FISH GROWTH MONITORING

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by

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COMPLETION CERTIFICATE

This is to certify that the dissertation report "FISH GROWTH MONITORING" is a bonafide work carried out by Mr Rutik Shanbhag, Mr Kunal Vaze, Mr Narayan Gaonkar under my supervision/mentorship in partial fulfilment of the requirements for the award of the degree of **M.Sc** in Electronics Discipline at the School Of Physical & Applied Sciences, Goa University.

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We would like to express our gratitude to our families and close friends for their unfailing support and inspiration during this project.

DECLARATION BY STUDENT

We hereby declare that the data presented in this Dissertation report entitled, "FISH GROWTH MONITORING" is based on the results of investigations carried out by me in the Electronics Department at the School of Physical and Applied Sciences, Goa University under the Supervision/Mentorship of Prof. Rajendra S. Gad and Dr. Jivan S. Parab and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities will be not be responsible for the correctness of observations / experimental or other findings given the dissertation.

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ABSTRACT

As the population is increasing at enormous rates, there will be a time in future where the problem of food shortage will be arising. Due to this reason we are already over exploiting the soil resources. When the soil is over exploited, we will have no other choice but to move to water resources. There will be a very high demand for the produce produced from the water resources.

The natural water resources are exploited due to over fishing. At that time we have to move to aquaculture to support the food chain and to maintain the balance. The aquaculture will be the future. The aquaculture industry will be a booming industry. To make aquaculture a technology friendly technique, we have interfaced it with IOT based system.

The water parameters such as Temperature, pH, TDS are very important to sustain the aquaculture system. After interfacing it with IOT we can monitor the water parameters such as Temperature, pH, TDS. Monitoring of this system will be very important, to take the decision like doing water change or to add some chemicals to maintain the pH and TDS. And also the relay was interfaced to control the heater to maintain the temperature of the system.

FISH GROWTH MONITORING

Chapter 1

INTRODUCTION

1.1 FISH FARMING

Fish farming as it was once practiced entailed the capture of young animals, which were then raised under ideal circumstances, including being well-fed and safe from predators and competitors for light and space. Farmed fish can be housed in constructed aquatic impoundments, such as ponds, tanks, or concrete pools, as well as in natural waters, such as in blocked coastal waters or in cages dangling in open water. The animals can be fed adequately and shielded from numerous natural predators in these enclosures. Fish farming is the practice of rearing fish for human consumption in tanks or other enclosed spaces for commercial purposes.

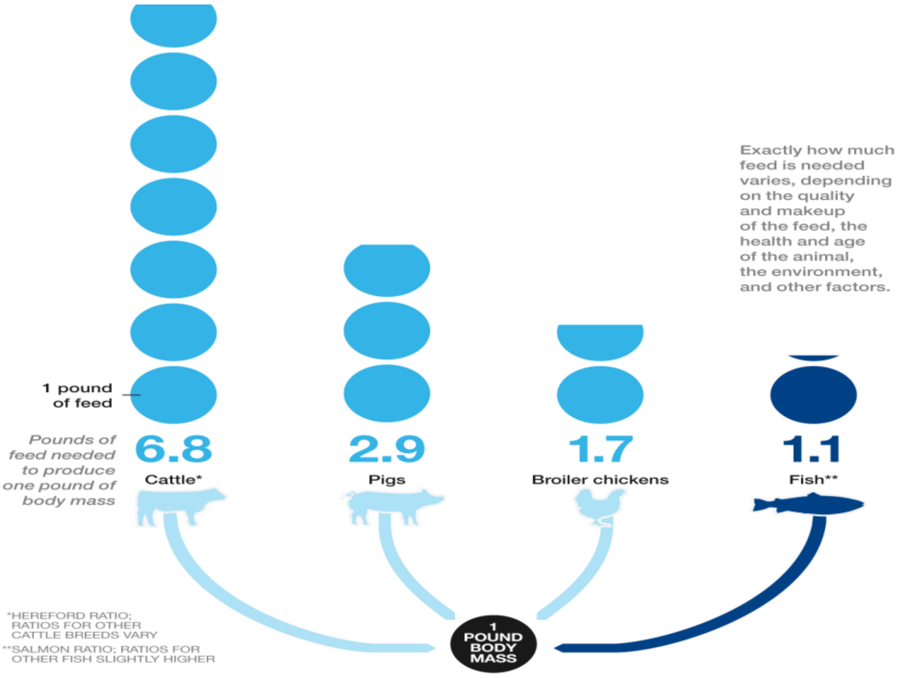


Figure.1. Animal feed consumption to produce 1 pound of body mass.

The above picture gives the clear representation of how economical is aquaculture when compared to other animal rearing. Here in very small amount of resource a very good profit can be made as compared to other animal rearing.

The image given below shows the consumption of seafood in the year 2015 and also gives a rough estimation on how the demand for seafood will be increasing in the future. It also gives the bifurcation of the fish that came from wild and the fish cultured in the farms.

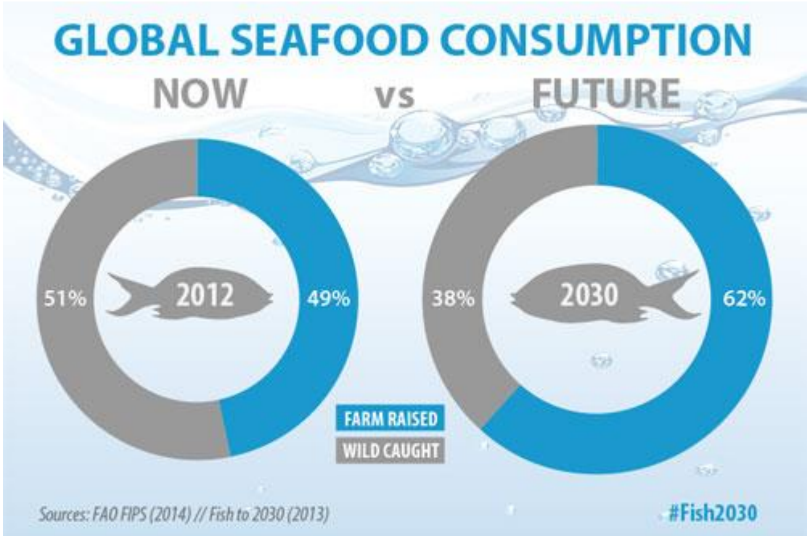


Figure.2. Global seafood consumption.

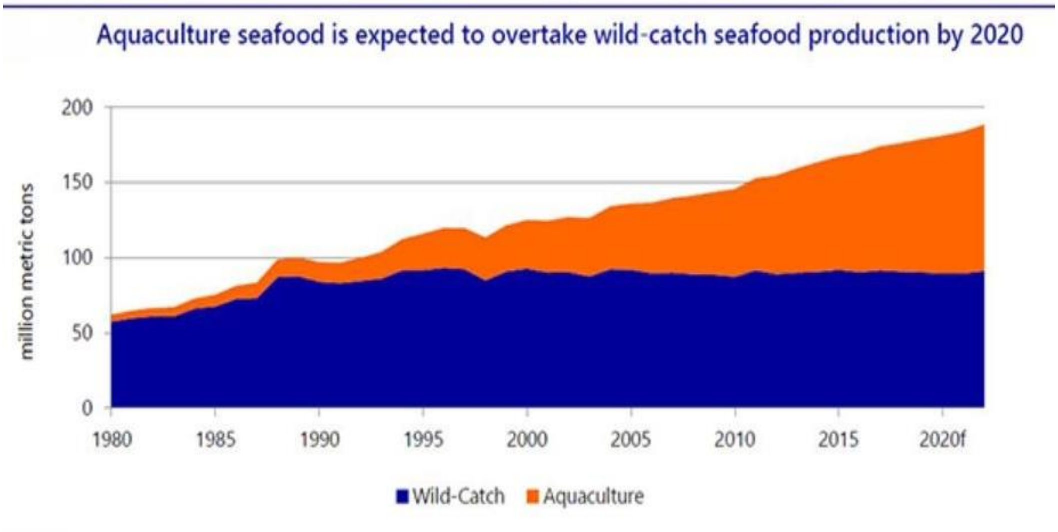


Figure.3. comparison between wild caught and cultured seafood.

1.2 AQUACULTURE

Aquaculture, often known as fish farming, fish culture, or mariculture, is the commercial, recreational, and academic production and care of aquatic animals, and other species. Aquaculture, or the raising of specific marine and freshwater species to supplement the natural supply, can be thought of as the aquatic version of agriculture. This includes production for stocking sport fisheries, for supplying aquatic bait animals, for stocking fee-fishing operations, for providing aquatic organisms for ornamental purposes, for supplying feed stocks to the pharmaceutical and chemical industries, as well as for providing food and industrial products. These actions can be practiced anywhere with sufficient land , capital and knowledge .

Figure.4. Aquaculture

From 500 BCE aquaculture started. However, its commercial significance has only grown since the middle of the 20th century. The cultivation of rather expensive species that are regularly consumed as a fresh product has played a significant role in the fast spread of aquaculture. Shrimp, crayfish, prawns, trout, salmon and oysters are some examples. The production of catfish, carp, and tilapia, which are raised in huge low-energy systems, is rising as well. For instance, since it started to expand in the 1960s, catfish aquaculture in the United States has more than quintupled its output. Some of these freshwater fish are also employed in aquaponics, a hybrid farming method that combines hydroponic plant cultivation with aquaculture; the plants are fed fish excrement.

There are various fish farms that use various aquaculture techniques.

1.2.1. CAGE CULTURE

The first technique uses cages that are positioned in fish-populated lakes, ponds, and oceans. This process is also frequently known as offshore cultivation. Fish are "artificially fed" and harvested while being housed in the cage-like structures. Over the years, the fish farming cage system has seen a number of technological advancements, particularly with regard to lowering illness and environmental problems. Fish escaping and getting loose among the wild fish population is the main worry with the cage method.

Figure.5. Fresh water cage culture

Figure.6. Marine cage culture

1.2.2. PONDS

The second option is to raise fish in ponds or irrigation ditches. A ditch or pond that can contain water is a necessary component of this strategy. Because fish are intentionally fed on a limited scale and the waste they create is then utilized to fertilize farmers' fields, this approach is unusual. The pond is self-sustaining on a wider scale, primarily in ponds, where it generates plants and algae for fish food.

Figure.7. Mud Pond

In India this type of fish farming is practiced the most. This kind of fish farming doesn't require much capital, a person with sufficient land and water source can easily practice it.

1.2.3. COMPOSITE FISH CULTURE

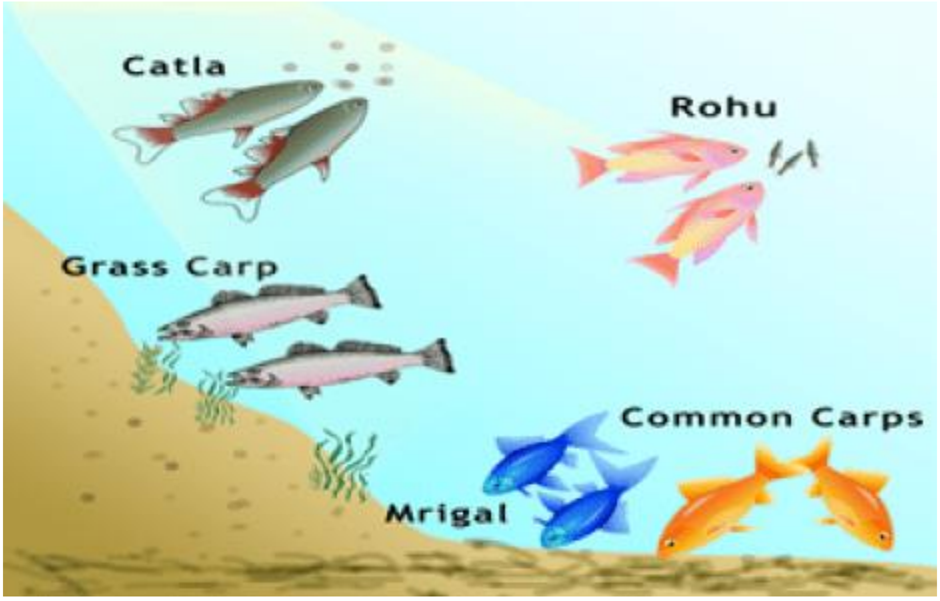


Figure.8. Composite Fish Farming

Composite fish farming the third method of raising fish, is a sort of fish farming that enables native and foreign fish species to cohabit in the same pond. However there might be up to six different fish species in a single pond. To guarantee that species may cohabit and lessen competition for food, the fish species are always picked with care.

1.2.4. INTEGRATED RECYCLING SYSTEM

The fourth technique is Integrated Recycling System. The foundation of the Integrated Recycling System is the idea that there is no waste, as well as a well-known technique for "pure" fish farming. In the Integrated Recycling System, hydroponic beds are situated close to big plastic tanks that are housed inside a greenhouse. The reason it is named "no waste" is because the fish feed waste and tank water are slowly circulated to the hydroponic beds, where plants are produced in nutrient-rich soil.

Figure.9. Integrated Recycling System

This technology adapts to practically all temperate regions because it exists in a greenhouse. This fish farming system's main goal is to boost edible fish output while raising the productivity of the water and related resources.

The main advantages of this approach are a reduction in waste production from farming operation as a whole and more environmentally responsible farming practices.

