SMART MEASUREMENT OF WATER QUALITY PARAMETERS AND MONITORING FISH HEALTH

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A thesis submitted to the Department of EEE in partial fulfillment of the requirements for the degree of
B.Sc. in Electrical & Electronic Engineering

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Approval

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Ethics statement

We, hereby, declare that this thesis is based on findings we obtained. All of the data and information are a reflection of our practical work. Other researchers' work has been properly acknowledged through the use of their materials. Nothing in this paper has anything to do with any project or publication. We did the entire project on our own, and this task was finished with the help of our advisor. Each member of this group has contributed in their own unique way. We fully acknowledge that this project is a reflection of our own thesis study in order for it to have its own distinct characteristics. This thesis has not been submitted for evaluation anywhere else, in whole or in part.

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Abstract

Every aspect of our daily lives is becoming more reliant on technology as it advances. Smart data measurement (smart data is information from which signals and designs have been extracted by using algorithms) is currently a critical feature in a variety of industries, including industrial, medical, aquaculture, and agriculture. Ammonia, pH, temperature, water level, dissolved minerals, and other water quality parameters are critical for aquaculture. We have used various sensors which are utilized to monitor water quality, and the information gathered will allow farmers to monitor fish health and take appropriate action. This smart measurement of parameters will reduce the labor and waste of water in aquaculture and also increase the productivity by a large quantity specially done on Biofloc. We have seen that people in Bangladesh are gradually moving towards Biofloc aquaculture. They have started this system by trial-and-error process which is generally lengthy, time consuming and waste. In our paper we tried to construct a system which will provide them with a proper set of date and allow to keep the water quality parameters at its optimum range. This will ensure more effective and hassle-free aquaculture and increase fish productivity by taking necessary steps if any parameter changes.

Keywords

Water monitoring

pH

Temperature

Water level

Ammonia

Biofloc

Rtp (Room temperature)

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Chapter 1

1.1 Introduction

Bangladesh has enormous catch fishery and aquaculture potential because of its abundant inland lakes and river systems. Bangladesh's excellent geographic location results in a high variety of aquatic species and ample resources to support its fishing potential.

The saying Maache-Bhate Bangali refers to fish as a favorite accompaniment to rice in the national diet (Ghose, 2014). Inland capture fisheries, inland aquaculture, and marine fisheries are the three main types of fisheries, with the inland aquaculture sector accounting for more over 55 percent of total production. The fisheries sector is extremely significant to the national economy, accounting for 3.69 percent of GDP and 22.60 percent of agricultural GDP (FRSS, 2016). The growth of the fisheries over the last ten years has been quite consistent, averaging 5.38 percent per year. This industry has had a fairly stable growth rate, ranging from 7.32 percent in 2009-2010 to 4.04 percent in 2013-2014. (Bangladesh Economic Review, 2014). The inland fisheries sector accounts for more than 2% of Bangladesh's export value. [1]

With sufficient government assistance, the fisheries sector has the potential to create a wide range of ancillary sectors in rural regions, many of which have a high rate of return on investment. Bangladesh features one of the largest and most active deltas in the world, fed by three powerful rivers: The Padma, Meghna, and Jamuna. In addition to the large marine resources, this leads to a significant potential for fresh and brackish water capture and culture fisheries.

Fisheries are underdeveloped in Bangladesh, despite the country's vast coastline and extensive freshwater and marine water bodies. According to a recent study, Bangladeshi fisheries have low adaptive capacity and are highly vulnerable to climate change. Wild fisheries are threatened by overexploitation as a result of poor management and habitat degradation, in addition to the challenges posed by climate change. To address these issues, one of the country's top fisheries development priorities is to improve the management of both inland and marine fisheries resources, as well as to restore some open water wild fisheries. [1]

Bangladesh ranked fifth in world aquaculture production in 2015–2016, with aquaculture accounting for half of the country's total fish production (55.15 percent) (DoF, 2016).Bangladesh produced 3,684,245 metric tons of fish in 2014–2015, with 1,023,991 metric tons from inland capture fisheries, 2,060,408 metric tons from inland aquaculture, and 599,846 metric tons from marine water production (FRSS, 2016).Few reviews of the growth and potential of fisheries and aquaculture in different parts of Bangladesh have been published, and no research on the current state of fisheries in Bangladesh have been published. [1]

Considering the importance of aquaculture and also the fact that not much work has been done on it, we are proposing a scientific and modern method in the hopes of providing useful insights that might aid the aquaculture community. We have tried to incorporate a smart system technology which will primarily enable us to measure and monitor the water quality parameters responsible for maintaining better fish health/behavior.

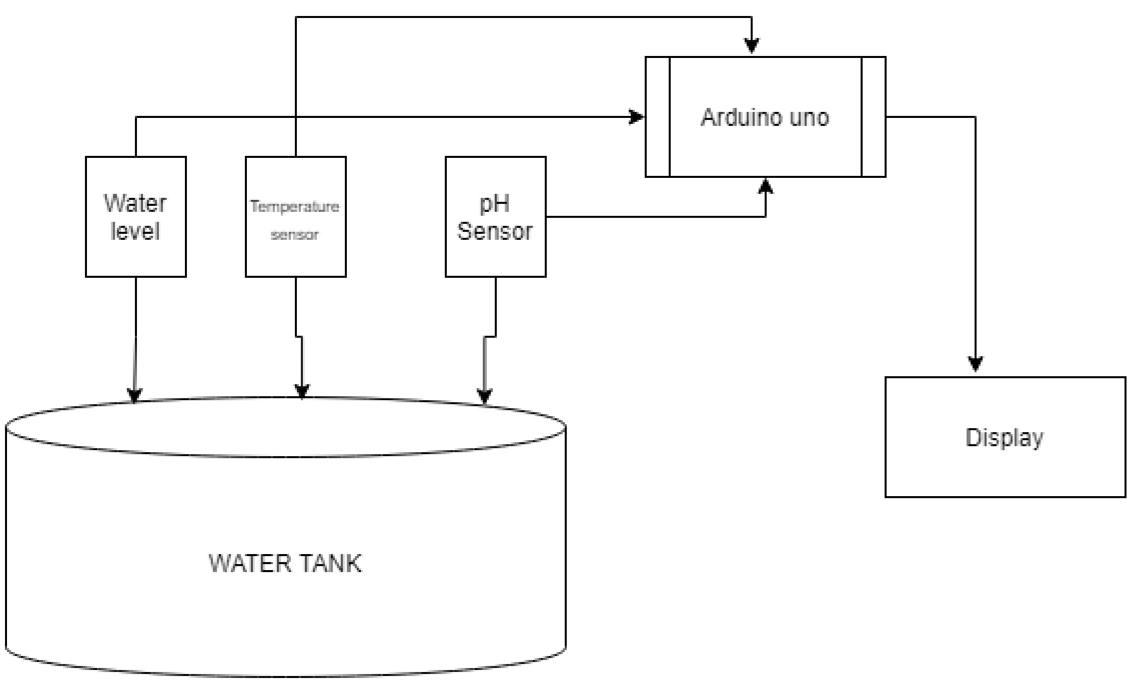

Fig:1.1 Flow chart of our smart system

The above figure represents a flow chart of the smart system which is proposed by our group in this project. The 3 sensors senses data from the water tank and converts the signal into electrical form which is then sent to the microcontroller, Arduino UNO. The data is then processed which gets displayed on the screen. The workings and the complex processes involved will be discussed in later chapters.

1.2 Motivation

The rise of Biofloc Technology in aquaculture has seen a successful breakthrough in Bangladesh for the last few years thanks to the number of ponds in the country. It is possible to produce 20 times more fish using Biofloc than in a normal pond. The quality and color of the fish also enhances. While all this is true, we were really surprised to see how the entrepreneurs and people who do fish farming had little knowledge about the science involved in the technology. One example that comes to mind is the excessive wastage of water and feed quantity. In many of the firms that we visited we discovered that the owners change water after 2/3 days which usually is done to ensure poison free water flow but the results we obtained from our research confirms that up to 4 days it is not necessary for making any changes. These subtle yet important factors could lead to saving a lot of water and feed usage which in turn would cut the cost put into the investment. Hence our goal was to spread this awareness amongst the farmers so that they could be benefitted while also reduce the amount of water and feed wastage.

1.3 Objective of the Thesis

The main contribution of this chapter is to depict the discussion about the quality of water and how it affects the behavior/health of the fishes. Other contribution of this chapter is to talk about the proposed smart system model for aquaculture system. The connected devices and sensors associated in this project has been tested and trained to collect data from practical experiments which were performed by our group. To confirm the validity of our data we went one step further and consulted with different Biofloc firms which gave us a head go in the direction of our project.

We further analyze the data that we collected and try to link each data of information with the other in the hopes of obtaining a new insight that could help us make predictions about improving on certain aspects of the aquaculture which in turn would improve the overall fish quality and growth in Bangladesh.

Finally, we highlight the important factor that all the data collection work will be done by our smart system making it easier to carry and process information. In future chapters we will be discussing all about the process and making of our device. We will also be proposing some solutions to problems that we faced along the road as we worked throughout the project.

