fish is a rich source of vitamins, minerals, protein, nutrients and micronutrients. It is an important part of consumer's diet especially in poor and underdeveloped countries. It is a big challenge for farmer to fulfill market demand with healthy sea food. Aquaculture is a tool to fill gap between of sea food supply and demand. Use of controlled environment production of aquaculture has been increased to a significant level but losses huge due to manual equipment and management failure. Farmers need real time and accurate information to monitor and maximize production potential. Farmers are using traditional techniques and procedures for the aquaculture. By following traditional approach, farmer measure and monitors the water quality, water level, oxygen level and stress level of the aquaculture manually. In this study, we proposed an Internet of Things (IoT) based smart aquaculture model that will measure water quality (pH, water level, temperature, turbidity and motion detection of fish) for aquaculture. In this work uses low cost and short range wireless sensors network module to monitor and control aquaculture in real-time. Water recycling mechanism also proposed to reduce the amount of aquatic waste materials. By using this system parameters of water are monitored continuously using a serial port which reduces internet consumption, transmitted data regularly with small latency with error free **and ensures survival of aquatic life also ensures the quality of growth and increases the economic benefits of aquaculture. The system also detects the movements of fish in the pond.**

Keywords: Aquaculture, Internet of things (IoT), PH, Turbidity, Water quality Monitoring,

Abbreviations: IoT, internet of things; GDP, gross domestic product; PH, potential of hydrogen; DO, Dissolved Oxygen.

I. INTRODUCTION

Aquaculture also called aqua-farming, breeding, raising, harvesting of fish, seaweed, algae and many other organisms. It is also defined as breeding species which develop in the aquatic environment under controlled conditions [1]. Aquaculture is one of most reliable and low environment impact process producing high quality protein for humans. This process is more efficient than other forms of agriculture because of higher food convergence. Aquaculture has become famous all over the world [2]. Asia contributes 40.1 percent of total world fish production, aquaculture production, which is 88.5 percent of world aquaculture production [3]. In South Asia especially in the last 15 years, the performance of aquaculture is increasing more rapidly. Of the seven countries in Southeast Asia, Indonesia, Malaysia, Myanmar, the Philippines, Cambodia, Malaysia, Thailand, and Viet Nam, all but in terms of the volume of aquaculture, Cambodia with its productive inland fisheries rank among the top according to UNFAO 2007.

In Pakistan currently fisheries contribute only 0.4 per cent to the gross domestic product (GDP) and the sector almost 350 million$ of exports appears to be at standstill. As compare to other South Asian countries Pakistan is failing to realize its potential for example India contributes nearly 1.70 [4] of the GDP, Bangladesh contributes nearly 3.69 percent of the GDP. Bangladesh fishes sector have spent 54 percent of all investments in fisheries sector in development of aquaculture. In Pakistan commercial aquaculture technology is lagging region compared to other areas such as agriculture. Farmer faces a lot of problems like water rescores, manual testing of water, sudden climate change, no government interest etc. Unlike daily monitoring of aquaculture behavior and health of thousand individual manually testing is very difficult [5]. Some other problems like inappropriate management technique, water quality, improper record keeping, poor site selection. Traditional water quality monitoring cannot change the dynamic of aquaculture water quality monitoring and also achieved a fixed point monitoring [6].

The aqua farmer presently in Pakistan depend on manual testing for water parameters. This leads in increase the death rate of fish, decrease the growth rate of the fish, and one of major drawback is more time consumption. Fish pond operators face the challenge of constant monitoring of the water and water changing in such a way that quality is compromised.

The model proposed in this work will assist the fish farmers in monitoring fish ponds using IoT. Integrating sensor and internet technology in combination with a user-friendly interaction interface smartphone application, desktop application, and web services to provide real-time monitoring of fish ponds; system database contributes significantly to reducing the risk of losses and improving efficiency. GSM modem is also used which reduces internet consumption. Internet is the main issue while former in the field area. Internet is used when former open their Android application or web application otherwise GSM modem send the message when parameters crosses the threshold range. Proposed system using water filtration plant to improve the water quality. By using the proposed system, we will increase the productivity of the fish, reduce the cost, minimize loss and increase the survival of aquatic life. There are vast opportunities to improve the fish farming.