1.2.5. RECIRCULATORY AQUACULTURE SYSTEM (RAS)

Recirculatory Aquaculture System (RAS) is a fifth technique that uses mechanical and biological filtration to remove suspended particles and metabolites from water before recycling and reusing it. This technique uses the least amount of water and land possible to cultivate several fish species in high density. The RAS system is kind of a subset of Integrated Recycling System because in RAS plants are not a part of the system, it is only the culture of fishes.

Figure.10. RAS

CHAPTER 2

LITERATURE SURVEY

1. IOT Based Aquaculture Monitoring and Control System.

The practice of growing fish and other aquatic life is known as aquaculture, and it has the ability to feed the entire planet during lean times. The system's monitoring and upkeep are its most crucial components. Farmers currently use manual meters to manually monitor the system over a predetermined period of time. An automatic monitoring system is required for the convenience of monitoring. An impending breakthrough for all the smart devices to connect people remotely is the Internet of Things (IOT). Various sensor nodes are utilized in farming systems to monitor the water parameter. The wireless sensors networks (WSN) are made up of numerous sensor nodes placed throughout a monitoring area to gather, transmit, and process data. The project's primary goal is to remotely monitor the farming system using various sensors to measure water parameters. This will save time, money on labor, and also reduce dangers.

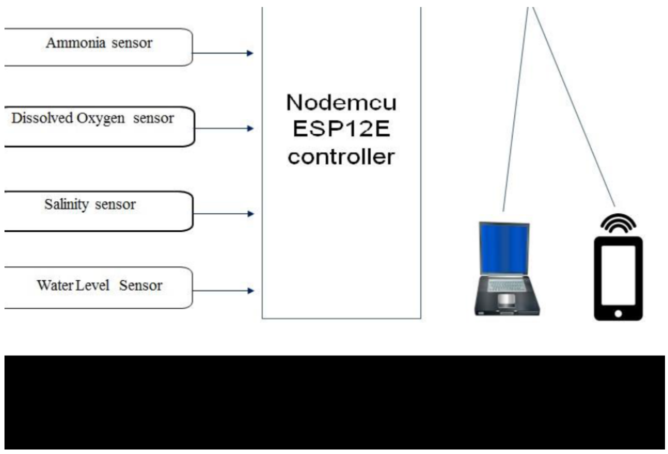


Figure.11. Sensors interfaced with esp.

This research presents a remote monitoring system using the concept of IOT for aquaculture water quality. In future the sensors will be submersed in water for the entire farming system as the data would be helpful before harvesting and some other important sensors can also be added if required according to the environment.

2. A Wireless Sensor Network for Aquaculture Using Raspberry Pi, Arduino and Xbee.

The wireless sensor network prototype for an aquaculture prawn pool is presented in this research. A Raspberry Pi 3 is connected to an Arduino Uno, an Xbee S2C module, a temperature sensor (DS18B20), as well as additional components like a fan, an aerator, a light, a DC motor, and a camera in the system design shown in this paper. The findings of this study assist farmers to log in to an Apache server to check the temperature and manage their pools by automatically turning on fans when it gets hot, turning on/off aerators via the internet, controlling a DC motor within 100 meters via the Zigbee protocol, or taking pictures every five seconds to check on their pools from a distance.

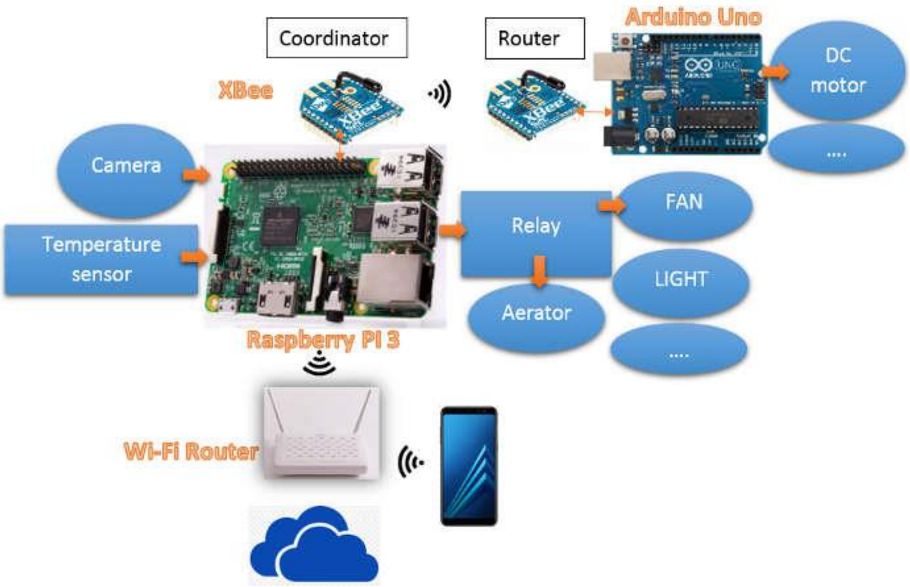


Figure.12. wireless sensor network

In order to control the temperature of water by automatically turning on or off a FAN or enabling an aerator, light, DC motor, and camera, this study discussed the creation of a wireless sensor network utilizing the Raspberry Pi, Arduino, and X-bee module. This prototype will be upgraded using a DO sensor and tested in an actual environment, or data is plotted and a temperature-changing graph is drawn.

3. IOT Based Smart Fish Farming Aquaculture Monitoring System.

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. This uses low cost and short-range wireless sensors network module to monitor and control aquaculture in real-time. By using this system parameter 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.

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 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.

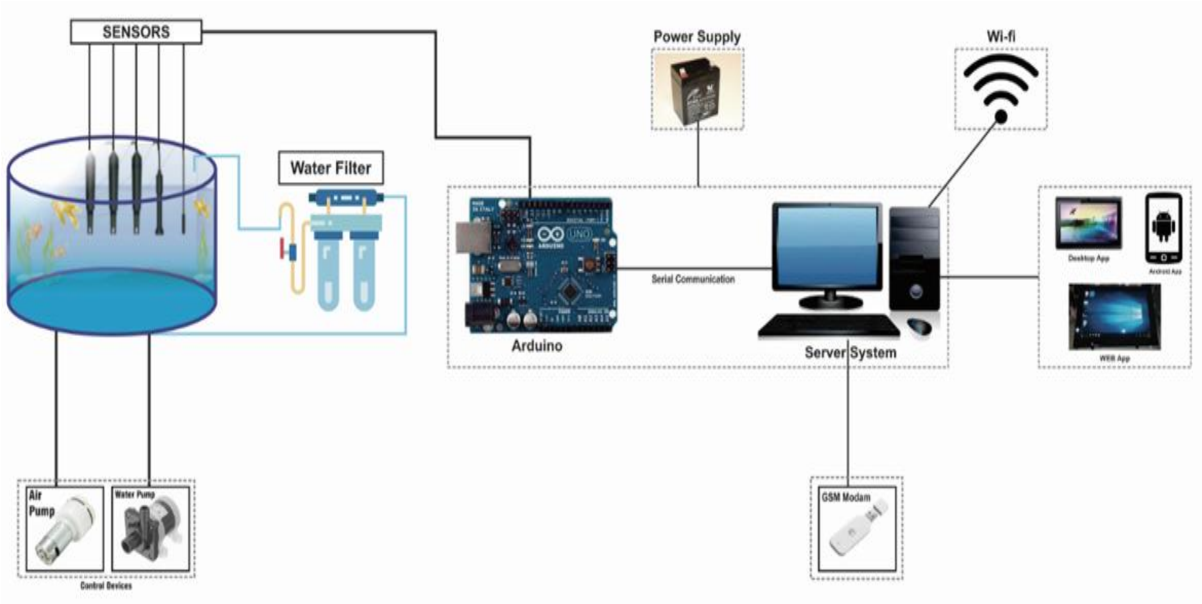


Figure.13. iot based aquaculture

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.

4. An internet of things framework for real-time aquatic environment monitoring using an Arduino and sensors.

Aquaculture is the farming of aquatic organisms in natural, controlled marine and freshwater environments. The real-time monitoring of aquatic environmental parameters is very important in fish farming. Internet of things (IOT) can play a vital role in the real-time monitoring. This paper presents an IOT framework for the efficient monitoring and effective control of different aquatic environmental parameters related to the water. In the used architecture the researchers have used 3 sensors temperature, pH, Turbidity sensors. Every sensor I connected to Esp32 with the help of various pins. The real time data from the sensor is directly uploaded on the server.

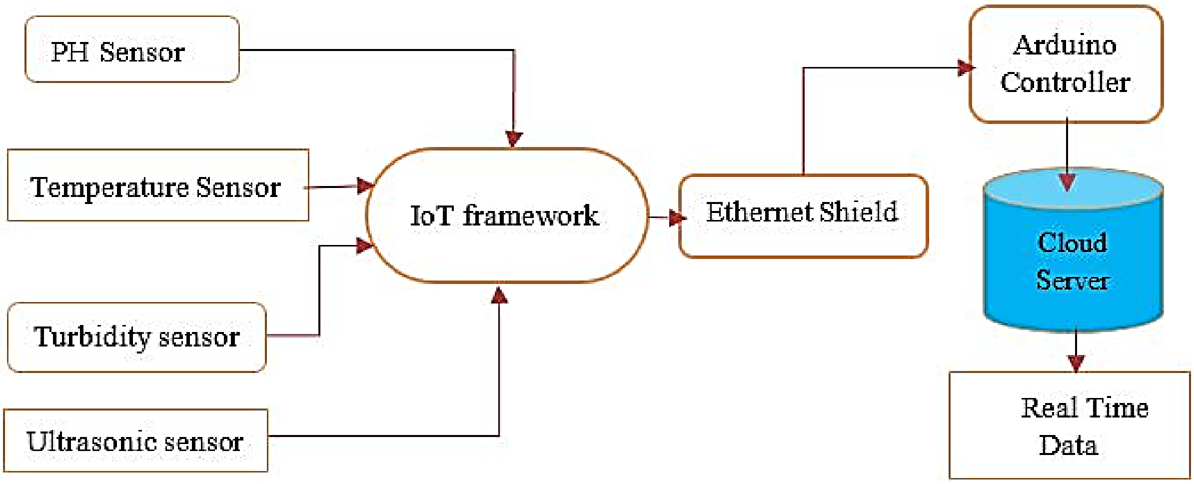


Figure.14. Iot network

In this paper, an automated IOT framework for real-time data monitoring is proposed and successfully instigated using diverse sensors and circuits as demonstrated. As the proposed model is automatically controlled, it will help the farmers to properly monitor their ponds. The implementation enables the sensor to provide data to the ThingSpeak server.

5. IOT-based smart monitoring and management system for fish farming.

For remote monitoring and control in fish farms, computer and communication equipment is required. The design and implementation of an internet of things (IOT)-based system for real-time fish farming monitoring, control, and management are the topics of this study.

Such a system's design is based on collecting data from various measurements and using it to regulate fish growth and boost output.

The node includes a wireless communication module, a set of sensors, actuators, and an integrated microcontroller. Utilizing three environmental sensors in addition to five sensors in each pond, two fuzzy controllers are created to regulate both the environment and the water quality in the ponds.

The suggested IOT-based system's major goal is to plan and implement real-time monitoring and control of fish farms in order to provide a secure environment at the lowest possible cost. For each pond, a collection of sensors connected to an embedded microprocessor with a wireless module can be chosen to do this. In order to automatically adjust the water quality in the ponds and the surroundings that influence fish growth, two fuzzy controllers were utilized. IOT technology has made a significant contribution to the wireless information transfer between system components. Real-time measurements and important alerts are also given to the farmer through cell phone or the internet.

6. Arduino based Fish Monitoring System.

Fish monitoring system is essential because many people love to grow fishes as their pet in the home. In our day-to-day life, it is difficult to monitor the aquarium tank regularly. As a consequence, it causes mortality of the fishes. The quality of water might be the main issue. It mainly depends upon parameters such as carbonates, ammonia, nitrates, salt, pH, temperature, turbidity, dissolved oxygen, etc. To maintain these parameters, various sensors are used in the fish monitoring system. This will increase the production of fishes and decrease mortality.

7. Principles of Water Recirculation and Filtration in Aquaculture.

Recirculating water systems are designed to minimize or reduce dependence on water exchange and flushing in fish culture units. A very small amount of water is replaced when needed otherwise the water is just recirculate after passing it through a filter, containing bio media and filter pads.

8. Aeration, filtration and disinfection in aquaculture.

Aeration

Oxygen is one environmental parameter that exerts a tremendous effect on growth and production through its direct effect on feed consumption and metabolism and its indirect effect on environmental conditions. For the aeration there are different methods such as air blower, oxygen cylinder etc.

Filtration

Removal of particles from a water flow in important in aquaculture. Suspended solids, dissolved solids and organic matter were removed from water by filtration of water through suitable media.

Disinfection

There are various techniques for sanitizing water. There are two types of disinfectants: chemical and non-chemical ones. Disinfectants are categorized into four groups: (i) chemical agents; (ii) physical agents; (iii) mechanical agents; and (iv) radiation. Although there are numerous ways to disinfect water, the quality of the water before disinfection is crucial. Compared to outlet water, which contains more particles, pure inlet water is considerably easier to disinfect.