Chapter 2

Literature Review

As we went through a few paper and we found some work done on this venture. In spite of the fact that the work may differ but a great sum of data has been accumulated for the papers. In paper [2] an overview was given almost the same sort of work. Firstly, in their observation appeared their concern at angle monitoring since the water parameters are changing due to sudden climate changes. This makes the farmers to stress since it let them in dark around the water parameters which changes. One of the reasons they appeared is that the farmer's employments manual testing which is able eventually deliver wrong information also time consuming. So they proposed a work where they will put an integrated chip on computer utilizing Raspberry Pi which can be included to a Wi-Fi module which makes it unique, a solar panel will be there to charge the module and the information will be transferred to the agriculturists by IOT. The engineering of this work is proposed by four modules. One of the modules is control module where the small-scale controller which will work in night and charge the battery will be done by solar panel. On the second module they proposed some sensors which will be worked by the Raspberry pi. In the third part they talked about the data which will be collected by sensors and written in python in Raspberry pi. In the last part they talked about the app how they will get to know about the result. In the end they produced some results based on it. But there is not any proper way given how the sensors work or how will they give the data. Or any code or way to operate the app. Just a proposed work which can be done. [2]

In further research the paper [3] which have similarity to our work but there are some major dissimilarities too. Their word proposed based on data. They correlate the temperature changes based on fixed pH, or changes of pH when temperature varies, pH value when water level changes. This whole project is done in Raspberry pi and the sensors are used are temperature(DS18B20), water flow (HZ21WA), pH (atlas-scientific pH probe and EZO circuit) and water level (e Gizmo water level sensor). More on their study they gave an experimental design and the correlation of the parameters. This may look similar but the difference is we will be doing this on Arduino. One more thing is how they correlate the data with other are not that clear but in our paper we will try to make it more clear. Same goes for the other paper they don't have a proper construction procedure about the project or how they merged all the sensors but, in our case a proper way is given. [3]

In terms of monitoring the research about the ammonia toxicity and pH correlation a paper [4] was found. In their study they talked about the correlation of the both elements. first of all, they talked about the Ammonia may be a nitrogen squander discharged by aquatic animals into the generation pond environment. It may be an essential byproduct of protein digestion system. Ammonia is let into the water directly by fish gill. And the amount is very high on the production time. Ammonia is very toxic which eventually have a very bad effect on pH, which eventually make the aqua life hard. Then in the paper, a study provided on two time and the data is given below,

Time	Tot/NH3-N (mg/L)	Temp C	pH	UI/NH3-N (mg/L)
	Type equation here.	Type equation here.		Type equation here.
0400 hr	2.6	28	7.0	0.0018
1600 hr	2.5	29	9.3	1.1

Here they find the data which they matched on standard value on UI/NH3-N [4]

In the monitoring of health and hatching monitoring we have come across a paper [5] where they have showed a work on hatching which is based on the pH. To find out the Mortalities and hatching rates the authors placed some eggs in pH solution. after that they took the data set and examine the rates. A set of data was taken from 4 to 9 pH and it was seen that 70% of higher chances are there of fertilizing. Note that no fertilizing was able to happen in 2 or 13 level pH. It was showed that at 9 the pH level is most lethal for fertilizing. They also found that hatching rate are almost 52%. In all the level in between there weren't many differences. It was seen that in acidic solution the hating rate is much higher. We tried to find out finding and try to match with this papers work. [5]

Chapter 3

3.1 Water Quality and Fish Health:

The most important factor that affects fish health is the water quality where the fish lives in. The water quality directly impacts on Fish health and their behaviors. In aquaculture this factor plays the most significant role. Good water quality refers to the quality of water that the fish wants. So for achieving production success maintaining good water quality is a must. The main aspects of water quality measurement are pH (expresses the acidity or alkalinity of water), Temperature, water level, salinity, oxygen concentration etc. but these aspect ratios are different for different fish. Different fish needs different optimum range of water quality measurement aspects where they can survive, grow, reproduce and perform best. So it must have to be ensured that for aquaculture of different fish, the chemical and physical properties of water must be maintained at the optimum range all the time.

Outside this optimum range the fishes will show erratic behavior, poor growth, disease symptoms, lack movements and even in extreme case fish mortality may also occur. Our Thesis paper is mainly about the measurement of the water quality aspects where fish can perform at their best and finding out if the range goes outside their optimum range how they perform. [6]

3.2 Temperature:

As we know fish are cold blooded animal they need an optimum water temperature to maintain their body temperature. So for their survival, growth and reproduction water temperature plays a vital role. Each fish has its own tolerance limit, outside the tolerance limit the fish body temperature may raise or fall which will eventually effect its growth and immunity even it can be lethal for the fish also.

Here we have provided a list where different fishes' optimum range of temperature is given:

Fish species	Lethal water temperature(degC) lower	Lethal water temperature (degC) upper	Optimum temperature range for adults (degC)	Temperature range for spawning (degC)
Oreochromis niloticia (tilapia)	12	38	27-30	22-32
Clarias gariepinus(African catfish)	-	-	25-27	20-30
Cyprius carpio(common carp)	2	36	23-26	Above 18
Micropterus salmoides (largemouth bass)	2	35	23-30	17-20

Tolerance limits and optimum temperature ranges for commonly cultured fish species (Nile tilapia, African catfish, common carp and rainbow trout) [6]

3.3 Water level parameter:

For aquaculture water level indicator is another vital physical aspect where different species are cultivated together. As different species live in different water level and need different temperature. Minimum range of water level should be kept for their natural habitats. In low water level their natural habitat will not be maintained so their growth, productivity may deflect. Even low water level may become lethal for some species like ***Heteropneustes fossilis*** (SHING FISH) in low water level the get in collision with each other thus harms each other.

Chemical aspects of water quality are the main properties for fish health. In aquaculture fish growth, productivity, immunity, performance and behavior directly depended on the chemical aspects of water quality. Among the water quality pH, Dissolved gases (Oxygen, Carbon dioxide, ammonia), Salinity. [6]

3.4 pH:

The substances dissolved in water can make it acidic, neutral or alkaline. This affects the fish life directly. The pH value determines the alkalinity or acidity of water. The values of pH usually range from 0-14, where pH value 7 indicates the water as neutral, less than 7 indicates acidity, greater than 7 determines alkalinity. Excessive pH value greatly affects fish health; it can even kill the fish. It even affects the production of natural food organisms in water. The lethal range of pH value may defer for different species. Most suitable pH value for fishes lies in between 6.5 to 8.5. Most cultivated fish may die if pH value falls less than 4.5 and rise above 10. For juveniles and eggs optimum pH value must be maintained as slightly change in the pH value less than 6.5 or above 8.5 greatly affects, even it becomes lethal as the juveniles are more sensitive than adults.

To maintain optimum pH value of the water first then according to the value different actions can be taken to make optimum range of pH values

- By using lime and alkaline fertilizers we can make acidic water pH level to optimum range.
- And for alkaline water we can use acidic fertilizers to get optimum range.

pH values usually vary over the course of 24 hours. As it depends on the photosynthesis activity that takes place for the phytoplankton's that lives on water.

At the time of sunrise, the pH of water is the lowest, as the light increases the pH values also keeps increasing and in the late afternoon the pick value of pH can be found. After the sunset these value keeps decreasing again. [6]

3.5 Dissolved Oxygen:

Among the dissolved gases, oxygen is the most important one. In water it comes from photosynthesis or atmosphere. But its major source is from phytoplankton's photosynthesis process. And photosynthesis process occurs during the day time when plenty of light available. So during cloudy sky, night time DO level may fall, it also depends on the amount of phytoplankton's present in water. As oxygen helps in respiration and decomposition it needs to be at optimum level at all the time for aquaculture. As we don't have any DO measurement tool we can relate the water level to measure the dissolved oxygen in water. As we have seen from our experiment during the day time when plenty of lights are available the fishes lie at the medium water level, at the night time the fishes come at the top level water surface so that they can get better oxygenated surface at the top. [6]

3.6 **Ammonia:**

In aquaculture ammonia also plays a vital role. It depends on the pH level and DO. If pH level rises above 9. The Un-ionized ammonia in water rises above the optimum 0.5 mg/L. which is very toxic for the fish and juveniles. So to keep the ammonia level below optimum 0.5 mg/L we need to keep the pH level at the optimum level 6.5-8.5. Also to maintain the ammonia level DO concentration must be kept at high level [6]

Chapter 4

Hardware and Software

4.1 Hardware Implementation:

To construct our smart system, we have used few sensors and microcontroller. Following is the list of equipment that we have used for our project:

- Arduino Uno
- Analog pH sensor
- Temperature sensor (DS18B20)
- Water level sensor
- 4.70k ohm resistor
- Breadboard
- Jump wire

4.1.1 Arduino Uno:

We have used Arduino Uno. Arduino Uno has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6 analog input pins, a USB connection, A Power barrel jack, an ICSP header and a reset button. [7]

4.1.2 Analog pH sensor:

For measuring the pH of water, we have used the analog pH sensor. This pH sensor is specially designed for Arduino and has a practical gravity sensor. It consists of an LED which shows the power indicator. It also contains a BNC connector and PH.2 sensor interface. A glass membrane is fused on to the glass electrode as a pH sensor. This electrode design generates an environment on the inside of the glass membrane with constant H+ ion binding, meanwhile glass membrane is exposed to the sample, which contains a variable number of H+ ions. [8]

Fig:4.1.2 Analog pH sensor

4.1.3 Temperature Sensor:

We have used Model DS18B20 Temperature Probe for measuring the optimum temperature of water. It consists of a ceramic resistance element (Pt. 100) with DIN IEC 751 (former DIN 43760) European curve calibration. A closed-end robust stainless-steel tubing houses the resistance element which protects it against moisture. The working principle of this probe is that the sensor resistance is a function of the sensed temperature. The platinum RTD has very good linearity, accuracy, repeatability and stability. The voltage across the diode terminals is the primary working mechanism of temperature sensors. When the voltage rises, the temperature rises as well, resulting in a voltage drop between the base and emitter transistor terminals of a diode. [9]

Fig:4.1.3 Temperature sensor

4.1.4 Water Level Sensor:

We have used the water level sensor for measuring the water level, and detect leakage in the water tank. It consists of ten copper traces, of which five are power traces and five are sense traces. When submerged in water, the traces are being bridged. The sequence of exposed parallel wires functions as a variable resistor, with resistance that varies with water level. The change in resistance is proportional to the distance between the sensor's top and the water's surface.