Water quality is a key to success and also has direct impact on production of fish yield, among all farms of aquaculture for all species most important parameters are Temperature, PH, dissolved oxygen, turbidity [7]. Water quality is an important factor for aquaculture and drinking water treatment plants and other related industries because polluted water not only claim losses of aquatic products but also face significant human health threats [8]. These parameters (temperature, turbidity, PH, Dissolved oxygen) are most important for aquatic life and each fish required suitable growth environment. To achieve the best quality production, we must use the IoT (i.e. sensors, controlling system, telecommunication system, mobile devices and solar system).

In this paper, we discuss multiple sections as a first step, introduction to the topic of aquaculture, what problems exist in this field, how to solve them, and the benefits. In which we discuss a range of works on aquaculture systems and what are the opportunity in this field, and which of these will be addressed in this work. The Methodology chapter presents the proposed system and a detailed description of the hardware or software. The features, some photographs and the results obtained using the system are shown in Experimental Results. We're reflecting on this job in conclusion. For this task, we suggest the next phases of future work and present the advantages.

II. LITERATURE REVIEW

In the start Conventional methods were adopted for monitoring the water quality, the samples of the water would be taken from the water and sent to the chemical laboratory for analyzing hazardous material. The drawback in the system is all the processing were being executed manually like measurements, maintenance and controlling of the system etc. On the other hand, manual system was time consuming. Some of the previous studies discussed the water monitoring models like culture models and forecasting models and integrated models [9], [10] but these systems had not ability of online monitoring, real time communication data collection. So we can say that these models are not good for fish monitoring but, IoT is one of the fast-growing technologies of recent decades. The purpose of IoT is identifying, monitoring, tracking, locating the things [11] telecommunication and interconnectivity between devices. The invention of new sensors technologies, wireless telecommunication technology, data transmission technology, many devices are made for real time monitoring in remote areas [12].

The growth of aquatic life is effected by the water quality variation which have been discussed in many studies [2, 4,13]. Mostly studies used a lot of sensors [4] but management of these sensors are costly but most papers concentrate on few forms of sensors such as PH, DO, Temperature, Turbidity, water level, [3,14,15] and suggested the solutions of the problems because all parameters are not nursery to monitor these parameters (PH, DO, Temperature, Turbidity, water level) are dependent on each other if one parameter unstable cause of other variable unstable [16] that why we are choosing these parameters.

Proposed architecture uses different sensors (Temperature, PH water level, Turbidity, Motion detection). These sensors are configured with Arduino Uno for sensing and observing measurements in aquatic environment. The previous proposed approaches by authors used cloud database [17] for the storage of output data which makes the architecture costly by maximum consumption of internet, to overcome this consumption Computer system acts like a server host to compute and manage the output values generated through sensors are easily managed and the necessary data could be retrieved by user by consuming minimum cost of internet. Local database helps the former for analytics and take pro-active measures when its needed. Most of models using focus on sending the sensor data but in our model we also provide proper solution if parameter crosses the limits that listed in below Table 1 and also discuss the factor that effect the fish growth. Our main focus is reducing internet consumption. In the field areas internet is main problem we reducing internet consumption also using GSM modem for sending the message if internet is not available, and also using Android application, desktop application for the formers.

In worldwide water quality decline has become a serious issue. Fresh water recourses consumption in future become a great significance and fundamental issue [18] [19]. The fisheries aquaculture water and its life has a direct correlation. When quality of water is too poor then water directly effects the health of the fish which results loss of production. Somehow different parameters are used to measure water quality for example ammonia, turbidity, corban dioxide, nitrite, nitrite concentrate but important are Temperature, pH, and dissolved oxygen turbidity and water level.

III. PARAMETERS

A. Physical Water Quality Parameters of Aquaculture

Water structure varies with the climate patterns but how the water is being used. The goal of good management of the fish culture is to control this structure in order to produce the best results. Farmers need to recognize the physical elements (temperature, turbidity, water level) and chemical elements (PH, Dissolved oxygen) which contributes to better and poor water quality.

Temperature. Temperature is the most important element and has a strong influence on biological and chemical processes. The values of chemical and biological reaction increased for each 10℃ increases in temperature. This is a fact that fish are cold blooded animals that adapt their temperature depending on the weather around them. Temperature is based on the fish species but temperature is controlled and maintain according to right range. Higher temperature accelerates the metabolism of the fish feeding and respiration increases, and there is a general also movement increases because temperature vary according to depth of water. If the temperature increases the need of dissolved oxygen demanded [20].