9. Deep Learning-Based Fish Detection in Turbid Underwater Images.

The recognition of fish in photographs with high turbidity and background noise is a challenge. In order to identify them and follow their paths, it is crucial to be able to recognise fish in cloudy and background noisy water. Two separate cameras were used to record videos from the Ceyhan section of Kahramanmara's reservoir basin for this study. Then, a brand-new data set with 400 photos is shown to aid in the discovery of fish in the wild. The most recent detection models, YOLO-V2, YOLO-V3, YOLO-V3 Tiny, and Mobile Net- SSD networks, are trained on this data set using a fine-tuning technique, and their performances are then compared for precision, recall, and mean Average Precision (mAP).

10. Research on the Growth Model of Aquaculture Organisms Based on Neural Network Expert System.

The growth of the aquaculture organisms will be more favourable in waters of high quality. It has the potential to increase aquaculture's economic value and is crucial to the advancement of water aquaculture. In this paper, the main research question is how to develop an artificial neural network-based expert system model of the growing state of aquaculture organisms.

11. Intelligent Deep Learning Based Automated Fish Detection Model for UWSN.

UWSNs, which are networks of underwater vehicles and sensors used to monitor the environment, are frequently employed to take advantage of such chances. It is exciting to develop an automated fish detection method in this scenario to quantify and track fish biomass in water bodies using underwater films and computer vision techniques. Mask Region Convolutional Neural Network (Mask RCNN) is used for fish detection. This model uses fish motion information from video, integrating the results with actual images to create candidate zones that depend on fish.

12. Detection, Localization and Classification of Fish and Fish Species in Poor Conditions using Convolutional Neural Networks.

This paper presents the first steps towards a system that can define fish schools in underwater photos. The Optical Fish Detection Network (OFDNet), a deep convolutional neural network, is introduced for this purpose. This uses visual data from underwater cameras to perform the tasks of fish detection, localisation, and species classification. It is built on cutting-edge deep learning object detection architectures.

13. Automatic fish detection in underwater videos by a deep neural network-based hybrid motion learning system.

Using a Region-Based Convolutional Neural Network, a cutting-edge machine learning technique used .we offer a unified strategy to recognise freely moving fish in unrestricted underwater environments. We use a novel method to train the neural network that makes use of fish motion data from movies by using background removal and optical flow, and then we integrate the results with the original image to provide fish-dependent candidate regions. To test the efficacy of our hybrid strategy, we employ two benchmark datasets taken from a sizable Fish4Knowledge underwater video repository: the Complex Scenes dataset and the Life CLEF 2015 fish dataset.

14. UNDERWATER FISH SHAPE RECOGNITION IN MALAYSIAN SEAWATER BY USING CHAIN CODE TECHNIQUES ALGORITHM IN REAL TIME IMAGE PROCESSING.

The system created is for classifying the types of fish in the seawater of Malaysia. In this paper, a MATLAB-based algorithm for pattern recognition is proposed.

The purpose of a recognition system is to distinguish between different fish species based on the species' shapes. The gap between the chain code and the input fish image is calculated using the Minimum Sum of Absolute Difference (SAD) approach. Results from the experiment utilising a straightforward technique are satisfactory. This system has an efficiency of roughly 72%.

15. Multi-stream fish detection in unconstrained underwater videos by the fusion of two convolutional neural network detectors.

In this paper, we offer two new fusion methods that combine appearance and motion data for automatic fish detection by using two convolutional neural network (CNN) streams. These strategies combine two Faster R-CNN models that either use the same classifier or the same region proposal network. On the Life Clef 2015 Fish benchmark dataset, we dramatically enhance the fish detection performances as compared not just to the traditional Faster R-CNN but also to all other cutting-edge methods. F-score and mAP measures that perform the best are 83.16% and 73.69%, respectively.

16. Automatic segmentation of fish using deep learning with application to fish size measurement.

This study suggests a novel image-based technique for identifying individual fish. On the processing of stereo pictures obtained by the Deep Vision imaging system, the idea is built. In order to correct for camera response nonlinearities, the photos are pre-processed. Then, each individual fish in the photos is localised and segmented using a Mask R-CNN architecture. The boundary of each fish is then precisely estimated using local gradients after this segmentation has been made. This concept has the unique feature of being able to deal with congested photos with overlapping fish.

17. Effects of image data quality on a convolutional neural network trained in-tank fish detection model for recirculating aquaculture systems.

Four commercially available sensors were modified for the purpose of creating an imaging platform (RASense1.0) for the capture of underwater images. Information gathered from image sensors under two different lighting situations. A one-stage YOLOv5 model was used to supplement and train the annotated photos. Model accuracy did not appear to be much impacted by light conditions, but sensor selection had a significant impact on model precision, recall, and mAP. Both models outperformed a two-stage Faster R-CNN in terms of mAP scores when their performance was compared, however the training time for the one-stage YOLOv5 was 6–14 times shorter.

18. Impact evaluation of deep learning on image segmentation for automatic bluefin tuna sizing.

Convolutional neural networks are suggested as a method for segmenting and detecting fish in videos taken in realistic settings. The findings demonstrate that the process of fish sizing has been improved as a result of the development of fish picture instance segmentation. In particular, utilizing Mask R-CNN and the Point Rend module enhances the number of fish measurements by up to 2.45 times, improving the accuracy of the fish length estimation. It also increases the number of measurements per minute of computing time by up to 3.5 times.

Our solution uses a stereoscopic vision system and a deformable model of the fish's silhouette, both from the ventral and dorsal views, to produce extremely precise fish length estimations in adolescent bluefin tuna. The number of segmented instances, the time needed to segment an instance, and the accuracy of the fish sizes attained all show that employing CNN results in a significant improvement.

19. Extracting fish size using dual underwater cameras.

The creation of the proper optical ranging system and the automation of data collection are prerequisites for the definition of a remote system in the monitoring of fin fish growth rate and shape modification. Images are gathered using a cheap, submersible dual camera module that is connected to a mobile, water-resistant PC with two frame grabbers. To get information on fish size and shape, two photos are synchronically taken. In order to correct the measurement inaccuracy, a neural network is constructed. The suggested approach can be utilized to monitor sea-based fish farming facilities, especially those that are continuously underwater, minimizing diver intervention and lowering fish sampling-related stress and mortality.

20. Modelling framework for establishing the power law between length and weight of fishes and a meta-analysis for validation of LWRs for six commercially important marine fishes from the north-western Bay of Bengal.

The erroneous LWRs were identified as doubtful reports by carefully scrutinizing the outliers obtained from Cook's distance method and subsequently validating them by observing their dispersion from modelled prediction intervals (PI) and interquartile range (IQR) based outlier detection methods using the form factor analysis. The study presents the decision support framework for an appropriate modelling approach while dealing with certain assumptions such as variance normality and homoscedasticity. The study also describes a combined approach for the validation of derived LWRs by a comprehensive meta-analysis.

21. Weight Prediction System for Nile Tilapia using Image Processing and Predictive Analysis.

This paper presents a low-cost monitoring and Hough gradient method-based weight prediction system for Nile Tilapia (Oreochromis niloticus) using Raspberry Pi microcontroller and two low-cost USB cameras. This study aims to improve fish growth rate through monitoring the growth of the fishes with image processing eliminating the traditional way of obtaining fish measurements. By using paired t-test, the acquired values imply that the weight algorithm used to measure the weight of the fishes is accurate and acceptable to use.

22. Weight Estimation of Asian Sea Bass (*Lates calcarifer*) Comparing Whole Body with and without Fins using Computer Vision Technique.

An optimal model to evaluate the weight of the whole body of Asian sea bass with and without fins was generated using computer vision image processing techniques. Image data of 25 fish randomly selected were collected every week for one month. The data were divided into two sets by means of a 40 - 60 % split-test, 40 % (10 fish; 100 images) were used as training data and 60 % (15 fish; 150 images) were used as out-samples or validation data.

Comparison between models, with and without fins, and normal manual measurement methods found no statistically significant differences ($P > 0.05$). Therefore, this technique may be applied for weight estimation in real pond conditions to give advantages of reduced time, stress and injury, with minimal interference in fish feeding compared to physical capture and weighing.

23. Effect of temperature, pH, and salinity on body weight of Asian Seabass (*Lates calcarifer*) at different stockings.

The Asian Seabass farming can be successful with optimum environmental conditions. Water quality as a culture media must always be maintained to suppress the occurrence of pathogen attacks on fish. The study aims to determine the effect of temperature, pH, and salinity in the maintenance of body weight Asian Seabass (*Lates calcarifer*) at different stocking. The field experiment method was applied in this study using a 6.28 m3 tank using 2 treatments, namely P1 (density 1000) and P2 (density 1400) fish measuring 2-3 cm for 30 days. Parameters observed included observations of growth and water quality (temperature, pH, and salinity). The result showed that there was an effect of temperature, pH, and salinity on the growth of Asian Seabass. The temperature, pH, and salinity showed an effect on body weight by P1

(35.2%) and P2 (28.9%). The conclusion of this study is that the density of 1000 shows a higher effect that the density of 1400 on the growth of Asian Seabass.

24. Estimation of length-weight relationship and condition factor of spotted snakehead Channa punctata (Bloch) under different feeding regimes.

Comparative study was conducted to observe the efficacy of different feeding regimes on growth of Channa punctata. Six iso- proteinous diets were prepared by using different agro industrial by-products. Maximum weight gain was recorded with diet having 66.75% rice bran, 11.50% mustard cake, 23.0% groundnut cake, 5% molasses,1.5% vitamin-mineral mixture and 0.5% salt with specific growth rate of 0.408. The experimental fish recorded the value of exponent 'b' in the range of 2.7675 to 4.3922. The condition factor 'K' of all experimental fish was above 1.0 (1.094- 1.235) indicating robustness or well-being of experimented fish.

25. Estimating Mass of Harvested Asian Seabass *Lates calcarifer* from Images.

Each fish was digitally photographed and weighed. A subsample of 200 images (100 from each location) were manually segmented to extract the fish-body area (S in cm2), excluding all fins. After scaling the segmented images to 1mm per pixel, the fish mass values (M in grams) were fitted by a single-factor model ($M = aS1.5$,$a = 0.1695$) achieving the coefficient of determination (R2) and the Mean .Absolute Relative Error (MARE) of $R2 = 0.9819$ and $MARE = 5.1\%$, respectively. A segmentation Convolutional Neural Network (CNN) was trained on the 200 hand-segmented images, and then applied to the rest of the available images. The CNN predicted fish-body areas were used to fit the mass-area estimation models: the single-factor model.

26. Length weight relationship in the Asian seabass, lLatescalcarifer (Bloch) under cultured condition.

Asian *seabass, Lates calcarifer* (Bloch) - a catadromous centropomid perch, is a good candidate species for brackish water aquaculture in India. The length-weight relationship and the relative condition of *L. catcarifer* were assessed under culture condition. The length of the fish samples ranged from 25 to 240 mm and the relative condition (wr) of the fish for different length groups ranged from 99.54 to 104.39, indicating the good condition of the fish. The regression analysis of log-transformed length-weight data was carried out and the 'b' coefficient indicates the good condition of fish showing an isometric growth in the juvenile phase under culture condition.

27. Length-weight relationship and relative condition factor of Asian seabass, Lates calcarifer (bloch) from Chilika Lagoon, Odisha.

The length-weight relationship and relative condition factor of Asian seabass Lates calcarifer (Bloch) was estimated based on the length and weight data collected from Chilika lagoon during March, 2008- February, 2009. The total length of fishes ranged from 20.0 to 113.70 cm and wet weight of fishes ranged from 500 to 3394.00 g. The length-weight relationship was estimated as W= 0.003 L2.890 and the size wise relative condition factor (Kn) fluctuated from 0.90 to 1.11. The ‘b’ value indicated that the growth pattern is not isometric even though, the general wellbeing of fish inferred from relative condition factor (Kn) was suitable during the study period.

28. LENGTH TO WEIGHT RELATIONSHIP OF SEA BASS *LATES CALCARIFER* (BLOCH) REARED IN A CLOSED RECIRCULATING SYSTEM.

The length to weight relationship of sea bass, *Lates calcarifer*, reared for two years in our laboratory in an indoor recirculating system, was determined as follows: W (g) = 0.0107 TL (cm)3.0347, R2 = 0.9974. The values found in this study correspond to length/weight relationships found for a natural population by other researchers.

29. Length-weight relationships and prediction equations of body composition of farm raised Astyanax aff. Fasciatus (Actinopterygii: Characiformes: Characidae).

The length-weight relationship was elaborated using linear (yi = B0+ B1xi) or second-order (yi = B0 + B1xi + B1xi 2) regression analysis. The value of the b slope in the length-weight relationship was 3.6971 and the intercept was 0.0031. The prediction equations obtained for body moisture, crude protein, crude lipid and ash were, y = 71.680 – 0.404BW, y = 17.140 – 0.095BW, y = 8.432 +0.364BW and y = 3.720 – 0.032BW, respectively, where BW is the body weight of fish (g).

30. Taxonomy, identification and biology of Seabass (Lates calcarifer) Grace Mathew

Lates calcarifer (Bloch), commonly known as giant sea perch or Asian seabass, is an economically important food fish in the tropical and subtropical regions in the Asia –Pacific. They are medium to large-sized bottom-living fishes occurring in coastal seas, estuaries and lagoons in depths between 10 and 50m. They are highly esteemed food and sport fishes taken mainly by artisanal fishermen. Because of its relatively high market value, it has become an attractive commodity of both large to small-scale aquaculture enterprises. It is important as a commercial and subsistence food fish but also is a game fish.