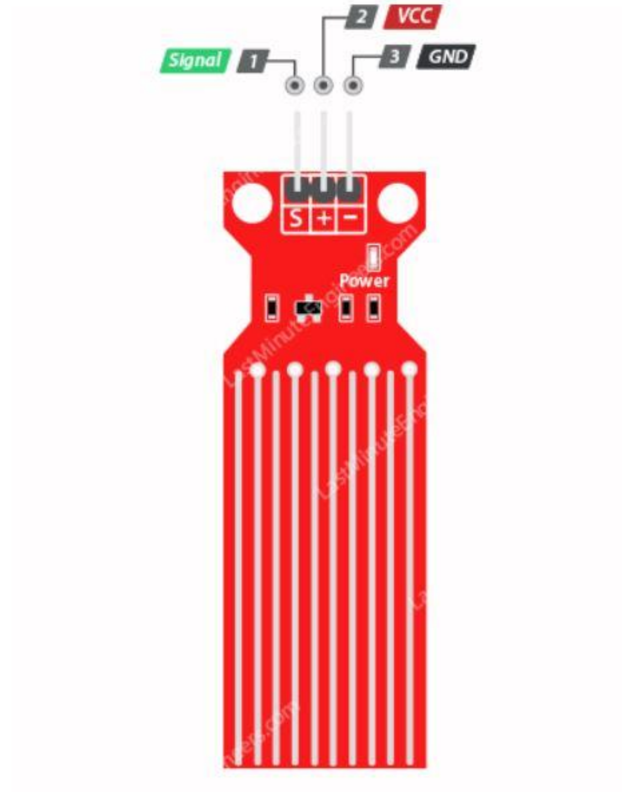

Fig:4.1.4 Water level sensor

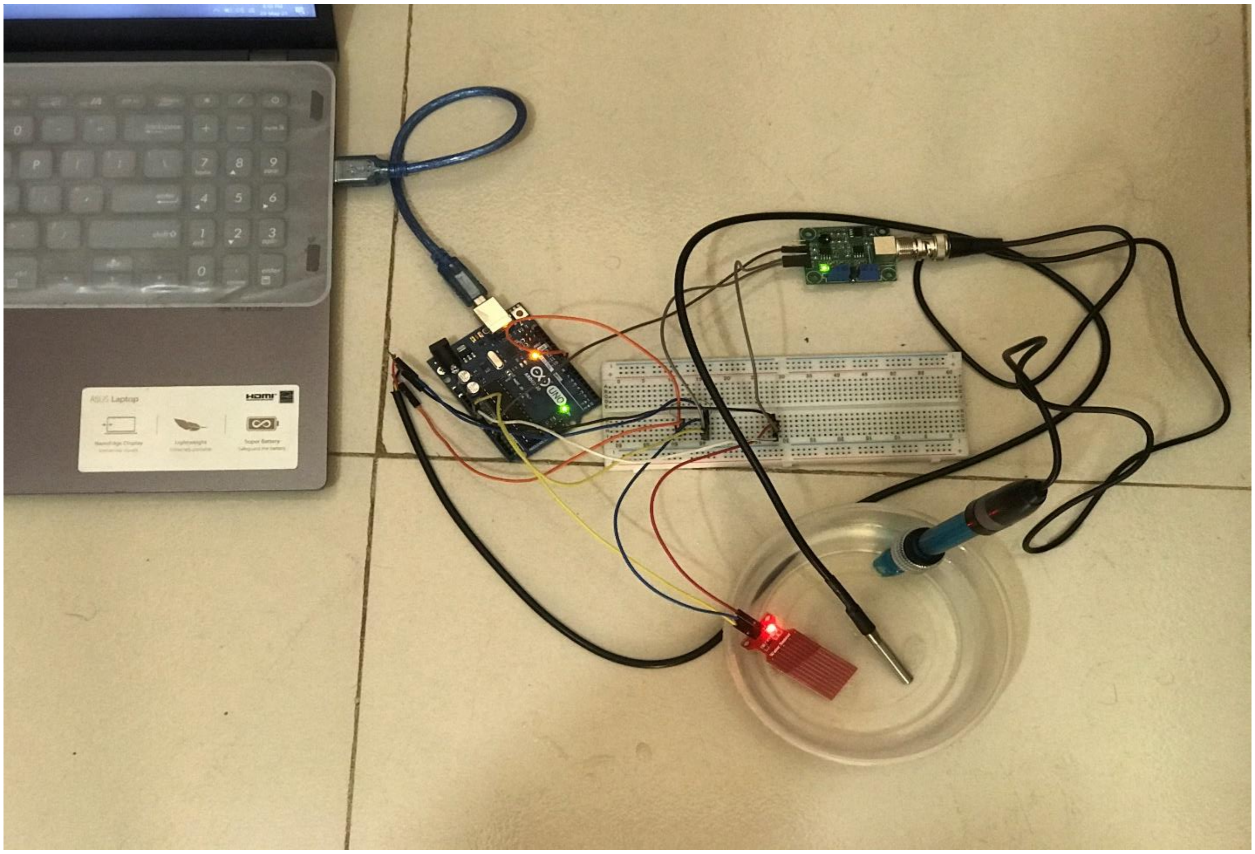

Fig:4.1.5 Smart system

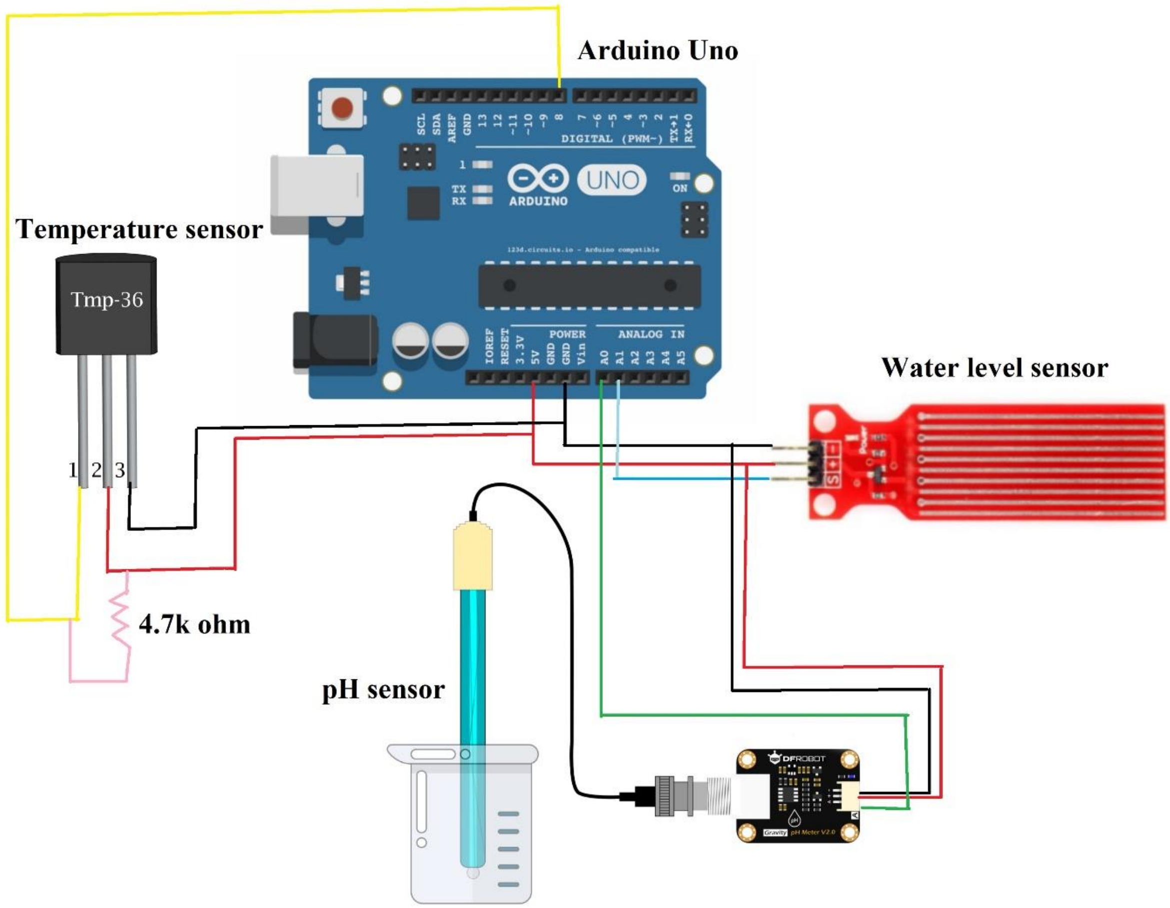

Fig:4.1.6 Circuit Diagram

Software

4.2 Arduino IDE for Controller and ESP Programming:

For writing the codes for our work we have used Arduino Integrated Development Environment (IDE). IDE. This is basically a cross-platform application. The programming language that is basically used for Arduino IDE is C and C++ and the programs are knowns as sketches. It consists of a software library which helps with common procedures. Text editor is used to write programs and the file is saved using. ino extension. The editor can cut/paste and has search/replace capability. The message section indicates faults and provides feedback while storing and exporting. The Arduino Software (IDE) outputs text to the console, which includes detailed error messages and other information. The configured board and serial port are displayed in the window's bottom righthand corner. You may use the toolbar buttons to validate and upload programs as well as compose, open, and save sketches, and launch the display to show the output values. [10]

4.3 Code:

At the beginning, we have to include all the header files which will run throughout the code. As we have used Model DS18B20 for temperature sensor we have included ARDUINO_MKRENV.h, OneWire.h and DallasTemperature.h liabraries.