Turbidity. The second physical element is turbidity. The color of water suggests that what kind of turbidity is. If the water color is clear that means low biological output so fish do not live well in it because it is not fertile enough. If the color is green, it's because of algae and if the color is brown, it's because of clay. Muddy water is also not good for fish, because fish can have gills that blocked the clay particles causing the fish to die. Greenish water indicates that over generation of planktons [16]. The presence of these suspended particles in varying amounts is responsible for water turbidity.

Water Level. The third one is water level. The variation in fish pond water levels affect the behavior of the fish. Fish have a tendency of moving to specific areas of the pond where they can feed and relax. When the water level for the area shrinks, then is likely to cause competition for survival among the fish.

B. Chemical Water Quality Components Of Aquaculture

Chemical aspects refer to the following parameters: pH, alkalinity, hardness, dissolved gases (Oxygen, Ammonia, Nitrogen, Carbon dioxide).

PH. There is another parameter for quality check of water is pH for the fish survival is between 6.5–8.5. Fish growth rate is slowing down and also stressed in water if pH is less than 6.5 than death of the fish is almost confirmed at pH 4.0 and greater than 11.0. PH is also called hydrogen potential, Night time respiration can cause the oxygen depletion for the fish. PH voicing whether the water is acidic or fundamental in response. During photosynthesis, the marine plant and phytoplankton remove carbon dioxide from the water; The pH of the water rises during the day and decreases during the night. In a day time, low heap alkalinity has a PH level of 6 to 8 but in the night time development of phytoplankton development is increases the PH level is also increases up to 10 or more. PH changes in pond water affected through carbon dioxide and ions [16].

Dissolved Oxygen. DO is the prime concern for water quality and that determines the growth health size of the fish population [21]. Dissolved oxygen should be in between 5-12 ppm. Oxygen comes from two resources first comes from photosynthesis and second diffusion from the air. At this harmful level, total concentrations of dissolved gas in water should not exceed 110 per cent. Oxygen problem occur when consumption of respiration exceeds as a result fish feeding increased. Increasing water temperatures can also contribute to a decrease in the DO content, as it cannot retain O_2. But dissolved oxygen (DO) level is crosses the limit, however, it can cause a disease of the gas bubble which can kill fish. If too small, it will allow bacteria to infect fish easily. The Air temperature also influences the normal DO variations. The DO can be under 3 mg in the morning and over 15 mg in the afternoon with L^{-1}. In order to encourage success in aquaculture, the DO quality must be preserved and stable. DO in water from two major sources: the environment and the water from plants. The principal source of oxygen is microscopic algae (phytoplankton) or submerged plants [3].

Table 1: Describes the different water parameters ranges and its solutions.

Parameters	Range	Solution (if parameters cross the range)
PH	6.5 ~ 8.5	(Caco3) calcium carbonate 0.05/letter calcium carbonate 0.05/letter calcium carbonate 0.05/letter calcium
Temperature	5C-35C	Pumping fresh water into the
Turbidity	Less than 25mg/l (TSS)	Change the water/Recycle the water
Motion detection	//	Detect the motion of fish

IV. MATERIAL AND METHOD

A. Required Hardware and Software

Sensors. Arduino analog pH sensor (SEN0161) referred to in Fig. 1. is used to measure the pH of the water. PH-sensor is specifically suited for Arduino series and features easy communication and integrated functions. To attach the sensor to Arduino it needs a BNC connector. This PH sensor has a range of 0-14. It is ±0.1 PH accurate at a standard temperature of 25-30℃ and running temperature range from 0 to 60 ℃ The water can only be fed to a few sections of the sensor. Reliability of the pH sensor will last a half of year if the water is clear, and a month for high turbidity water.

Fig. 1. PH sensor.

Proposed system also used temperature sensor DS182B0. We have used Arduino DS18B20 which is a water resistant temperature sensor displayed in the Fig. 2. It works within ±0.5 ℃, from-10 ℃ to +100 ℃.

Fig. 2. Temperature sensor.

We have also used turbidity sensor, for measuring turbidity rate or opacity, the Arduino gravity turbidity sensor senses water quality. The sensor uses measuring light transmission and the dissipation rate to distinguish dissolved particles in water, that differs in water with total suspended solids (TSS) (displayed in the Fig. 3. A turbidity monitor responds by transmitting a laser rays into the water for analysis. Any suspended particles would then disperse the light. The sum of the reflected light is used to identify particle density within the water.