2.1 LITERATURE SURVEY CONCLUSION

The Insights from some of the research papers are about the IoT based Automation system and machine learning. It highlights the main aspects like, How the IoT based Aquaculture system make it efficient to maintain the friendly environment for the fishes. The IoT based RAS system makes everything fast and easy to maintain the parameters of the entire system. By taking the highlights from the research papers the low-cost Cloud based IoT RAS system which includes the different types of sensors that are interfaced to a cheap microcontroller board was implemented.

In the case of Machine learning implementation in aquaculture system some research papers talk about the process of data acquisition and machine learning. Different methods like deep learning, hybrid machine learning, convolution neural networks were implemented by different researchers. Different pre-trained models like ODFNet[12], YOLO-V2 [9] YOLOv5[17] etc were implemented by different researchers. Different image processing algorithms like RNN, CNN[15], R-CNN[18] were implemented.

CHAPTER 3

RECIRCULATORY AQUACULTURE SYSTEM (RAS)

Recirculatory aquaculture systems (RAS) are a type of aquaculture system where water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. This method is used for high- density culture of various species of fish, utilizing minimum land area and water.

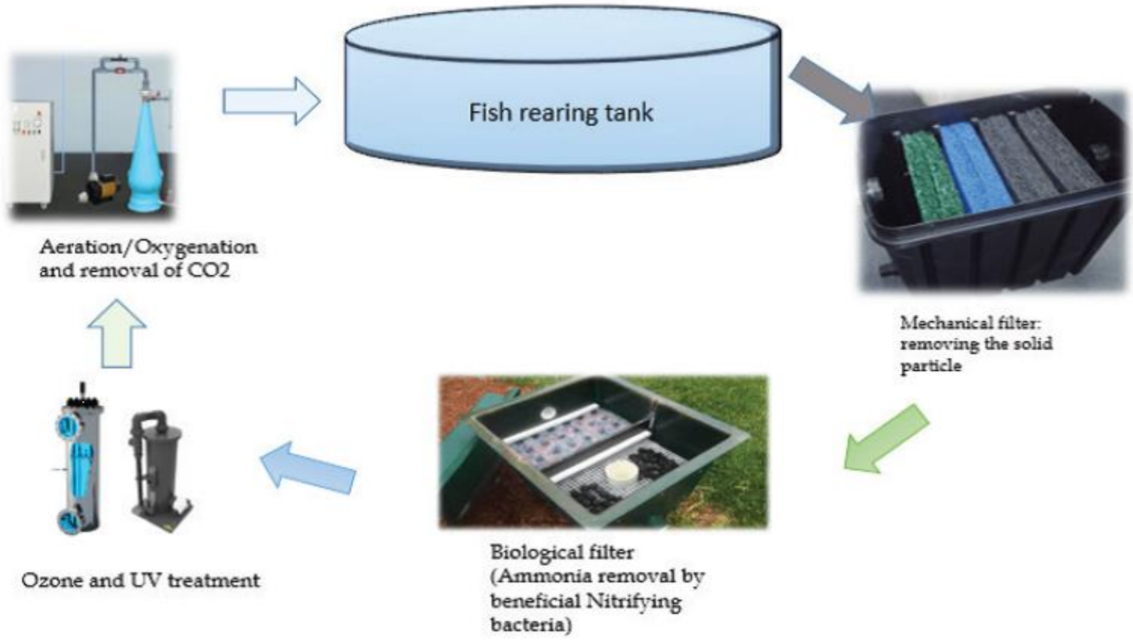


Figure.15. RAS Block Diagram

It is an intensive high density fish culture unlike other aquaculture production systems. Instead of the traditional method of growing fish outdoors in open ponds. In this system fish are typically reared in indoor/outdoor tanks in a controlled environment. Recirculating systems filter and clean the water by recycling it back to fish culture tanks. The technology is based on the use of mechanical and biological filters and the method can be used for any species grown in aquaculture. New water is added to the tanks only to make up for splash out, evaporation and that used to flush out waste materials.[7]

3.1.Benefit of RAS

- Water conservation: RAS systems use much less water than traditional open-loop aquaculture systems, as the water is recirculated and reused.
- Waste reduction: RAS systems can significantly reduce waste and pollution from aquaculture operations, as the water is filtered and treated before being reused.
- Disease prevention: RAS systems can be designed to minimize the risk of disease transmission and outbreaks, as the closed-loop system prevents the introduction of pathogens from outside sources.
- Better control over water quality: RAS systems allow for greater control over water quality parameters such as temperature, dissolved oxygen, and pH, which can improve fish health and growth.
- Increased production efficiency: RAS systems can improve production efficiency by reducing the time required to grow fish to market size, as well as reducing the need for manual labor.
- Enhanced tank and equipment durability
- Advantage of purchasing high-quality fish is decreased dependence on antibiotics and therapeutic drugs.
- Reduction in feed, predator, and parasite-related direct operational costs.
- Eliminate the potential for parasite dissemination into recipient waters.
- When feeding can be carefully monitored for 24 hours, feed management in RAS is much improved.
- Permit safe non-endemic species cultivation

Overall, RAS systems can offer several benefits over traditional aquaculture systems, making them a compelling option for those looking to produce fish sustainably and efficiently.[7]

3.2.RAS disadvantage

- If the electric power goes out, backup electricity is needed. Constant uninterrupted power supply is necessary.
- Compared to ponds and raceways, a recirculating aquaculture system has a higher initial capital cost.

Figure.16. Developed RAS

Figure.17. RAS system

3.3 Tank

A RAS system can be built with a wide range of tank sizes and water volume. The range starts from to a 1000l tank up to   20000l tank. To build a RAS system prototype we are using a tank with the water holding capacity of 1000 liter. This is a very good size to start with in the initial stages. When we see the progress in the system similar tanks could be set up. Or we could go for a tank with bigger dimensions.

3.4 Pumps

In a RAS system one of the important factors is water circulation and water filtration. For this purpose, we use submersible pump. It is a recommended and practiced technique to choose a pump in such a way that the flow of the pump should be at least 3-4 times the water volume of the tank per hour.

We use a pump that can pump water with max flow of 5500 liter per hour that is around 5.5 times the water volume. It is always good to have a higher filtration. The pump is used to pump the water into the filter.

SUNSUN HJ 5500 Submersible Pump

- Model Number HJ-5500
- Power Consumption – 100W
- Flow Rate – 6000 L/hr
- Maximum Height – 400 cm
- Power Source – Electrical 220-230V AC
- Suitable For Salt Water and Fresh Water
- Weight 2300 g

3.5. Filtration

Recirculating water systems are designed to minimize or reduce dependence on water exchange and flushing in fish culture units. These systems have practical applications in commercial aquaculture hatcheries, holding tanks, and aquaria systems, as well as small scale aquaculture projects. Water is typically recirculated when there is a specific need to minimize water replacement, to maintain water quality conditions which differ from the supply water, or to compensate for an insufficient water supply [7].There are innumerable designs for recirculating systems and most will work effectively if they accomplish: 1) removal of particulate matter, 2) biological filtration to remove waste ammonia and nitrite.

There are mainly two types of filters, Mechanical filter and Biological Filter

3.5.1.Mechanical filter:

Particles that are suspended in water in a fish tank can harm the ecosystem's general health and wellbeing. These particles may originate from a number of things, such as leftover food, garbage, and decomposing plant stuff.

To remove suspended particles from an aquarium, it is important to use a good quality filter that is appropriate for the size of the tank and the types of organisms living in it. Regular water changes and proper maintenance of the filter and other equipment can also help to keep the water clean and clear.[8]

Figure.18. Mechanical filter unit

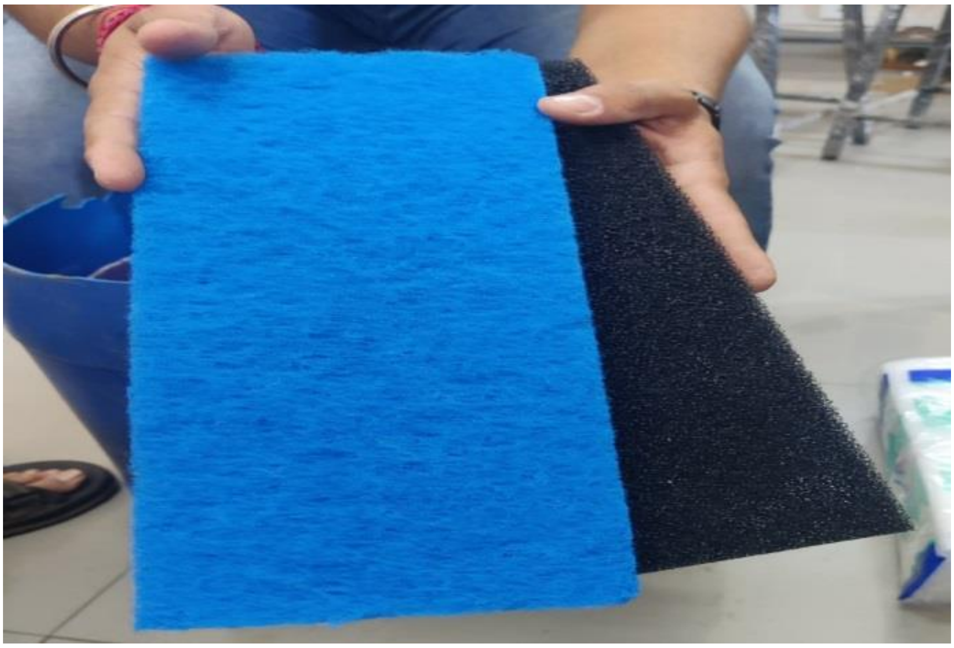


Figure.19. Mechanical filter pads

A mechanical filter consists of a sponge or a filter floss as shown above .These sponges and floss trap the suspended particle .The sponges and the floss come with different densities.

For the first layes we have used less denser sponge , so that bigger particle are seperated here, after thet the denser flosses are used to make sure that even the smmaler particle are seperated.

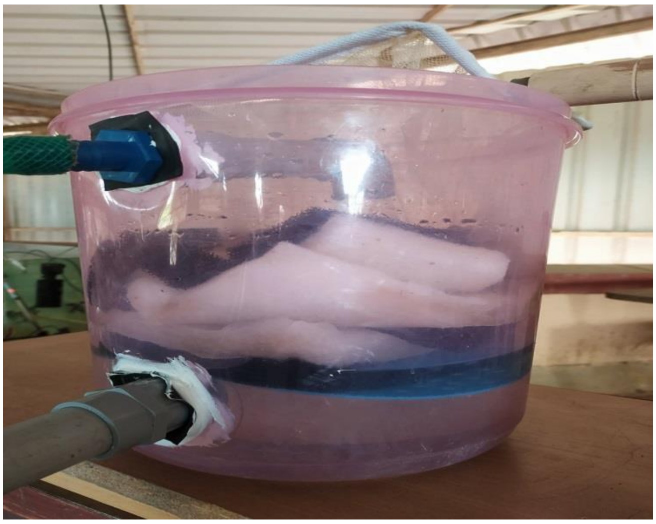


Figure.20.Mechanical filter bucket

Solids resulting from fish waste and uneaten feed contribute a portion of the oxygen demand and toxic ammonia in the system and should be concentrated for removal. This can be accomplished in a settling basin with reduced water turbulence, or by mechanical filtration through porous material such as sponge, screen, sand or gravel. Solids that accumulate will gradually be mineralized (broken down) by bacterial action and their volume reduced. Although this process adds additional oxygen demand to the system, it reduces the need for frequent cleaning if the solids do not become re-suspended or interfere with normal water flow. The water from the tank is directly pumped to the mechanical filter where it is passed through the filter flosses.[8]

Mechanical filter requires regular cleaning since they are prone to clogging when dirty. To prevent excessive amounts of solids from accumulating in the bio-filter, small particles of matter are usually removed prior.

3.5.2. Biological filter:

A biofilter is an essential component of any healthy aquarium ecosystem. Biofilters are designed to provide a habitat for beneficial bacteria that break down harmful waste products produced by fish and other aquatic organisms.

Common types of bio media include ceramic rings, bio balls, and foam pads. These materials are typically porous and have a high surface area-to-volume ratio, allowing for the growth of large populations of beneficial bacteria. As water passes through the bio media, the bacteria break down organic waste, such as uneaten food and fish waste, into less harmful compounds like nitrate.

Figure.21. Bio filter

To control ammonia levels in recirculating water systems, extensive surface area is provided for bacteria which biologically oxidize ammonia to relatively harmless nitrate (NO_3^-).

Bacterial nitrification is a two-stage process resulting first in the transformation of ammonia to nitrite (NO_2^-), then a further oxidation of nitrite to nitrate. Nitrite is also toxic to fish at low concentrations, hence, both reactions must occur for successful bio-filtration. The bacteria responsible for these reactions occur widely in soil and water environments and can be easily introduced into bio-filters from natural sources, or with material from established filters.