For the next step, we need to define the pins of Arduino where the temperature sensor is connected. After that we define one wire class and DallasTemperature class which are required to measure temperature. Now the calibration value is defined where we will measure temperature in Celsius and Fahrenheit

In next step we need to set the analog input and output pin for the water level sensor. Now we will get two values one of which is the value that we read from the pot and the other is value output to the PWM (analog out). This is why we set to int values.

Next, we define the pin where the pH sensor will be connected. The value of pH will be recorded as average of 10 values each time it shows the output. We store 10 sample average analog values in array.

Inside the void setup, initialize serial communication at 9600 bps and test the serial monitor.

Inside the void loop part, we first work with the water level sensor. First to read the analog in value and map it to the range of the analog out we write sensorValue and outputValue. Then, analogWrite is used to change the analog out value. Finally, the result is printed in the serial monitor.

For measuring the temperature first, we have to request the temperature from the sensor. As we want two sets of values each time (Celsius and Fahrenheit) so the request should be on both parameters. Finally, the serial monitor will print the sensed data.

Next we work with the pH code. Analog values we receive is sorted into ascending order. This is done to calculate the average of samples we obtain in later part.
At the last part of our code, the average value is calculated. 2.5V is set as the neutral voltage when the value of pH is 7. In the if else part the code describes whether the pH of water is around 7 or acidic or basic.

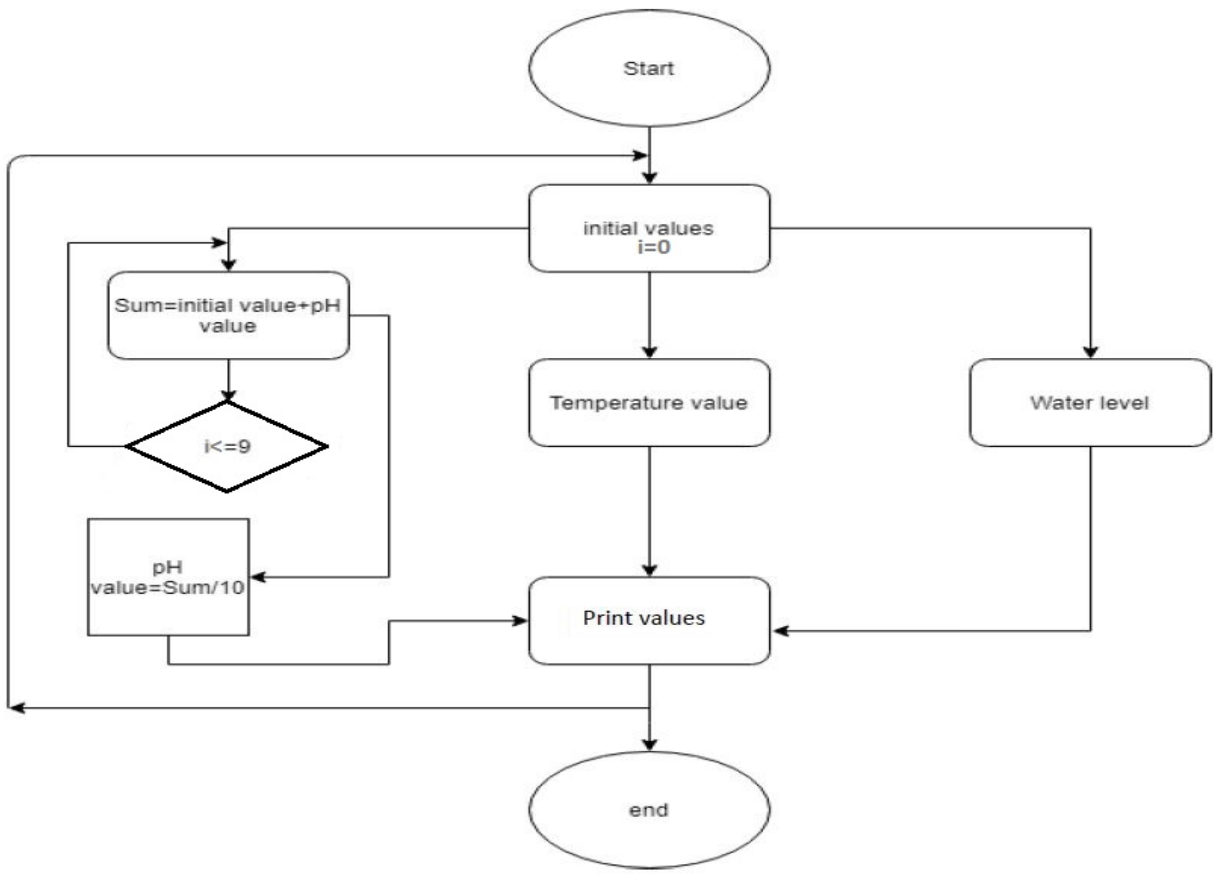

Fig:4.3 Flowchart of code

Chapter 5

Sensor Testing

In this chapter we begin by discussing the testing of individual sensors at normal room temperature and pressure. This was done solely to ensure that each individual sensor works at its optimum before lumping them together and performing the overall experiment.

Table A: The table below depicts the information when the water level sensor is dipped into water.

We divided the sensor configuration into 3 parts. For easier calculation and understanding we split each level in terms of millimeters (1 mm = 1 water level). Initially we did not dip the sensor into the water and the reading was zero as showed on the table below. A moment later we dipped the sensor into the aquarium at a depth of 260-450 mm submerging it partially. This level is considered "medium" in our experiment. Later we dipped the sensor at a depth of 500-580 mm open which the sensor was completely dipped. This level we call as "high" in our experiment.

Water Level: 0	**Sensor is dry**
Water Level: 260-450	**Sensor is partially submerged**
Water Level: 500-580	**Sensor is completely submerged**

<u>Table B:</u> The table below depicts the temperature sensed by the temperature sensor at room temperature and pressure. The readings were taken after progressive time intervals and the temperature obtained were normal ensuring the sensor working at its optimum.

Temp :	
27.62 C	81.72 F
28.62 C	83.52 F
29.62 C	85.32 F
30.62 C	87.12 F

<u>Table C:</u> The table below depicts the pH of distilled water at normal room temperature and pressure measured after progressive time intervals.

pH: for pure water
6.65
6.70
6.72

<u>Table D:</u> The table below depicts the pH of soap at room temperature and pressure measured after progressive time intervals.

pH: for base (soap)
12.28
11.91
11.80

Table E: The table below illustrates the data obtained for pH of lemon after successive time intervals.

pH: for acid (lemon)
3.22
3.17
3.25

5.1 **Sensor testing with all devices connected**:

Now that we have confirmed that our individual sensors work we will be discussing about the unified system as a whole.

Table F: The table below shows the readings obtained from different sensors simultaneously after certain time intervals. Initially we measured the pH of distilled water at normal room temperature and pressure without dipping the water level sensor and gained results as shown on the table below. Gradually we started to add acid (lemon juice) and observed changes in pH while also dipping the sensors with gradual pace. Finally, we poured base (soap water) into the aquarium and observed the results. There was a significant increase in the ph. The water level also rose as we dipped the sensor almost touching the base of the aquarium.

Time (hr.)	pH	Temperature(C)	Water Level (mm)
00 00	6.8	28	0
04 00	3.2	28	125
12 00	4.5	29	207
16 00	12.3	30	450
20 00	11.6	28	536

5.2 Experiment and Discussion performed at home:

Here we will be discussing about our observation and analysis obtained from performing the experiment at home using an aquarium of size 1m x 1m x 1m.

Day 1:

The table below shows the experiment performed in Day 1 at normal room temperature and pressure under the "low" water level. We started off without pouring any ingredient into the aquarium and observed the fish behavior. This followed by addition of acid and the results were recorded and finally we poured base into the aquarium and on each term noted the fish behavior. The temperature throughout the experiment did not alter much as the experiment was performed at home.