Fig. 3. Turbidity sensor.

Proposed model also used water level sensor. This sensor contains SONAR to measure the distance of an object, just as the bats do. This guarantees high non-contact detection of the range with great accuracy and accurate readings from 2 cm to 400 cm or 1 to 13 feet in an easy to use kit. The water is measured using a water level sensor Fig. 4. This sensor functions by transmitting sound waves at frequencies that are too high for detection by humans. They also wait to see the sound reflected backwards and measure distance depending on the correct time. This is closely related to whether the radar measures the time it would take for an object to return to a radio wave. The module sensing the water level uses an ultrasonic emitting transmitter to ultrasonic receiver. The tone of it wave reflection time is translated to depth of the surface.

Fig. 4. Water level sensor.

The PIR sensor used for motion detection, itself includes two slots, each of which can be made of a special IR-sensitive material Fig. 5. The lens used here doesn't really too much, so we see that the two slots can 'see' some distance past (basically the sensitivity of the sensor). Both slots detect the same amount of IR, the number of ambient radiation from either the room, walls, or outside the sensor while free.

Fig. 5. Pir sensor.

In this model use liquid pump model number (cjwp40-a1) as shown in Fig. 6. This water pump uses centrifugal force to move fluid outwards as it turns, allowing the fluid to be constantly pulled from the center. This pump moves fluids (liquids or gases), through mechanical action, usually converted from electrical energy to hydraulic energy. Its voltage range is DC12v-24v and current is 50mA. Its water flow is 1.5L/ min.

Fig. 6. Water pump.

Lithium-ion (Li-ion) batteries means that most Lithium batteries are not rechargeable but Li-ion batteries are rechargeable. Electrodes of a lithium-ion battery are lightweight lithium and carbon. Lithium is also a reactive element that allows it to store a great deal of energy in its atomic bonds. That converts into a very high power density for lithium-ion batteries Lithium-ion battery shows in Fig. 7.

Fig. 7. Lithium-ion battery.

Aquaculture water. Fish pond in which the fish are grown. It is composed of different sensors which send to microcontroller.

Microcontroller: Arduino Uno Fig. 8. used as Microcontroller. Arduino is a microcontroller kit which is free software, focused on the Atmega328P Microcontroller board created by Arduino.cc. The board has combination of 14 digital and 6 analog input / output pins that can communicate with different boards and other circuits, 16 MHz ceramic resonator and also reset button and forwards the data to the system using serial port and save into system data Base.

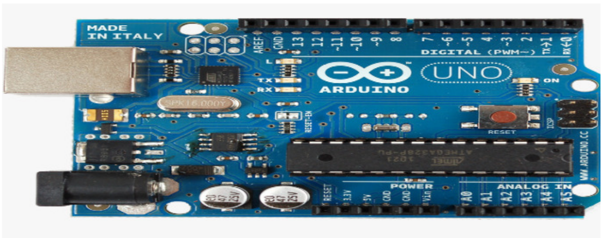

Fig. 8. Microcontroller.

Sever. The server analyzes the data received and acts predefined conditions.
Applications. The Mobile App, desktop App, and web provides a means of viewing data on the different applications Server and provides decision making and interface to the user.
Actuators. The actuators act upon the aquaculture environment based on instructions received from the IoT system.
The proposed model primarily focuses on the continuous monitoring of parameters of water quality from time to time, to take inhibitory measures for avoiding the actual damages in inhospitable environment. Proposed architecture uses different sensors (Temperature, PH water level, Turbidity, Motion detection). These sensors are configured with Arduino Uno for sensing and observing measurements in aquatic environment. Arduino Uno a low cost small computer board used as controller hub comprises with various analog and digital pins and operated with Arduino IDE software for interaction with computer system with controller using serial port. The previous proposed approaches by authors used cloud database for the storage of output data which makes the architecture costly by maximum consumption of internet, to overcome this consumption Computer system acts like a server host to compute and manage the output values generated through sensors are easily managed and the necessary data could be retrieved by user by consuming minimum cost of internet. This model provides us facility to avoid periodic computation of data and internet cost of uploading. The proposed desktop application provides directly view to analyze the measurements and daily basis reports. For remote monitoring android application and web based application are proposed with interactive GUI (Graphic User Interface) provides services for a user to monitor the aquatic field. Motor pump and air pump is also working automatically using actuator relays. Proposed architecture shown in Fig. 9. embedded with GSM modem in provide services as system alert which sends the notification to farmer if the aquatic pond is in critical condition. Moreover, advantage of GSM is when farmer does not have internet then this alert notification helps in emergency condition with feasible solution shown in Fig.10. Water filtration plant is coming in to play when turbidity level is high and worked until when level of turbidity comes into normal range and saves the water also. Proposed system Block diagram is shown in Fig.11.