Media for bio-filters can be virtually any substrate which provides maximum surface area for bacterial growth: oyster shell, gravel, nylon netting, plastic rings, corrugated fiberglass panels, and sponge foam pads are among popular choices (Figure 2). In designing bio-filters, the principal concerns should be maximum surface area for bacterial growth, high dissolved oxygen levels, uniform water flow through the filter, sufficient void space to prevent clogging, and proper sizing to ensure adequate ammonia removal capability.

After the water is passed through the mechanical filter, now it’s time for biological filter. Now the water is passed to the bio filter chamber via PVC pipes.

Figure.22. water flowing from tank to bio filter via mechanical filter.

The water that comes in the bio filter chamber directly goes to the bottom of the chamber, where we used a plastic bottle to keep some gap at the bottom so that the filter doesn’t clogs if at all some bigger particles make their way to the bio filter. The picture below clearly shows the same.

Figure.23. Bio media unit

3.5.2.1. Bio balls

In order to establish a biological filtration system for the fish tank, bio balls are employed in filters. Establishing and maintaining a colony of helpful bacteria that aid in the breakdown of toxic waste products in the water is the fundamental goal of biological filtration.

A lot of surface area is available on bio balls for good bacteria to grow on. The dangerous waste products are consumed and converted by these bacteria as the water flows through the filter into less harmful elements like nitrate, which may subsequently be removed from the water using additional filtration techniques like mechanical or chemical filtration.

We chose the bio balls at the bottom because, they have large air cavity and hence there is very negligible chance of the filter getting clogged.

Figure.24.Bio balls

After the bio ball layer there is mesh that separates the bio balls and the media that is on the next level of the filter i.e. ceramic rings.

Figure.25. Mesh for separating two layers of.

3.5.2.2. Ceremic ring

In aquaculture systems, ceramic rings are frequently used as filter medium to establish a biological filtration system. Establishing and maintaining a colony of helpful bacteria that aid in the breakdown of toxic waste products in the water is the goal of biological filtration.

Ceramic rings are a great substrate for biological filtration because they have a large surface area where good bacteria can grow. A lot of bacteria can colonise the medium because to the porous structure of the ceramic rings, which aids in the breakdown of hazardous pollutants like ammonia and nitrite in the water.

Figure.26. Ceramic ring

Ceramic rings are also long-lasting and sturdy, even when used continuously in a filter. They can be rinsed with water to get rid of any buildup or dirt that may develop over time, making them simple to clean and maintain as well. [8]

In conclusion, ceramic rings are utilised in filters to offer a large surface area for advantageous bacteria to flourish and establish a colony that aids in the breakdown of dangerous waste items in water. They are a fantastic option for biological filtration in ponds and aquariums because they are long-lasting and simple to maintain.

Ceramic rings and bio balls are both common biological filter medium in ponds and aquariums, and each has its benefits. Here are some benefits of ceramic rings over bio balls, though:

- **Greater surface:** Compared to bio balls, ceramic rings have a greater surface area per unit of volume. This increases the ability of the good bacteria to break down dangerous waste products in the water by giving them more room to develop and colonized.

- **Greater durability:** Unlike bio balls, ceramic rings can survive for a longer period of time before needing to be replaced. They also keep their potency for a longer period of time since they are less prone to degrade or break down over time.
- **More effective:** When compared to bio balls, ceramic rings offer a more effective biological filtration process. They maximize the elimination of harmful toxins like ammonia and nitrite from the water because of their porous structure, which allows for improved water flow and interaction with helpful microorganisms.
- **Simple to clean:** Ceramic rings may be cleaned with water to get rid of any dirt or buildup that may develop over time. They are therefore easy to maintain and practical for use in ponds and aquariums.

3.5.2.3. Clay balls

After the water gets polished through the ceramic rings, the next stage of the filter is the clay balls, these balls are much more porous then the ceramic ring. We also used a filter mesh for the sole purpose of separation of ceramic rings and clay balls.

Figure.27.mesh and Clay balls

Because of its porous nature, which provides good water and air flow, clay balls are frequently used in filters. For a number of applications, such as aquariums, swimming pools, and wastewater treatment plants, they are therefore an efficient filtration medium.

The porous nature of the clay allows pollutants, such as dirt and debris, to be trapped as water runs through a filter made of clay balls. Additionally, the clay balls' enormous surface area serves as a home for helpful bacteria that can aid in the breakdown of organic materials and the maintenance of water quality.

Figure.28. clay balls

For water filtration applications, both clay balls and ceramic rings make good filtration media.

Clay balls offer a few advantages over ceramic rings:

- Cost: Clay balls are a more cost-effective solution for bigger filtration systems because they are less expensive than ceramic rings.
- Lightweight: Compared to ceramic rings, clay balls are often lower in weight, making them easier to handle and transport.
- Clay balls are more porous than ceramic rings, which permits greater water movement and increased filtration effectiveness.
- Clay balls are a great home for good bacteria that aid in the biological filtration of water and the breakdown of organic materials.
- Durability: Clay balls are a dependable filtration medium for long-term use because of its excellent durability and ability to endure a variety of environmental conditions.

Ceramic rings, however, also have benefits of their own, including a larger surface area for bacterial growth and a longer lifespan. In the end, the particular needs and specifications of the filtering system will determine whether clay balls or ceramic rings should be used.

Clay balls are a well-liked option for many applications due to its filtration capabilities, affordability, and ease of maintenance. They are dependable filtration media for long-term usage since they are strong and resilient to a variety of environmental factors.

In addition to the filter media that we used to build our system, we can also use the media shown below:

Figure.29. Other bio medias that can be used.

- Lava rock is very porous and has a lot of surface area where bacteria can colonize. Because of the rough roughness of the rock, helpful bacteria can grow and thrive there, which aids in the breakdown of organic waste and the maintenance of water quality.
- K1 media is a kind of plastic bio medium with a distinctive form that provides a lot of surface area for bacterial colonization. Larger fish ponds and aquaponic systems frequently employ it.
- Zeolite is a sort of bio medium that is created from volcanic rock and is frequently utilized to remove ammonia from aquarium water. It can be effective in saltwater and freshwater aquariums.

After all the filter media, lastly we use activated carbon , so that if at all there is any pollutants will be removed.

3.5.2.4. Activated Carbon

Numerous dissolved pollutants like chloramine, chlorine, tannins (which give the water its colour), and phenols (which give off odours) are adsorbable by activated carbon. Over time, it will aid in preventing aquarium water from turning yellow.

It's crucial to recognise that there are a number of significant pollutants that activated carbon cannot get rid of. Most significantly, it does not eliminate nitrite, nitrate, or ammonia. As a result, it is ineffective in toxin removal during initial days of RAS setup.

Figure.30. activated carbon

If activated carbon is exposed to a lot of aquarium trash, it will quickly lose its potency. As a result, carbon should be added to the filter after the mechanical filtration media. The only to remember is that the activated carbon won't work if you don't maintain your tank clean and debris accumulates in the filter. The carbon in a recirculating filter system will also act as a home to the beneficial bacteria that turn ammonia into nitrite and then nitrate. We have to make sure that the activated carbon is properly packed in a filter mesh or mesh bag, otherwise if it gets in to the fish tank and if the fishes consumes it , it might lead to fish death.

3.6. Aeration

Water must be aerated to maintain adequate dissolved oxygen concentrations for fish and for proper functioning of the biological filter. Aeration is usually applied in the fish culture tank and again prior to or within the biological filter, that portion of the recirculating system where organic waste products are broken down through bacterial decomposition. Trickling filters and revolving plate bio filters are designed to be self-aerating. Vigorous aeration of submerged filter beds is not recommended because beneficial bacteria can be dislodged from the substrate decreasing the filter's effectiveness.[8]

Figure.31. Aeration in bio floc.

Aquaculture requires the process of aeration, which involves adding oxygen to the water to promote the growth and wellbeing of aquatic organisms. High stocking densities, warm water temperatures, and bacterial activity are just a few examples of conditions that can cause the dissolved oxygen in the water in aquaculture systems to become depleted.

Simple air pumps that add air to the water can be used as aeration systems, as can more sophisticated ones that use blowers or compressors to raise the concentration of dissolved oxygen in the water. Diffused, surface, and mechanical aeration are a few of the methods that can be utilized to achieve aeration.

Diffusers or air stones are used in diffused aeration to introduce air bubbles into the water, which break the larger bubbles into smaller ones to increase the surface area of air and water in contact. Increasing the water's surface area through the use of paddlewheels or fountains will allow for a greater flow of gases between the air and the water. Diffusers or other aeration techniques may be used in conjunction with mechanical aeration, which involves the use of blowers or compressors to drive air into the water.

Aeration can increase oxygen levels as well as circulate and mix the water, remove excess carbon dioxide and other gases, enhance water quality, and prevent the buildup of dangerous gases like ammonia and hydrogen sulphide. Overall, aeration plays a crucial role in maintaining healthy and productive aquaculture systems.[8]

Figure.32. aeration and airstone

3.6.1. Aerator

Aquaculture uses aerators, which stir up the water's surface to enhance the amount of oxygen in the water. They function by sucking air from the atmosphere and releasing it into the water as tiny bubbles. Turbulence is produced as the bubbles rise to the surface, increasing the surface area of the water that is exposed to the air. More oxygen can be absorbed from the environment and dissolved into the water as a result of the increased exposure.[7]

Ponds, raceways, and tanks are just a few of the aquaculture environments where surface aerators can be used. They are especially helpful when the water is still or has a low oxygen content. By increasing the amount of dissolved oxygen in the water, surface aerators can also aid in preventing the buildup of hazardous gases like carbon dioxide and ammonia.

We used a airator of 80L/min capacity ,as it is recomended to use 70L/min for 1000L tank

Figure.33. Aerator

- Model : HAP-80
- Power :60W,
- Output :80L/m
- Size: 210x185x171mm
- Voltage:220-230
- Hailea HAP-80 Hi-Blow Air Pump is an advanced air-compressing system, with sound damping and multilevel muffler for extremely low in noise level.
- Compact design for long service life with lowest energy consumption.
- Lightweight aluminium alloy case for quick heat-dissipation.
- Diaphragms made from special artificial rubber for long life and a steady air output and pressure.

3.7. Heater

In India we have 3 seasons, summer, rainy and winter. In summer there is no need of heater as the temperature won’t go below a certain level. But in winter or rainy season this is not the case, the temperature will decrease. This decrease in temperature will definitely affect the health of the fish. The fish might also get disease, which will eventually spread in the whole system and all the fishes will get affected. To prevent all of this, and to prevent the temperature from falling we need to add a heater. It is very much needed that we take care of the problem of overheating, so we use a relay module that will help to maintain a constant temperature.

Figure.34. Heater

3.8. Ideal species for RAS

- Baramundi, Asian Seabass, and Bhetki (Lates calcarifer).
- Rachycentron canadum, the cobia.
- Trichinotus blochii/Trichinotus mookalee, often known as silver/indigenous pompano.
- Oreochromis niloticus ,tilapia.
- Pearl spot/Karimeen (Etroplus suratensis).
- (Pangasianodon hypophthalmus) Pangasius.
- Rainbow trout (Oncorhynchus mykiss), particularly in areas with hills and cold water.

3.9. Seabass

In the tropical and subtropical areas of Asia-Pacific, Lates calcarifer (Bloch), often known as giant sea perch or Asian sea bass is a commercially significant food fish.

Figure.35. seabass after receiving the parcel

We chose seabass for our project because it’s a high priced edible fish. It is very tasty. It is very much accepted in Goa. Its comparatively high market value has made it a desirable commodity for both large and small-scale aquaculture businesses.

It is a species with broad physiological tolerances and a reputation for being relatively hardy. The high fertility of female fish gives an abundance of resources for seed generation in hatcheries. Production of seed in a hatchery is comparatively easy. Pelletized meals work well for seabass, and young fish can be easily weaned to them. Seabass develops quickly, taking six months to two years to reach a size that may be harvested (350 g to 3 kg).[23]

Seabass can be raised in a number of different methods, such as in sea cages or on land. The fish are reared in sea cages in enormous floating pens in the open sea or in protected harbours. In land-based facilities, the fish are kept in water-filled tanks or ponds under close observation to ensure the best circumstances for growth.[30]

The farming of seabass is referred to as seabass aquaculture. Due to the great demand for this fish species and the dwindling wild fish populations, seabass aquaculture is a rising industry.

Figure.36. seabass

Today, sea bass is raised in cage farms throughout the coasts of most of its range, with Southeast Asia producing the majority of the species. A variety of species, including Seabass, groupers (Family Serranidae, Subfamily Epinephelinae), and snappers (Family Lutjanidae), are frequently raised in these farms.

Figure.37. seabass fishes

The majority of the sea bass's 2- to 3-year growth period is spent in freshwater areas that are connected to the sea, such as rivers and lakes. It grows quickly, frequently reaching a size of 3–5 kg in just 2–3 years. In order to mature their gonads and breed, adult fish (3–4 years old) move from inland waters to the sea near the river's mouth, where the salinity is about 30-32 ppt.[30]

To make RAS a success, it is very much needed to atomize the system. And it is also important to monitor the fish growth regularly.

CHAPTER 4

IOT BASED RAS SYSTEM

4.1. Implementation of IOT based system

As we are successfully done with RAS system, now it's the time to make it smart for that we integrate IOT system to it. IOT stands for Internet of Things which describes as the network of physical objects (things) which are embedded with tons of sensors integrated with software and other technologies just for the purpose of interchanging and exchanging the data with other devices and systems over the internet. Now a days from simple domestic appliances to huge industrial systems are already into the hands of internet. Based on the current 7 billion devices which bare connected to internet, prediction has been made that the number will cross 22 billion till 2025.