Time	pH	Temperature	Water level (mm)	Fish Behavior
12 00	6.68	29	0	normal
12 15	6.7	29	10	normal
12 30	6.9	30	23	normal
12 45	6.2	32	30	normal
01 00	5.9	30	46	Slow movements
01 15	5.7	32	59	Slow movements
01 30	5.6	32	62	Slow movements
01 45	5.2	32	74	Jumps on the surface
02 00	5.1	33	82	Jumps on the surface
02 15	5.5	33	94	Jumps on the surface
02 30	5.8	33	102	normal
02 45	6.3	33	125	normal
03 00	6.9	32	135	normal
03 15	7.4	32	142	normal
03 30	7.9	32	155	Slow movements
03 45	8.2	32	163	Slow movements
04 00	8.3	32	178	Slow movements
04 15	8.3	30	180	Jumps on the surface
04 30	8.5	30	194	Jumps on the surface

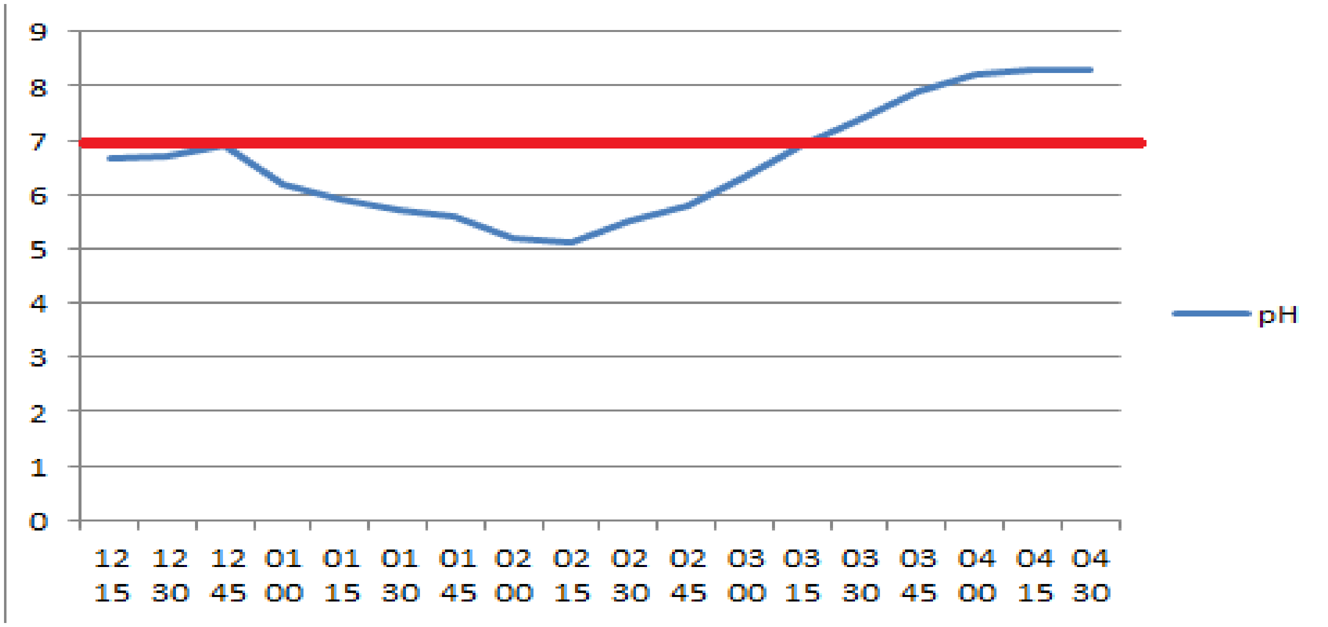

Fig:5.2.1 pH vs time graph for the above Table

This graph shows the change of pH and fish behavior at certain moments of time performed in an aquarium under “low” water level. The red line in the graph indicates the optimal behavior of the fish and any distortion above or below this line signals uneasiness experienced by the fish. At the start of the experiment we observed the fish behavior without altering the pH and saw normal movements as expected. After some time, we started to pour acid and observed the behavior which led towards gradual concoction of haphazard movement.

Again after a while we started to pour base into the aquarium and in the initial stages the movements were normal but upon more addition the fishes again started to show slow movements and also some rare jumps.

Day 2:

The table below shows the experiment performed at Day 2 with the same conditions as Day 1 only with the exception of dipping the water level at “medium”. The temperature was also unchanged due to performing it at home.

Time	pH	Temperature	Water level (mm)	Fish Behavior
12 00	6.6	30	270	normal
12 15	6.3	29	289	normal
12 30	6.7	31	300	normal
12 45	6.8	31	310	normal
01 00	6.9	32	321	Slow movements
01 15	7.2	32	332	Slow movements
01 30	7.5	32	325	Slow movements
01 45	7.9	33	356	Slow movements
02 00	8.5	33	364	Jumps on the surface
02 15	8.7	33	376	Jumps on the surface
02 30	8.1	29	359	Slow movements
02 45	7.6	29	388	normal
03 00	7.0	30	397	normal
03 15	6.2	32	412	normal
03 30	5.9	30	415	Slow movements
03 45	5.5	32	420	Slow movements
04 00	5.6	32	407	Slow movements
04 15	5.3	32	431	Jumps on the surface
04 30	5	33	447	Jumps on the surface

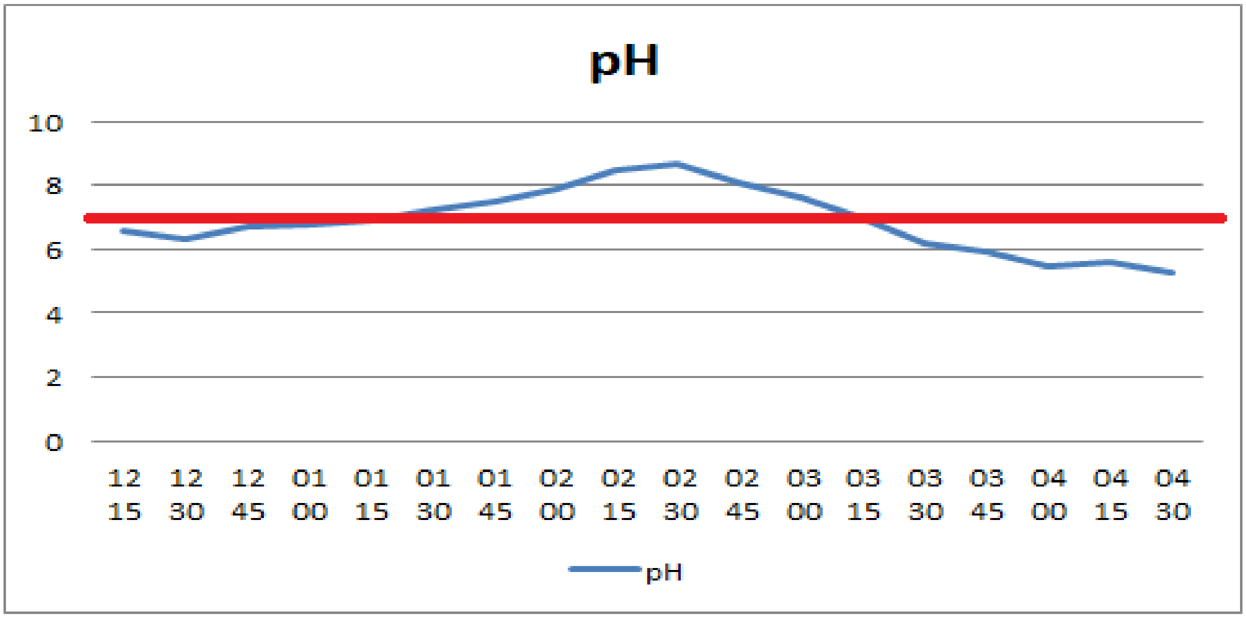

Fig:5.2.2 pH vs time graph for the above Table

This graph shows the change of pH and fish behavior at certain moments of time performed in an aquarium under medium water level. The red line in the graph indicates the optimal behavior of the fish and any distortion above or below this line signals uneasiness experienced by the fish. The results obtained were same as that of Day 1 but only with a small difference that the fish behaved more normally. Our assumption is that the more water quantity, the more normal/robust the fish behaves even upon addition of acid/base

Day 3:

The table below talks about performing the experiment at Day 3 with all the same conditions as Day 1 and Day 2 only with the exception of "high" water level meaning dipping the sensor close to the base of the aquarium. The change in temperature as usual is not significant as the experiment is performed at home.