Block Diagram proposed System

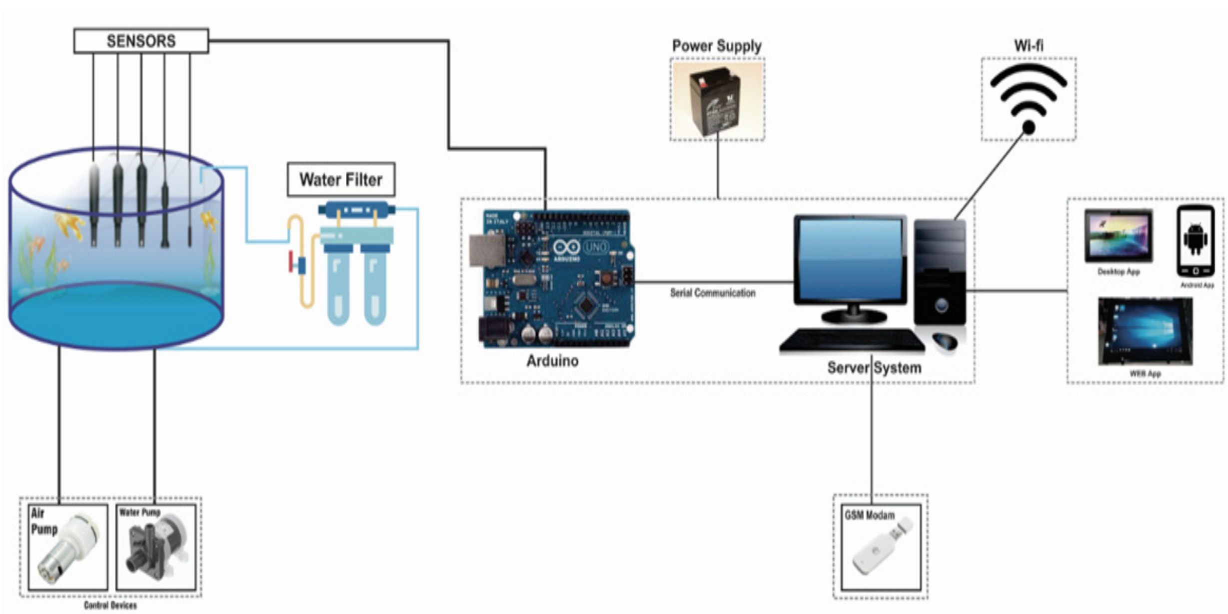

Fig. 9. Proposed System.