Most beautiful advantage of IOT implementation is that it helped many fields to improve their operational efficiency because IOT provides features such as Remote monitoring and management of assets / resources. Real-time, predictive and prescriptive insights and many more

In our project we employ IOT system just for kind of same exact reasons. We simply do the job with a biscuit sized microcontroller board ESP32 which we have discussed earlier and a great cloud IOT platform known as Things peak. Our first task was to see the parameters which are crucial to monitor on continuous bases and are necessary to be controlled for optimum fish growth.[5] For aquaculture system no. of water parameters must be regulated and maintained for creating best possible environment for fishes. The first sensor that we integrated to the system is the temperature sensor. The aim is to monitor the temperature of water suitable for the fishes and for the same reason there was need to integrate Heater which is controlled by the system according to the temperature sensed by the temperature sensor. To do so code is being written in Arduino ide software for the same condition that if the temperature is <= 26 degree Celsius then the heater will turn on and for the other temperature condition heater will turn off.[5]

The problem to be encountered was the driving issue. The heater runs on 230 V Ac supply. This problem is solved by employing a relay module in the system. The module serves as a switch controlled by the command of microcontroller board in the electrical domain. Here the hardware part is done, now it is expected that user should receive the constant feedback of how the system is working from even remotely and for this the IOT concept comes into picture.[6] To do this we are using the platform “Things peak “which is an IOT analytics platform which allows to visualize and analyse the data with live stream. Thing’s peak is a cloud platform that allows user to upload their sensor data to the cloud platform for the remote monitoring of systems. Similarly, we uploaded the temperature monitoring data on the cloud. We created the Things Peak account with a API key which needs to be added to the code module and uploaded into the microcontroller board of course with the Wi-Fi ssid, password and the server details and the board must be compatible with Wi-Fi provisions. By creating related fields in your Things peak channel setting up the right scales one can visualize the variations in the sensor data. [6]

Things peak also gives the updates when the data last uploaded and the other details. Further in the same manner we added other sensors which were very important for our aquaculture system. Maintaining the water quality parameters such as pH and TDS levels of water was important. Similar like temperature sensor we integrated the pH and the TDS sensors to the ESP 32 microcontroller board by configuring its GPIO pins and combining the code. The pH sensor is first need to be calibrated with the distilled water before proceeding to the aquaculture tank. TDS can be added to the system directly and doesn’t need any special calibration. After deploying all the sensors to the aquaculture tank, the hardware system is ready. By switching the Wi-Fi and enable of microcontroller board all these sensor data will be uploaded on Things peak cloud for constant remote monitoring over internet. This successfully completes our Smart IOT based Aquaculture system.

4.2. ESP32

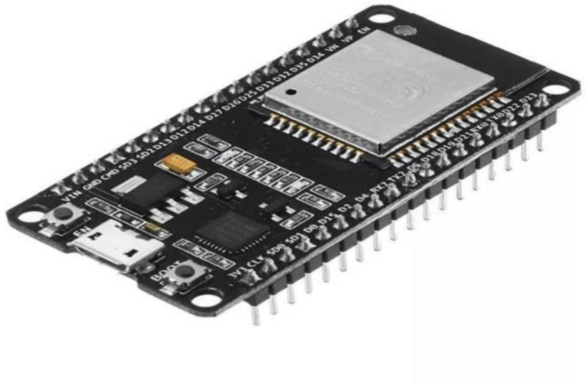


Figure.38. ESP32

The ESP32 is a powerful and versatile microcontroller designed for IoT (Internet of Things) applications. It was developed by Espress if Systems and is based on the Xtensa LX6 dual-core processor.

Wireless connectivity

The ESP32 is perfect for Internet of Things (IOT) applications that need wireless connection because it has Wi-Fi and Bluetooth connectivity. The Wi-Fi module can function in both access point and station modes and supports IEEE 802.11 b/g/n/e/i standards. Both the Bluetooth Classic and Bluetooth Low Energy (BLE) protocols are supported by the Bluetooth module.[1]

ESP32 power

The ESP32 is made for Internet-of-Things (IoT) and wearable electronics applications. It includes fine-grained clock gating, numerous power modes, and dynamic power scaling, among other cutting-edge traits of low-power processors. For instance, ESP32 is only awakened periodically and when a specific condition is recognised in a low-power IoT sensor hub application scenario. To reduce the amount of energy the chip uses, low-duty cycles are used. The power amplifier's output can also be changed, which aids in finding the best balance between communication range, data rate, and power usage.

Memory:

The ESP32 includes 520 KB of SRAM (Static Random Access Memory) and 4 MB of Flash memory for program and data storage. The Flash memory can be partitioned to support multiple applications and data storage.

Operation

The ESP32 can run various operating systems, including Arduino, Micro Python, and Free RTOS. These operating systems provide high-level programming interfaces and libraries that simplify application development. Operating Voltage: 2.2 V to 3.6 V. Operating Temperature Range: - 40°C to +85°C. Sleep current: < 5 µA. Active mode current: 20 mA to 200 mA depending on operating frequency, RF conditions, and active peripherals.

Integrability

With about 20 external components, ESP32 is a highly integrated solution for Wi-Fi and Bluetooth IoT applications. Antenna switch, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules are all integrated into the ESP32. Because of this, the overall system uses a small amount of printed circuit board (PCB) space. The

ESP32 employs CMOS for single-chip, fully integrated radio and baseband, and it also incorporates sophisticated calibration circuitries that enable the solution to fix flaws in external circuits or adapt to changes in the environment. As a result, costly and specialised Wi-Fi testing apparatus is not necessary for the mass manufacture of ESP32 solutions.

Processor

The ESP32 has a dual-core, 32-bit CPU that operates at up to 240 MHz and is based on the Xtensa LX6 architecture. The processor handles both integer and floating-point operations and features a 4-stage pipeline.

ESP32 supports various operating systems, including Arduino, Micro Python, and Free RTOS. It also supports programming languages including C, C++, Python, and JavaScript and various development tools and IDEs available, including the Arduino IDE, Visual Studio Code, and Eclipse.

Numerous applications for the ESP32 exist, including wearable technologies, smart gadgets, home automation, and industrial automation. Its Wi-Fi and Bluetooth features make it perfect for wireless communication, and its strong processor and variety of interface possibilities provide programmers and other device interfaces a tonne of versatility. Overall, the ESP32 is a well-liked and trustworthy microcontroller that is appropriate for a wide range of Internet of Things applications. It is a flexible platform for creating and delivering IoT solutions because to its potent processor, wireless connectivity, and interface possibilities.

There are several pins on the ESP32 microcontroller that can be utilised for connecting to other electronics or sensors.

4.2.1 ESP32 PINOUTS

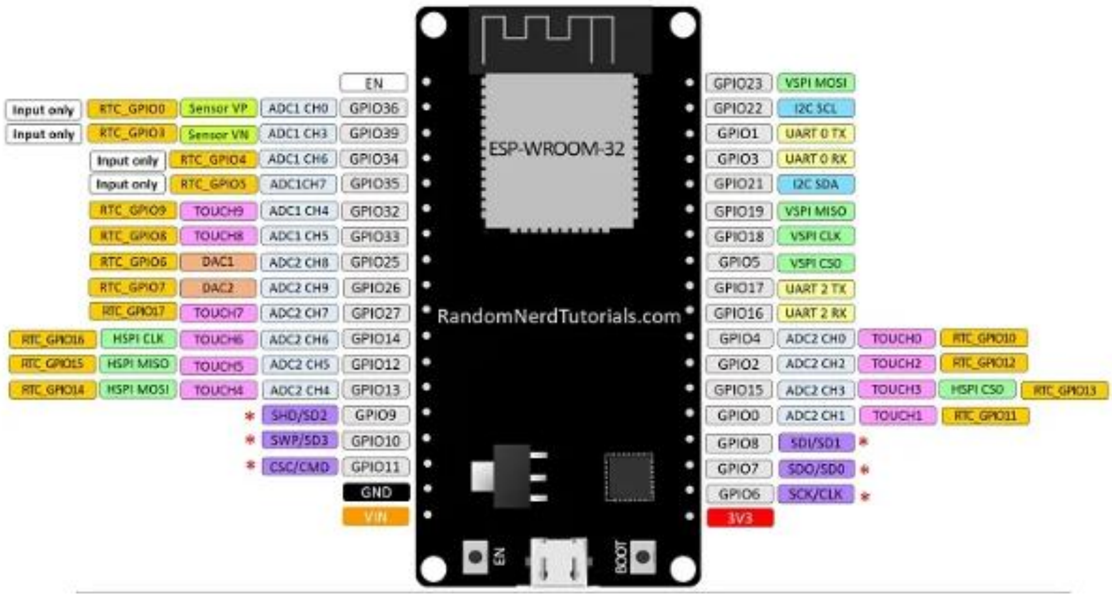


Figure.39. ESP32 pinout

GPIO Pins:

The ESP32 has 34 GPIO (General Purpose Input/Output) pins that can be used for digital input/output, analog input, or pulse-width modulation (PWM) output. These pins are labelled GPIO0 to GPIO33.

UART Pins:

The ESP32 has three UART (Universal Asynchronous Receiver/Transmitter) pins, which are labelled TX, RX, and RTS. These pins are used for serial communication between the ESP32 and other devices.

DAC Pins:

The ESP32 has two DAC (Digital to Analog Converter) pins, which are labelled DAC1 and DAC2. These pins can be used to output analog signals, such as audio or voltage signals.

Touch Pins:

The ESP32 has ten touch pins, which are labelled T0 to T9. These pins can be used to detect touch input from capacitive touch sensors.

Analog Input Pins:

The ESP32 has 18 analog input pins, which are labelled ADC1_CH0 to ADC1_CH7, ADC2_CH0 to ADC2_CH7, and ADC2_CH8 to ADC2_CH11. These pins can be used to measure analog voltages, such as those from sensors or potentiometers.

I2C Pins:

The ESP32 has two I2C (Inter-Integrated Circuit) pins, which are labelled SDA and SCL. These pins are used for two-way communication between the ESP32 and other devices that support the I2C protocol.

SPI Pins:

The ESP32 has four SPI (Serial Peripheral Interface) pins, which are labelled MOSI, MISO, SCK, and CS. These pins are used for communication between the ESP32 and other devices that support the SPI protocol.

4.2.2. Circuit diagram

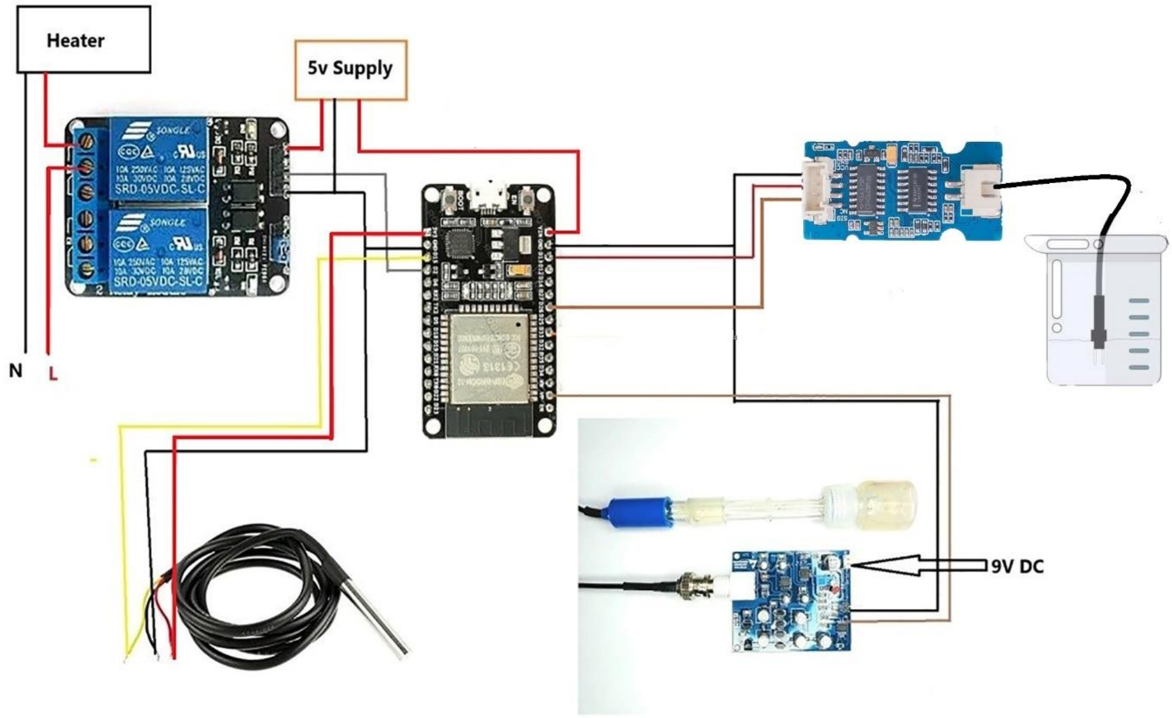


Figure.40. ESP32 network

This is the circuit diagram of entire IoT hardware system in which one can see the main ESP 32 development board powered with 5V SMPS supply and all the sensors are interfaced to it according to their specification weather it is analog type or digital type sensor. The temperature sensor gives the digital output and is connected to the digital D2 pin of the ESP 32. The sensor works on very low power this is why it is directly powered via ESP32 boards 3.3v power pin. In the case of TDS and pH sensors, It is powered with External 5V and 9V supply respectively, since the signal conditioning boards require that much constant power so that it remains calibrated. The 9V supply for pH signal conditioning board is generated from 12V SMPS supply using the 7809 regulator IC. The heater works on 230v AC supply that's the reason the relay module is introduced so that the heater can be easily controlled based on the temperature which is sensed by the temperature sensor.[4] The entire data of the system is transferred to the cloud using the ESP32 WIFI and this completes the IoT hardware system.