Time	pH	Temperature	Water level	Fish Behavior
12 00	6.6	30	450	normal
12 15	6.8	29	465	normal
12 30	6.6	31	473	normal
12 45	6.3	31	480	normal
01 00	6.9	32	489	Slow movements
01 15	7.4	32	492	Slow movements
01 30	7.6	32	499	Slow movements
01 45	7.9	33	505	Slow movements
02 00	8.3	33	512	Jumps on the surface
02 15	8.7	33	517	Jumps on the surface
02 30	8.1	29	515	Slow movements
02 45	7.5	29	519	normal
03 00	6.9	30	524	normal
03 15	6.3	32	530	normal
03 30	5.9	30	538	Slow movements
03 45	5.7	32	540	Slow movements
04 00	5.6	32	537	Slow movements
04 15	5.2	32	548	Jumps on the surface
04 30	5.1	33	550	Jumps on the surface

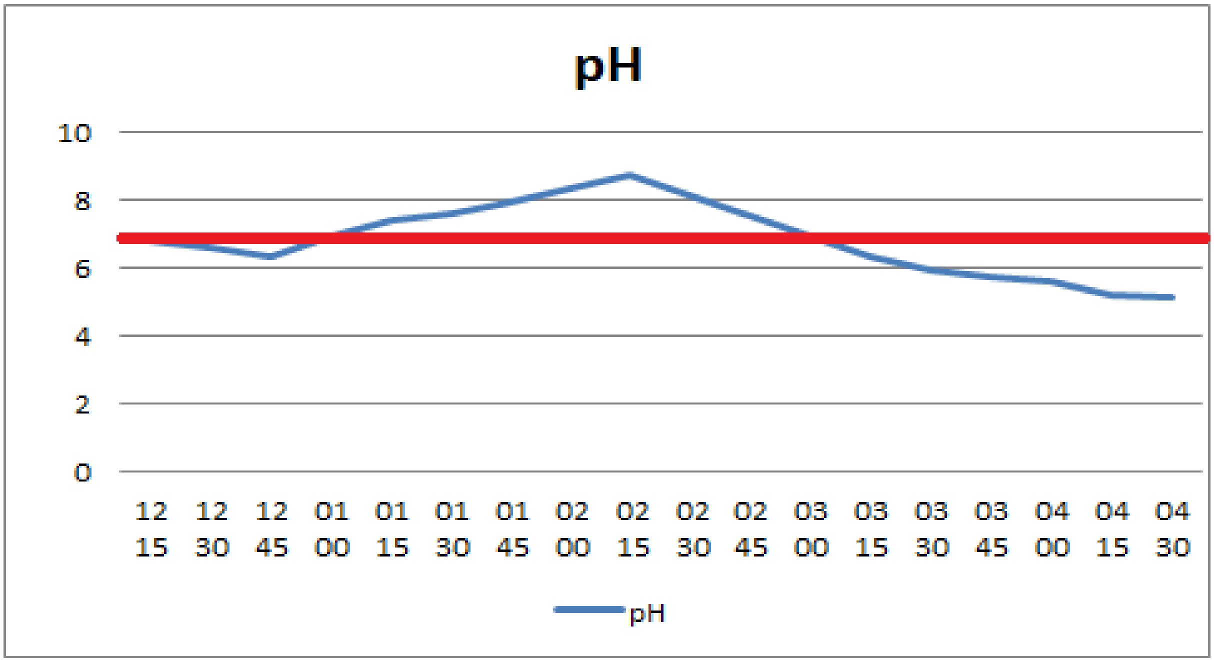

Fig:5.2.3 pH vs time graph for the above Table

This graph shows the change of pH and fish behavior at certain moments of time performed in an aquarium under high water level. The red line in the graph indicates the optimal behavior of the fish and any distortion above or below this line signals uneasiness experienced by the fish. The results obtained in this experiment is also very similar to that of Day 2.

The overall conclusion and results obtained from these experiments is that at higher water levels the fish's survival threshold increases even upon addition of acid/base and other ingredients.

Other assumption is that slight changes in temperature does not affect the fish behavior/health to any significant degree.

5.3 Correlation of pH and Ammonia:

In the Aqua Culture ammonia plays a big role on it. But unfortunately, we couldn't manage to get the ammonia sensor due to Covid-19 situation but we would like to have some work on ammonia in our paper. So, we researched about it and found out this paper [11] which is very close to our work. Here the authors find out the data of ammonia in some temperature and pH which actually matches our value. From the given table made by the authors we can get or approximate the amount of ammonia in the water. So, this table will also give us data about ammonia without using ammonia sensors. [11]

Total Ammonia Nitrogen (PPM)

	pH										
Temp(ºc)	**6.0**	**6.4**	**6.8**	**7.0**	**7.2**	**7.4**	**7.6**	**7.8**	**8.0**	**8.2**	**8.4**
4	**200**	**67**	**29**	**18**	**11**	**7.1**	**4.4**	**2.8**	**1.8**	**1.1**	**0.68**
8	**100**	**50**	**20**	**13**	**8.0**	**5.1**	**3.2**	**2.0**	**1.3**	**0.83**	**0.5**
12	**100**	**40**	**14**	**9.5**	**5.9**	**3.7**	**2.4**	**1.5**	**0.95**	**0.61**	**0.36**
16	**67**	**29**	**11**	**6.9**	**3.3**	**2.7**	**1.8**	**1.1**	**0.71**	**0.45**	**0.27**
20	**50**	**20**	**8.0**	**5.1**	**3.2**	**2.1**	**1.3**	**0.83**	**0.53**	**0.34**	**0.21**
24	**40**	**15**	**6.1**	**3.9**	**2.4**	**1.5**	**0.98**	**0.63**	**0.4**	**0.26**	**0.16**
28	**29**	**12**	**4.7**	**2.9**	**1.8**	**1.2**	**0.75**	**0.48**	**0.31**	**0.2**	**0.12**
32	**22**	**8.7**	**3.5**	**2.2**	**1.4**	**0.89**	**0.57**	**0.37**	**0.24**	**0.16**	**0.1**

5.4 Case Study:

To work on our project and take practical values we have visited a Biofloc on Jalessar, Savar on 25th May,2021 and 27th May,2021. There we installed our device on the fish tank and took the values. We conducted our experiment on three phases each day. On the first day we carried out our experiment from 9 am to 10 am, 2 pm to 3 pm and 5.30 pm to 6.30 pm. On the following day, the time of our experiment was same as first day.

Fig:5.4.1 Fish tank

Fig:5.4.2 Biofloc system

Following are the values we have obtained from measuring the water quality parameters of the Biofloc we have visited.

Day 1:

Time	pH	Temperature	Water level(mm)
9.00	6.20	29.21	581
9.10	6.23	29.35	581
9.20	6.21	29.17	575
9.30	6.25	30.11	571
9.40	6.26	30.05	570
9.50	6.29	30.24	567
10.00	6.32	30.56	564
2.00	6.81	32.05	531
2.10	6.84	32.21	529
2.20	6.79	32.78	519
2.30	6.86	32.97	511
2.40	6.88	33.01	510
2.50	6.91	33.23	507
3.00	6.95	33.02	499
5.30	7.91	31.58	499
5.40	7.96	31.25	498
5.50	7.99	31.12	491
6.00	8.12	30.94	488
6.10	8.07	30.46	487
6.20	8.12	30.21	479
6.30	8.21	30.17	471

We have taken the average values we obtained while measuring the parameters in three phases. From the above-mentioned values our finding was that the value of pH was lowest from 9.00 am to 10.00am. and the water level was high. It is also seen that the temperature was relatively low. From the data obtained while experimenting from 2.00 pm to 3.00 pm it is seen that the value of pH has risen to almost near 7. This is because of the photosynthesis of the phytoplankton. The water level has also decreased a bit and the temperature is highest at this point. Data from 5.30 pm to 6.30 pm shows us that pH value is highest but temperature was decreasing gradually. The water level was same as the values of noon.

Day 2:

Time	pH	Temperature	Water level(mm)
09 00	6.17	28.41	435
09 10	6.18	28.15	434
09 20	6.26	28.84	431
09 30	6.17	29.21	428
09 40	6.31	29.63	427
09 50	6.24	29.87	421
10 00	6.30	30.04	413
14 00	6.84	31.26	402
14 10	6.82	31.34	399
14 20	6.79	31.57	397
14 30	6.81	31.27	392
14 40	6.89	32.31	384
14 50	6.93	32.16	382
15 00	6.91	32.72	372
17 30	7.99	31.97	371
17 40	8.02	31.86	364
17 50	8.12	31.89	361
18 00	8.14	31.48	356
18 10	8.10	30.94	351
18 20	8.19	30.67	350
18 30	8.26	30.19	347

These are the values we have obtained for day 2 which is basically one day after the first data was taken. From the data we have seen that the pH value increases gradually in the day time and the water level slowly decreases. The temperature was lowest in the morning and rises in the noon. It decreases again in the evening.