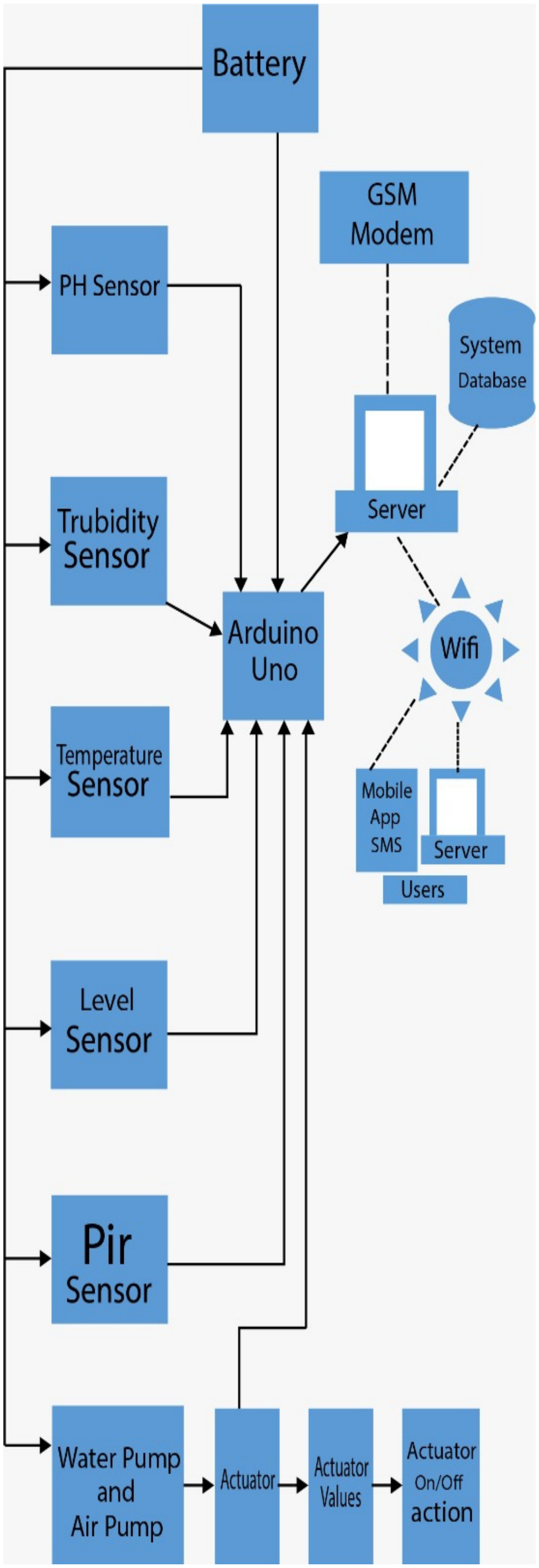

Fig. 10. Block Diagram.

Flow chart

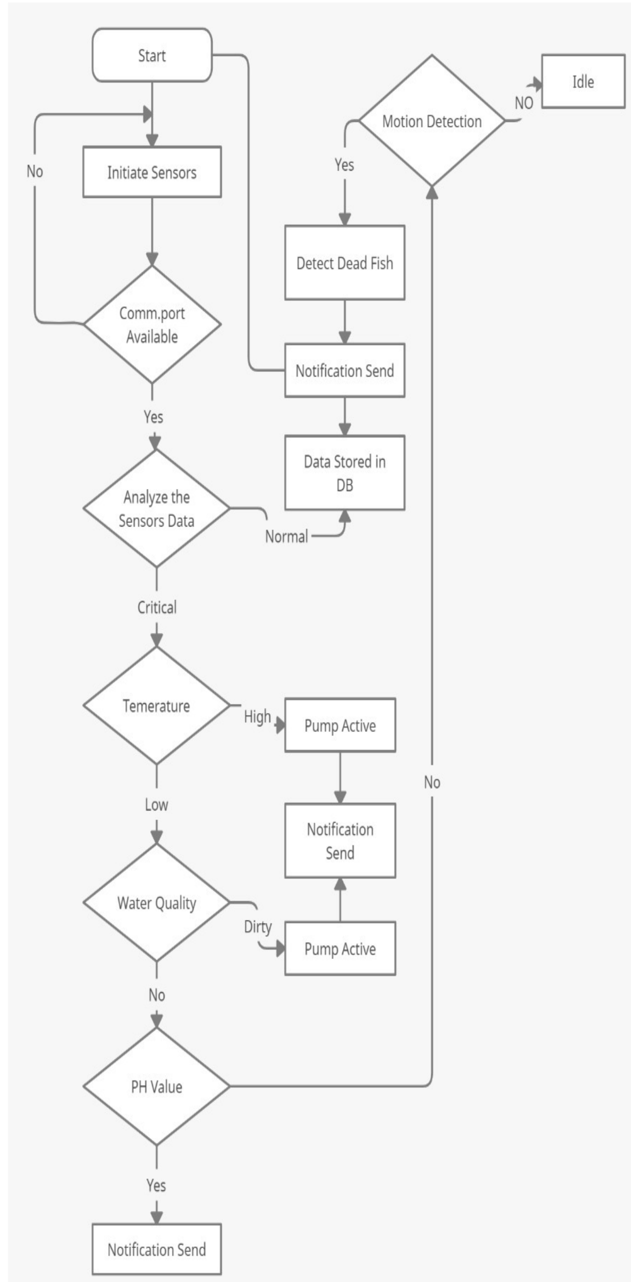

Fig. 11. Flow chart for the proposed system.