4.3. Power Supply Unit

4.3. Switching mode power supply (SMPS)

A switching regulator is incorporated into an electronic power supply known as a switched-mode power supply to efficiently convert electrical power. An SMPS, like other power supplies, converts voltage and current characteristics while transferring power from a DC or AC source (often mains power; see AC adapter) to DC loads, like a personal computer. In contrast to a linear power supply, a switching-mode supply pass transistor alternates between full-on and full-off states with low dissipation and spends comparatively less time in transitions with high dissipation, minimizing lost energy. In an ideal switched-mode power supply, there is no power loss. Varying the ratio of on-to-off time, sometimes referred to as duty cycles, regulates voltage.

Figure.41. smps

A key benefit is the greater electrical efficiency of the switched-mode power supply. Because the transformer can be far smaller, switched-mode power supplies can also be significantly lighter and smaller than a linear supply. This is due to the fact that, in contrast to the 50 or 60 Hz mains frequency, it operates at a high switching frequency that ranges from several hundred kHz to several MHz. Despite the smaller transformer, commercial designs often have a substantially higher component count and accompanying circuit complexity due to the power supply architecture and the need to control electromagnetic interference (EMI).

When switching regulators are needed, linear regulators are swapped out for them when a higher efficiency, a smaller size, or a lighter weight is needed. However, they are more difficult; switching currents, if not carefully suppressed, can lead to electrical noise issues, and simple designs may have a low power factor.

In our IoT based aquaculture system the sensors and esp32 are powered with the help SMPS.

4.3.2. 12 V to 9V converter

The circuit diagram given below is a basic 12v to 9v converter from the 780X voltage converter family. In everyday electronics, 9V Power Supply Units (PSU) are a typical but crucial component. They are frequently utilized in academic and industrial applications with test equipment. Therefore, in this project, we'll use a L78S09 voltage regulator IC to create a 9V power supply.

Voltage regulators are very common in electronic circuits. They provide a constant output voltage for a varied input voltage. The name 7809 signifies two meanings, “78” means that it is a positive voltage regulator and “09” means that it provides 09V as output.

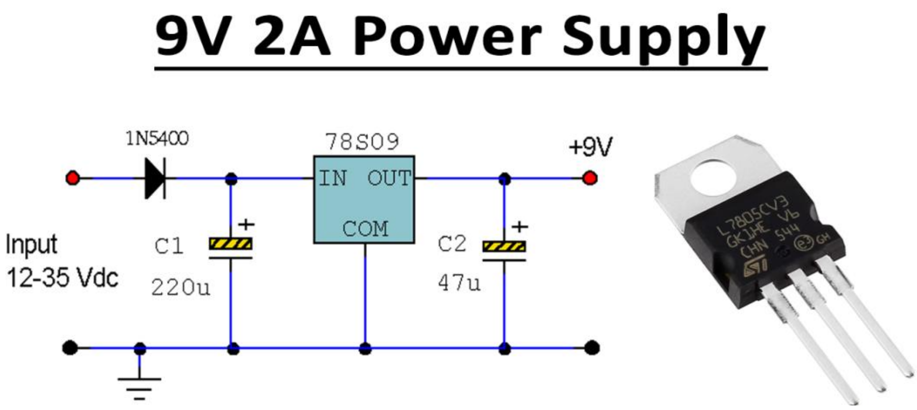


Figure.42. L78S09 circuit diagram.

Local on-card regulation offered by L78S09 regulators can solve the distribution issues brought on by single-point regulation. It is practically unbreakable because it incorporates internal current limiting, thermal shut-down, and safe area protection. They are capable of delivering more than 2A of ou/tput current if suitable heat sinking is offered. Despite being primarily intended for use as fixed voltage regulators, they can also be used in conjunction with outside parts to provide adjustable voltages and currents.

Figure.43. L78S09 pinout

L7809 Regulator Features

- 9V Positive Voltage Regulator
- Minimum Input Voltage is 11V
- Maximum Input Voltage is 35V
- Output Current: 1.5 A
- PSRR / Ripple Rejection: 55 dB
- Output Type: Fixed
- Internal Thermal Overload and Short circuit current limiting protection is available.
- Junction Temperature maximum of 125 degree Celsius

4.4. SENSORS

4.4.1. pH sensor

The pH of water is one of the most important parameters which determines the quality of water and is Crucial for good fish growth. This is the main reason we are using pH sensor.

A pH sensor is a type of transducer which makes pH of a liquid measurable in terms of numerical values. The pH scale ranges from 0-14 in traditional measurements in scientific studies. Similarly the pH value from 0-14 is determined by detecting change in electrical potential across the electrodes of the sensor.[4]

Figure.44. pH sensor kit

To explain the working of the senor we must first understand the structure and construction of the sensor. The pH sensor consists of capillary like glass made structure, with a bulb at bottom which holds the sensing probe.[2] The glass bulb is selective to hydrogen- ion concentration present in the glass electrode. The main principle is the exchange of ions from the test solution with the inner solution via glass membrane (tube) of the electrode. Hydrogen ions in the solution under test exchange with other positively charged ions on the glass bulb. In this process electrical potential difference is created between the two electrodes which need to be detected. This signal is detected and amplified further which is elaborated in Signal conditioning process.[4] The electrochemical potential across the glass bulb is linearly dependent and is related directly to pH which is defined by Nernst equation. In the earlier discussion we stated about the solution inside the bulb, typically the solution is potassium chloride surrounded by porous ceramic membrane. This porous membrane allows the solution to interact with the test solution and intern the pH of test solution is sensed.

Specifications:

- Module Power: DC 9.00V 1A
- Measuring Range: 0-14PH
- Accuracy: ± 0.1pH (24)
- Response Time: 1min
- Industry pH Electrode with BNC Connector
- PH Interface (2 foot patch)
- Power Indicator LED
- Output: Analog values in the range of (0.5V to 3V)
- Alkali Error: 0.2PH
- Internal Resistance: 250MO
- Response Time: <1min
- Operating Temperature: 0-60°
- Terminal Blocks: BNC plug
- BNC Connector suitable for most PH meter and controller.

- Suitable for wide range of application: Aquariums, Hydroponics, Laboratory etc.
- This PH sensor is calibrated @ 24 degree centigrade on room temperature.
- Calibrated values are: PH4 = 1.5V, PH7 = 2.0V and PH9 = 2.5V.

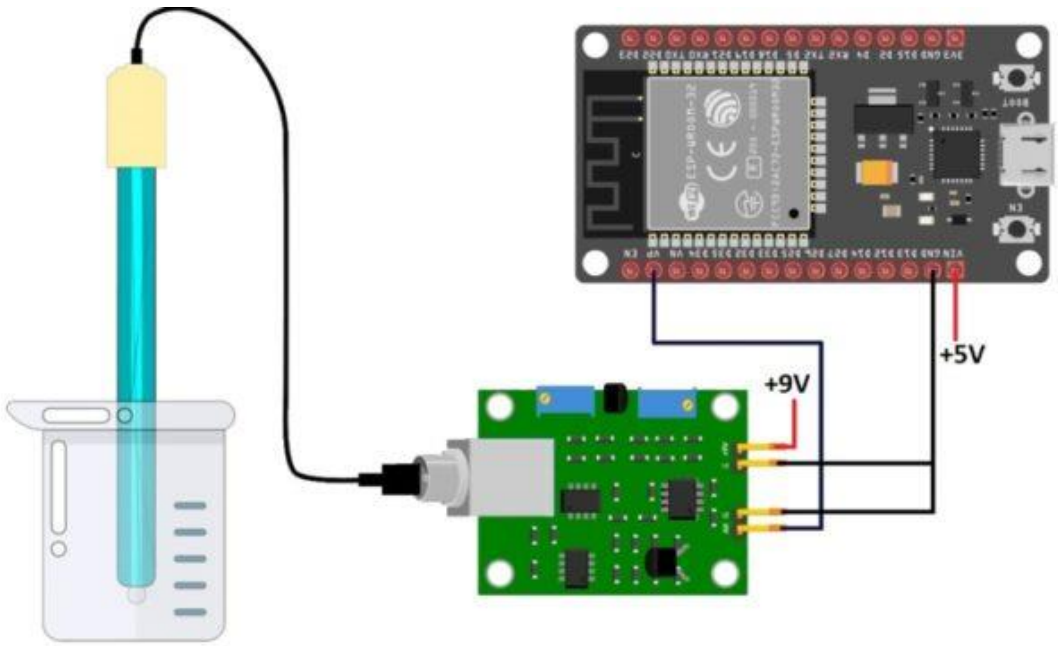


Figure.45. pH sensor interfaced with esp32

To interface the sensor to the ESP32 we first need to know the output of the sensor, whether it gives analog or digital output and this can be done with the help of the sensor's datasheet. Based on this information the GPIO pin of the board is selected. In the case of pH sensor, the output is analog that's the reason analog pin is selected. One can choose any analog pin from the GPIO of ESP 32 board in our case we randomly selected pin A1 and the sensor works perfectly. As can be seen in the circuit diagram, the signal pin is connected to the pin A1 and ground pin is made common of the signal conditioning board of the sensor and the ESP32 board. The pin A1 is configured as a input pin. To configure the pin simply program the board with the "pinMode(pin number, INPUT/OUTPUT); " command and further add the functional code. Since this signal conditioning board of the sensor is powered externally with the 9V supply there is no load on the ESP32 board and is just to get the signal input via a signal line. There is no special need to connect VCC from the board as that of other sensors.

4.4.2. Temperature Sensor

A temperature sensor is a device that senses and measures hotness and coolness of a surrounding and converts it into an electrical signal. Temperature sensors are categorised into Negative Temperature Coefficient (NTC) & Positive Temperature coefficient (PTC). In the case of Positive temperature coefficient (PTC) type sensor the output varies in proportion with temperature which means as the temperature increases the output of sensor increases. The output of sensor may be a change in resistance or change in voltage signal depending upon the type of sensor being used.[2] Where as in the case of Negative temperature coefficient (NTC) type sensors the output changes inversely proportional to the temperature. The type of sensor is chosen depending on the application.

Why temperature sensor in aquaculture systems…?

Water temperature is very essential and is important for the better growth and survival of fishes. The aquaculture system needs temperature control because the fishes are poikilothermic (coldblooded). Poikilothermic animals unable to control body temperature and they are equilibrated with the temperature of the surrounding.

In this project we make use of DS18B20 Water Proof Temperature Sensor Probe. The dimensions are very compact it’s a Stainless-steel tube 6mm diameter by 30mm long. The sensor has three wires in which two are the power wires and one is the signal out.

Figure.46. Temperature sensor

The sensor works on 3.3v and has 2 bit register inbuilt and give the digital output which can be directly fed to microcontroller boards to apply corresponding voltage level to temperature conversions.

This one wire digital temperature sensor is very much precise for this application (±0.5°C over much of the range) and can offer up to 12 bits of precision with the digital-to-analog converter. It works perfectly fine with any microcontroller boards by using a single digital GPIO pin, and one can also connect multiple this type sensors to the same pin, since each one of this type sensors has a unique 64-bit ID burned in it to differentiate them. The sensor is greatly compatible with 3.0-5.0V systems.[2]

The only down view of this is they use the Dallas 1-Wire protocol, which is complex, and requires some coding to excess out the communication. While using it with microcontroller board there is a need to connect a 4.7k resistor to sensing pin, with power line 3.3v which acts as a pull up from the DATA to VCC line. There we connect the sensor to the digital pin of ESP32 which is configured as a input pin and the voltage to temperature conversion is done into code and is uploaded on Things-peak cloud.

Cable specs: -

1. Stainless steel tube 6mm diameter by 30mm long
2. Cable is 36" long / 91cm, 4mm diameter (1 Meter Long)
3. Contains DS18B20 temperature sensor
4. Three wires - Red connects to 3-5V, Black connects to ground and White is data.