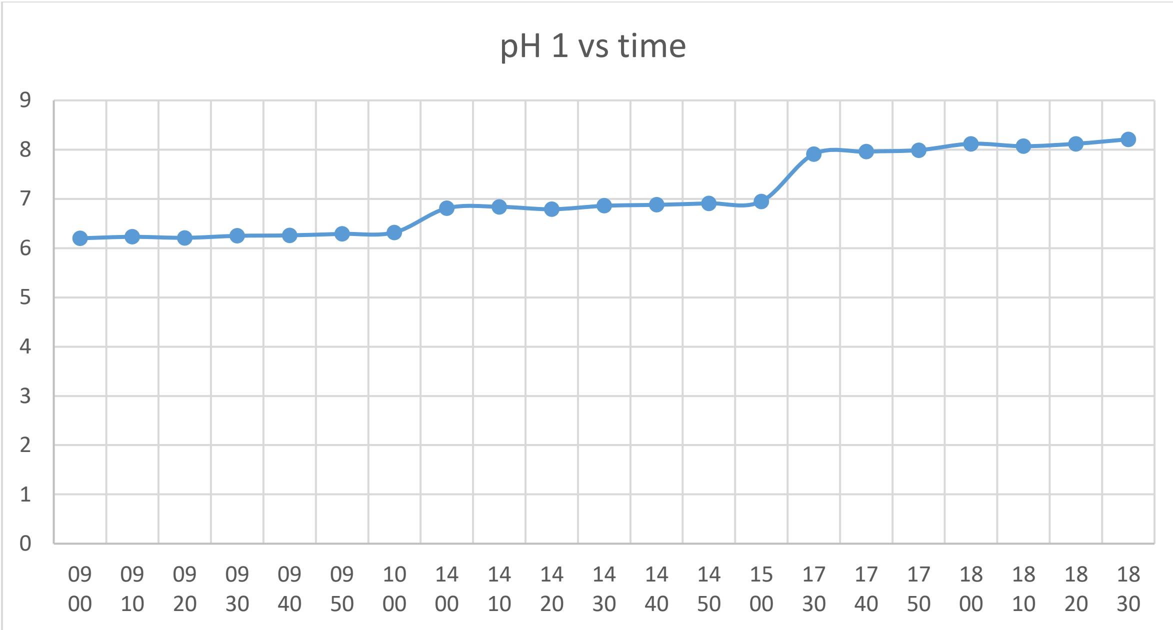

Fig:5.4.3 pH 1 vs Time graph

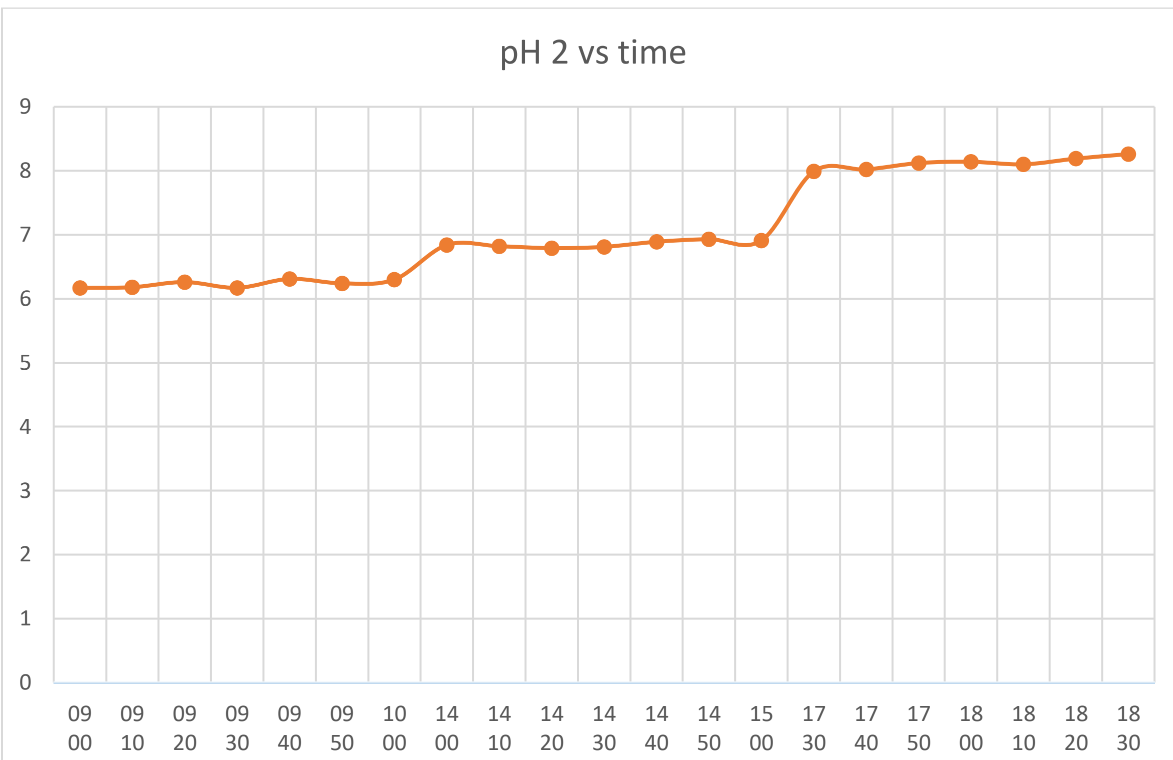

Fig:5.4.4 pH 2 vs Time graph

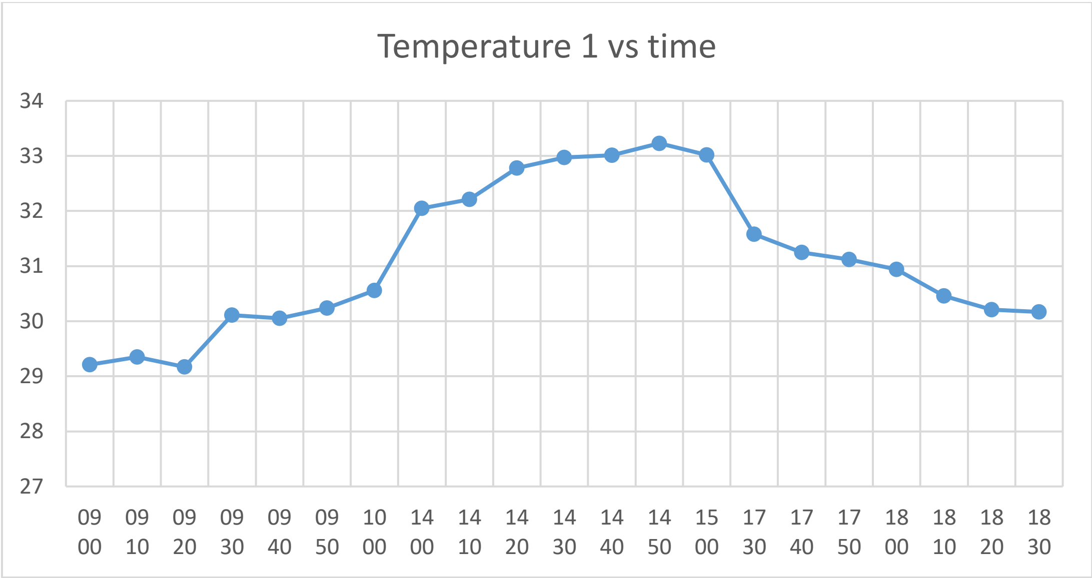

Fig:5.4.5 Temperature 1 vs Time graph

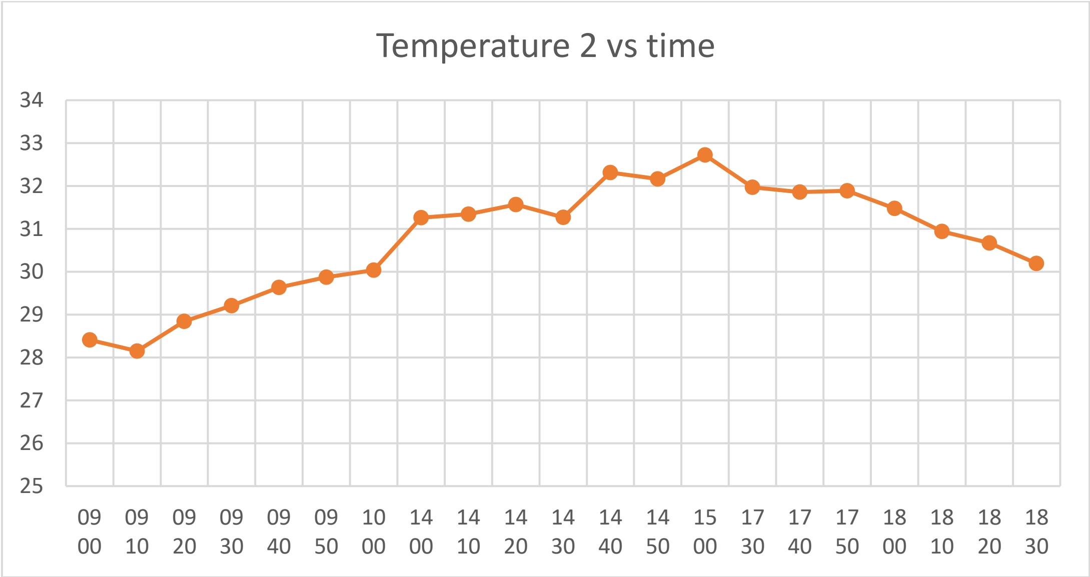

Fig:5.4.6 Temperature 2 vs Time graph

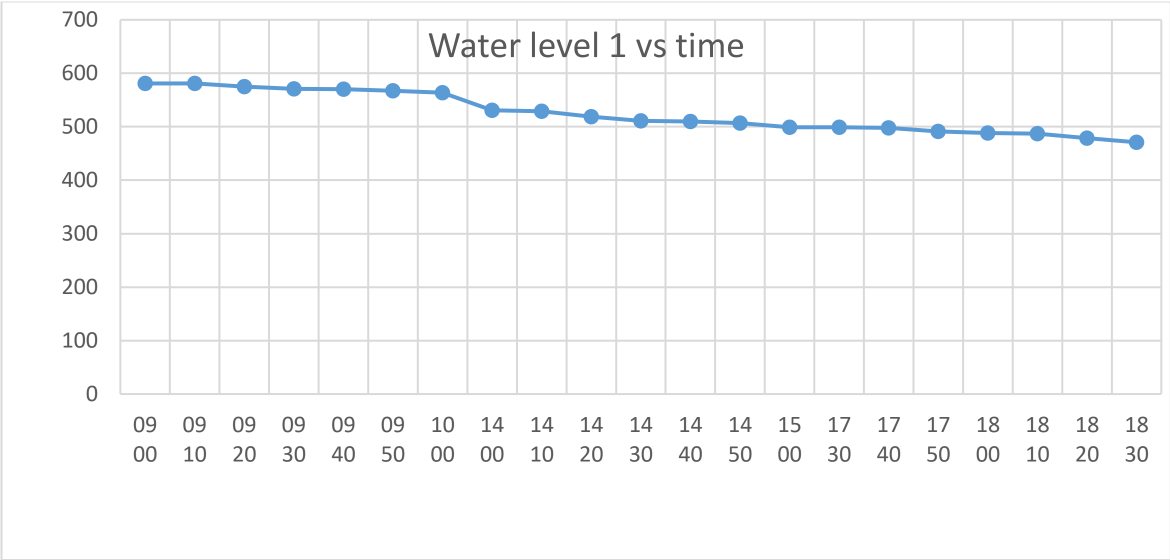

Fig:5.4.7 Water level 1 vs Time graph

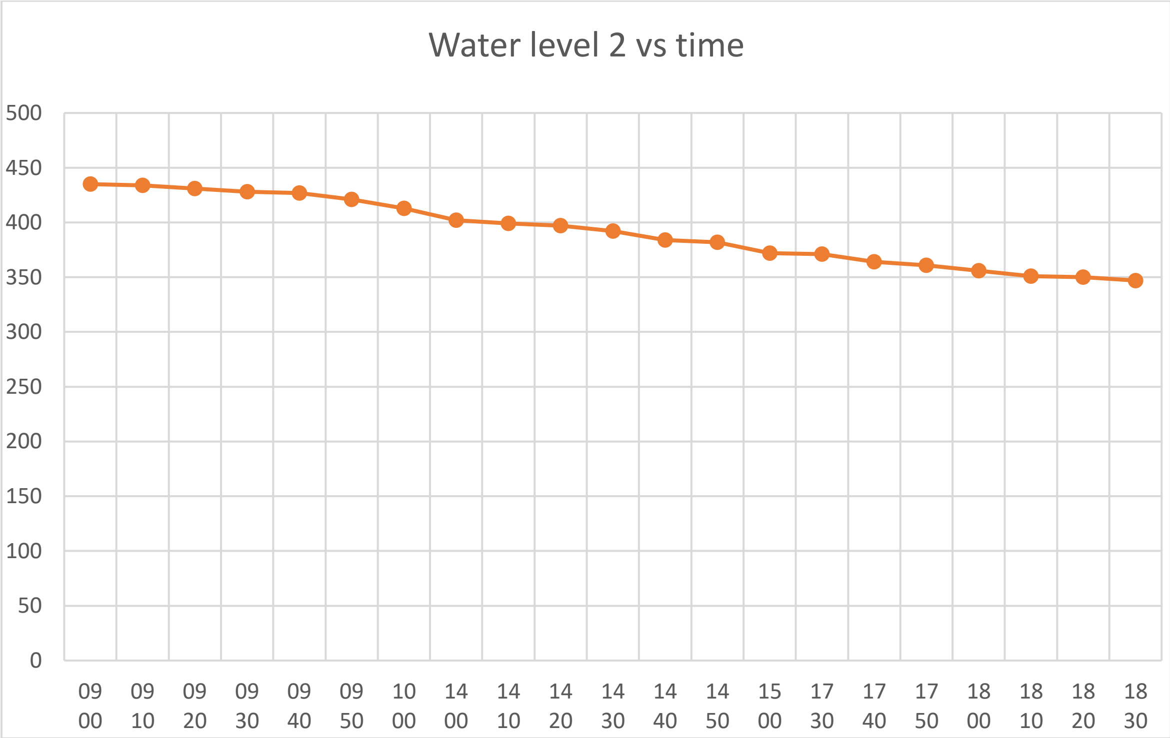

Fig:5.4.8 Water level 2 vs Time graph

The conclusion that can be drawn from all of the above graphs is that, the water parameters do not change at a huge rate in between two days. If we take a look on the pH vs time graph, it is clear that the values of pH of day 1 and day 2 are almost identical. There is no mentionable change. Temperature change in water is as same as the weather condition of the respective days. There is change in water level, if we look at the water level vs time graphs it gives an output that on day 1 the water level was high at the beginning and gradually it came to medium level. On day 2 while we took the values the reading showed us that the water level was medium in the morning and slowly it came to low level. This is due to temperature change and the movements of fishes. Basically, it indicates that the farmers do not need to change water frequently. They can add just a small amount to keep the water level at optimum range rather than making drastic changes like refilling the entire tank. This saves their time, labor and cost as well.

Chapter 6

Observation and Discussion:

We have done the project to get the exact values of water parameters that are necessary for aquaculture. Our main goal is to use scientific methods for aquaculture so that we can ensure good health of fish, less labor, maximum productivity with minimum waste. As for aquaculture these parameters play a vital role, if these parameters optimum range changes drastically it can be fatal for the fish. So, to ensure perfect optimum range at any time, continuous measurement is necessary but as for aquaculture fish (Biofloc or pond) measuring these parameters are quite a hassle. It takes a lot of effort and labor as most of our fish farms use traditional methods of measuring these parameters.

From our project we have successfully managed to get the exact values of the parameters by using a smart water monitoring device which we have constructed. These devices not only provide the exact values but also reduce the hassle to measure the parameters in traditional methods. As fish health and activity is directly related to these parameters we can make sure that these parameters lie in the optimum range where they would be healthier, active and fertile. And for this to be ensured no extra labor is required.

As we get the exact values for the parameters it becomes easier for us to take the precautions before it becomes lethal for the fishes especially during the reproductive season as it is the most important time for production. So taking precaution and ensuring the optimum range of the parameters we can increase productivity by a large amount.

As most of the fish farms specially Biofloc farms use oxygen, chemicals, and change water frequently without knowing the exact time to use these which cost them extra money that usually get wasted. So by using our constructed device we can also minimize this waste of money also.

All these observations were noted during the visit of a BIOFLOC of Mr. Rassel located Jalessor, Savar where our smart water monitoring has a great effect on the Biofloc. After creating all the necessary steps, we have done a case study to check the effect of it. First, we get to know about the process he obeys to run the Biofloc. He changes the water every two days and uses by hand checking of pH and water color. He doesn’t know about the temperature and water level so he doesn’t check it and changes the water every 2 days as he thinks this will balance the water element. When we examined his Biofloc for two days without changing the water we found out that there is no such drastic change in pH, water level, temperature and ammonia which can be visibly shown