V. RESULTS AND DISCUSSION

As already discuss that farmer using traditional method and techniques and also use the forecasting models to measures the water quality parameters. In our model we reduce internet consumption and also creating a cost effective model and cannot use cloud database because of internet consumption but some of studies uses a cloud database [22]. Some of the models are cost efficient [23] but it cannot fulfill the demand of water quality because system use less amount of sensor. The main objective of this system is to provide real time monitoring using GSM, android app, desktop application. In this system using a serial port, the advantage of serial port is transmitted data regularly with small latency and also error free. The proposed model has been applied in an aqua pond and the tests were obtained from different sensors for 24 hours. The following are the plots collected for varying quality of water parameters about time.

A. Temperature sensor graph

Fig. 12. illustrates a type of test sample of historical temperature data described in a chart. During a certain period, the user is able to know the trend of the temperature and this would help to investigate any incidences that may arise due to fluctuations in the temperature. When temperature is crosses the threshold range (35c) water pump in on until the temperature back to its normal condition.

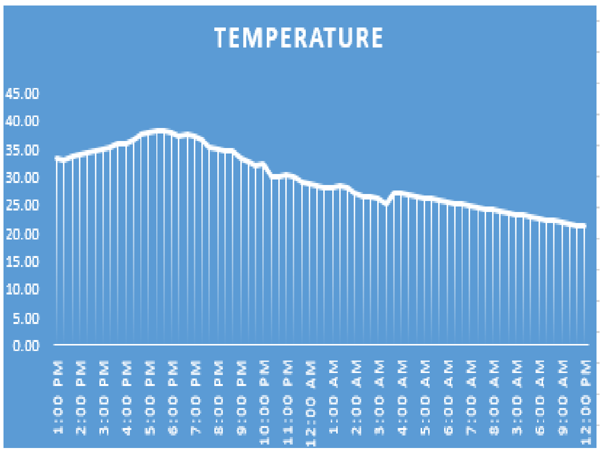

Fig. 12. Temperature graph.

B. PH Sensors Graph

Effects of pH sensor measurements taken once every 40 minutes when the water pH value is downstairs the minimum limit, the aerator must be activated and calcium carbonate 0.05 / letter (Caco3) used to raise the oxygen content of water until the pH level returns to normal. When the PH level is higher than the acceptable limit, the machine should Switch the aerator off so pH back to work (Fig. 13).

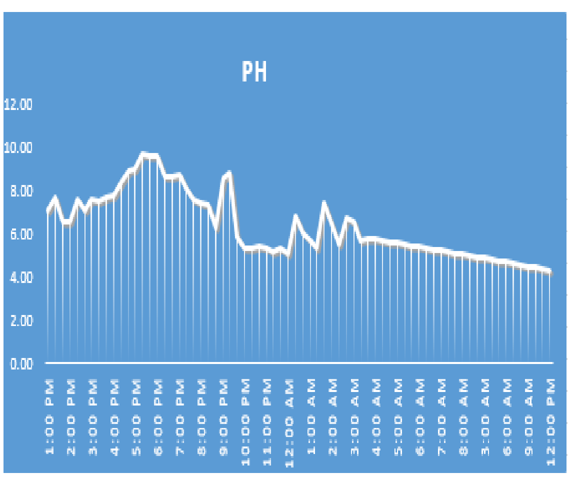

Fig. 13. PH graph.

C. Turbidity sensor graph

Fig.14. shows the Turbidity sensor tests, in which the different number of times a fish is fed, affect water purity. Four times feeding is usual, so Tilapia is rapidly increasing. Turbidity can be seen to increase sharply at 17.00, 21.00, 12.00 and 16.00 as this time is the feeding period for the fish, this would impact the quality of the water, such that the fish feces also increases. Water as a certain amount of turbidity affects fishery production positively, as turbidity reduces the light intensity go in for the water. Where water drainage is greater than 50 NTU, it is necessary to drain the pool water 40-50%, is on and add new water, add dolomite and probiotics as well, water pump is on and water recycling mechanism comes in to play until water is less than 25mg/l (TSS).

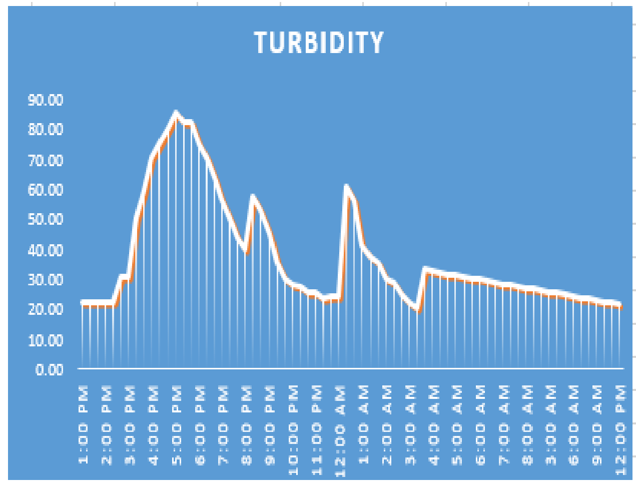

Fig. 14. Turbidity graph.

Fig. 16. android application and Figure 17 desktop Application shows the status of water quality parameters when requested by the farmer.

Fig. 15. Android application.

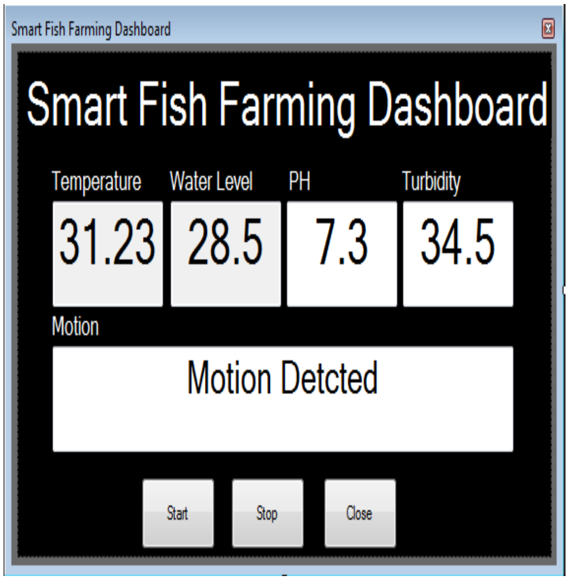

Fig.16. Desktop application.

Fig. 17. shows the alert message by the GSM when the parameters cross the threshold range and also shows the prototype in Fig. 18.

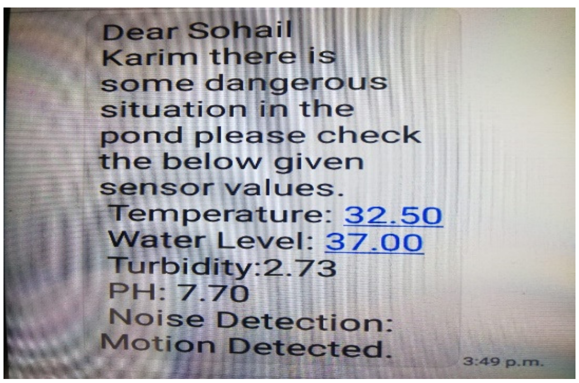

Fig. 17. Alert Message.

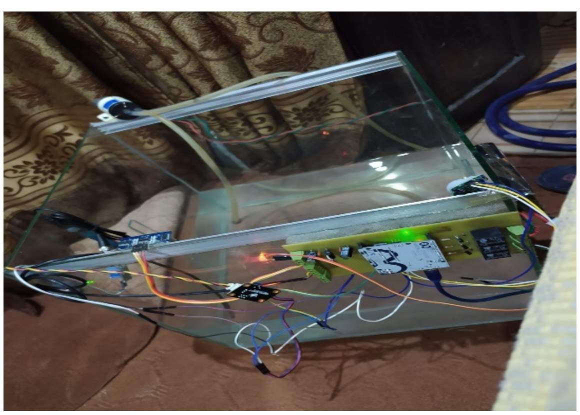

Fig. 18. Prototype.

VI. CONCLUSION

This work represents the design and implementation of aquaculture monitoring system. IOT technology is applied while developing this system. It is scalable, mobile and accurate. This will help to increase the aquaculture production to a significant level. Further there is no need for manual testing, reduction of losses saves the labour cost, and also prevention of critical condition. It is difficult to manage the fish farms with traditional and non-technical methods. The developed model provides the technological solution which would monitor the quality of the water in real time.

VII. FUTURE SCOPE

In near future we are expecting to use upgraded sensors and collection of more data that can be used for big data and analytics or to develop some AI algorithms for process optimization.

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Conflict of Interest: There is no conflict of interest.

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