Chapter 7

Conclusion and Future development scopes:

In this era everything is gradually getting connected with modern technologies. Even the world population is also increasing gradually. By using technologies in every aspect of our life, the demands of this increasing population are maintaining gradually. But unfortunately in some areas there are yet to use modern technologies for example fisheries. In most of the fisheries of our country still uses traditional methods for aquaculture. If they can use technologies incorporating with fisheries the amount of productivity will increase with a very significant number. So to make correlation between fish farming and technology we have developed the system called smart water monitoring device. We have integrated different types of sensors like pH, temperature, water level with microcontroller unit which are capable of collecting the important data that are necessary for fish health and productivity. If fish farms use our technology they will be hugely benefitted. As they will get opportunity to measure the water parameters continuously without any extra labor, they can maintain the optimum level of parameters at any time, any difficulties of fish that is caused by the fluctuation level of parameters can be known, can take appropriate action if there's any difficult situation comes, as they will not need to change water frequently and use chemicals unnecessarily they can save a big amount of money, most important by using this technology we can keep the fish healthy, active and more productive. Our device will be very much beneficial during the reproductive season as at that time the water parameters affect the most on production. Slight change on the parameters will be noticeable through our device so that farmers can take necessary action. However, in future IoT can be implemented with our device so that we can get access of the data from anywhere. Also, a mobile app can be developed so that any unusual change in water can be transferred directly to the farmers using push notification automatically. Even in near future image processing can be implemented to our system by which we can directly see the fish growth, activity along with the parameters. So that any difficulties can be noticed during any change of parameters. So we can say that using our device will play a vital role in aquaculture. As we will be able to increase the production of fish which will eventually meet the demand of the ever growing population, keep the fish healthy by decreasing the production cost by huge margin, incorporate technology with fish farming.

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Appendix

Specification of Arduino

- Microcontroller: ATmega328P – 8-bit AVR family microcontroller
- Operating Voltage: 5V
- Recommended Input Voltage: 7-12V
- Input Voltage Limits: 6-20V
- Analog Input Pins: 6 (A0 – A5)
- Digital I/O Pins: 14 (Out of which 6 provide PWM output)
- DC Current on I/O Pins: 40 mA
- DC Current on 3.3V Pin: 50 mA
- Flash Memory: 32 KB (0.5 KB is used for Bootloader)
- SRAM: 2 KB
- EEPROM: 1 KB

Specification of analog pH sensor

- Module Power: 5.00V
- Module Size: 43 x 32mm (1.69x1.26")
- Measuring Range :0 – 14pH
- Measuring Temperature: 0 - 60 ℃
- Accuracy: ± 0.1pH (25 ℃)
- Response Time: ≤ 1min
- pH Sensor with BNC Connector
- pH2.0 Interface (3-foot patch)
- Gain Adjustment Potentiometer
- Power Indicator LED

Specification of temperature sensor

- Sensor type: Pt 100
- Range: -55º to 125º C
- Accuracy: ± 0.5º C
- Calibration: DIN IEC 751
- Operating Voltage: 3-5 VDC
- Dimension (Φ x L): 8 x 135 mm
- Cable: 3 cores shielded

Specification of water level sensor

- Temperature range: -20º to 80º C
- Trace: 10 copper traces
- Pin: 3 Pinouts
- Module Power: 3.3V-5.00V'