DS18B20 Sensor Technical specs: -

- Usable temperature range: -55 to 125°C (-67°F to +257°F)
- 9-to-12-bit selectable resolution
- Uses 1-Wire interface- requires only one digital pin for communication
- Unique 64-bit ID burned into chip
- Multiple sensors can share one pin
- ±0.5°C Accuracy from -10°C to +85°C
- Temperature-limit alarm system
- Query time is less than 750ms
- Usable with 3.0V to 5.5V power/da

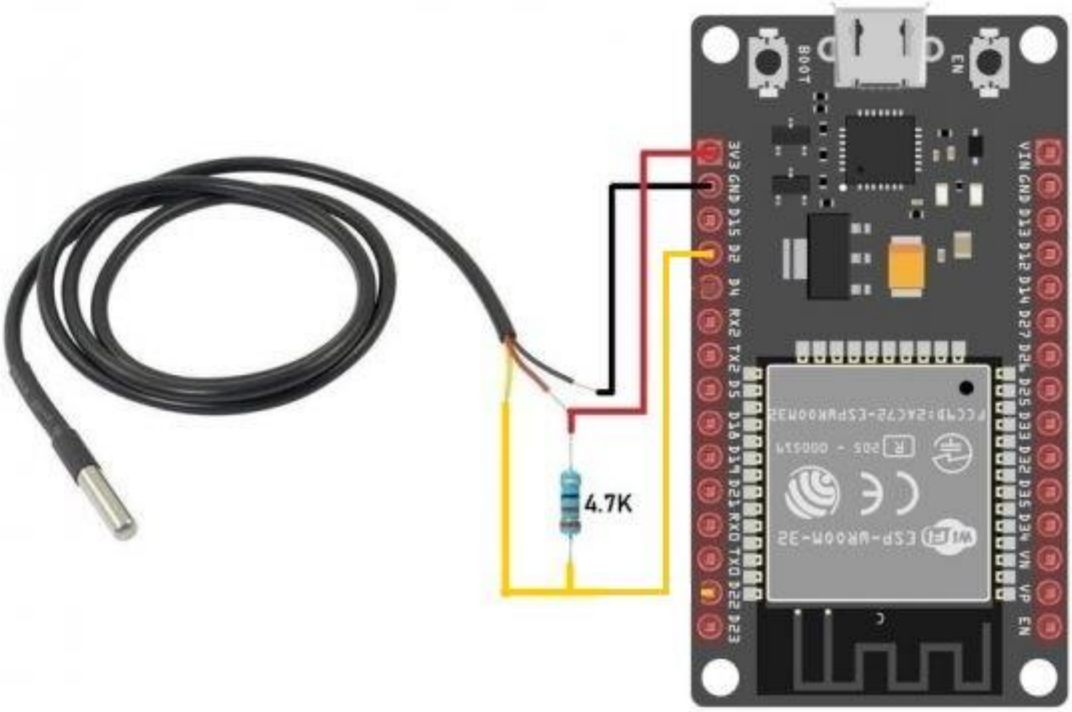


Figure.47. Temperature sensor interfaced with esp32.

To interface the sensor to the ESP32 we first need to know the output of the sensor, whether it gives analog or digital output and this can be done with the help of the sensor's datasheet. Based on this information the GPIO pin of the board is selected. In the case of temperature sensor DS18B20, it gives a digital output since it has 2 bits register inbuilt and the third yellow color-coded wire is the data output line. Based on this info we selected the digital pin of ESP32 and configured it as an input pin because the ESP 32 will receive the data from the sensor. DS18B20 temperature sensor can be powered with two modes one is with the VDD pin of the ESP32 known as the normal mode, or it can draw power required from the data line and this mode is known as parasite mode.[4] One can choose either of these modes but we preferred the normal mode for simplicity. The 4.7k ohm resistor is connected between the data line and VCC and acts as a pull-up resister which holds the data line in active mode always. This successfully completes the sensor interfacing process.

4.4.3. TDS sensor

The term TDS stands for Total Dissolved Solids, it is the measure of total concentration of dissolved substances in the water. TDS may comprise of salts mainly inorganic and a very less amount of organic matter as well in the water. The TDS level is in the form of numerical values ranging from 50ppm to 1000ppm (ppm – Parts per million) and like pH, TDS is also one of the crucial parameter which determines the fitness of water favourable for living organisms. Image below demonstrates clearly what TDS is.

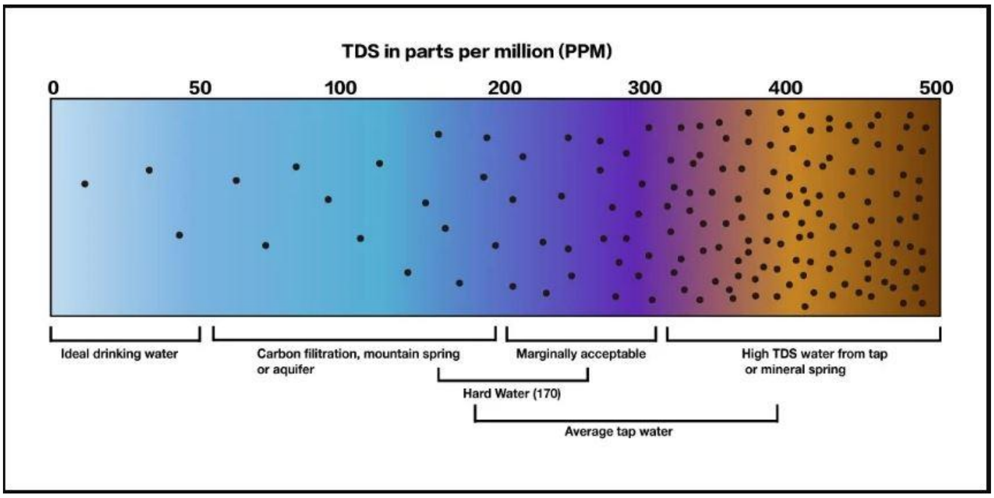


Figure.48. TDS

Now, the question is why TDS in aquaculture system?

Since the density of TDS determines the flow of water inwards and outwards in any organism cells and unsuitable TDS values can be catastrophic for fishes and the environment will be harmful for good fish growth. Concentrations ranging too high or too low can cause unsuitable environment for fishes and can intern result in to death. A stable TDS value of 400ppm is recommended for most fresh water fishes for ideal and good fish growth.

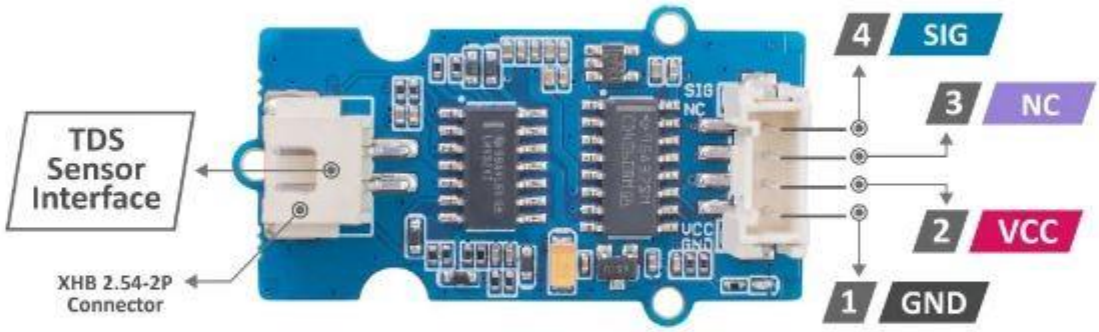
To measure the TDS parameter of water there is a use of TDS sensor which senses the TDS in the water in terms of electrical signal. In the project we make use of Grove SKU: 765936

TDS sensor. The Grove – TDS Sensor detects the Total Dissolved Solids (TDS) levels in the water which can indicate the water quality. The Sensor can be deployed in water quality applications such as TDS meter, aquaculture, well water, aquarium, hydroponics, etc.

Figure.49. TDS sensor

The sensor supports 3.3/5V input voltage and 0 ~ 2.3V Output Voltage which makes it easy to be compatible with all micro controller boards such as Arduino. The sensor also provides a waterproof probe which makes testing easy and flexible.

The sensor consists of two electrodes separated by fixed distance and are connected to signal conditioning board. The basic principle here is the conduction of electricity through water. More the dissolved solvents / contaminants more the conduction of electricity, which means less or more current will flow from one electrode of sensor to other depending up on the solvents dissolved. Due to this there will be a potential drop across the electrodes considering the liquid under test is similar to resistor. Since the current flowing through solution is proportional to the dissolved solvents, this is a great way to measure the TDS value. Now there comes the signal conditioning unit which is employed on the PCB board. In this case the main process is the current to voltage conversion, because further we need a voltage output for feeding it to a microcontroller board. The TDS sensor PCB also performs a special job is that it provides AC signal to the electrodes to avoid electrode deposition, so the current flowing through solution under test is infect a small AC signal. This is the same AC current signal is being converted to voltage signal to readout corresponding value of TDS.



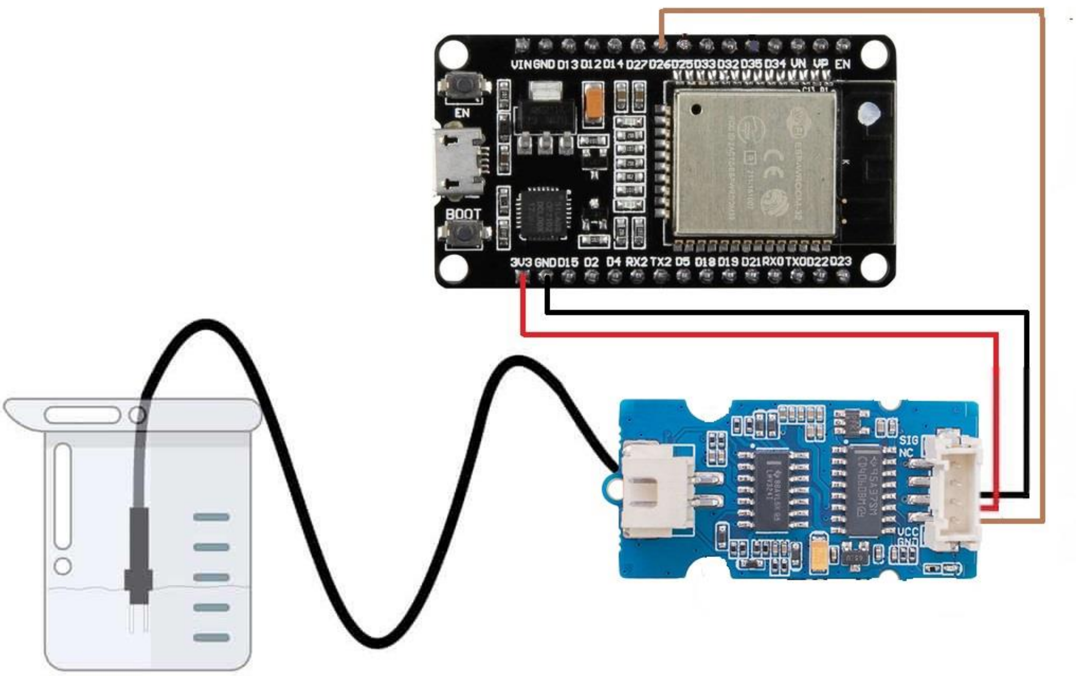


Figure.50. TDS sensor interfaced with esp32.

To interface the sensor to the ESP32 we first need to know the output of the sensor, whether it gives analog or digital output and this can be done with the help of the sensor’s datasheet.

Based on this information the GPIO pin of the board is selected. In the case of TDS sensor, the output is analog that's the reason analog pin is selected. One can choose any analog pin from the GPIO of ESP 32 board in our case we randomly selected pin 26 and the sensor works perfectly. The VCC and GND can be given via board since it has very low current consumption which can be easily supported by ESP board. As can be seen in the circuit diagram, the signal pin is connected to the pin 26 which is configured as input pin. To configure the pin simply program the board with the "pinMode (pin number, INPUT/OUTPUT); "command and further add the functional code.

4.5. Relay modules

The relay is one kind of electro-mechanical device which performs the function of a switch. The relay design and construction are very simple is that it has a coil which acts as an electro magnet which can be energised by applying voltage. The relay is nothing but a switch and the switching mechanism is infect driven by this electromagnetic coil. The construction inside has a metallic plate with an attached retractile spring system which pulls and push the metallic plate with the help of this magnetic coil. The contact is switched to normally open (NO) contact when the voltages is applied otherwise the metallic contact is at the position of normally closed (NC). DC is used to power the relay coil, which opens or closes contact switches. In a single channel 5V relay module, a coil and two contacts, such as usually closed (NC) and ordinarily open (NO), are frequently present. In automatic control circuits, a switch known as a 5-volt relay is widely used to control high currents with low current signals. The input voltage range for the relay signal is 0 to 5V.

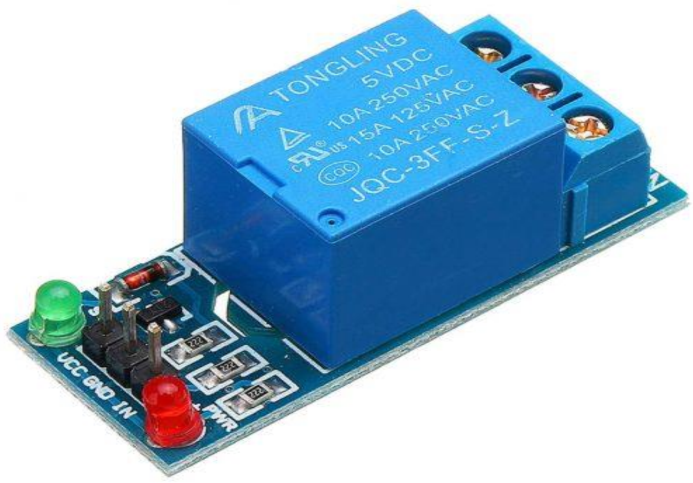


Figure.51. Relay module

The 5V relay's pin arrangement is displayed below. This relay has five pins, and the functions of each pin are listed below.

Pin1 (End 1): It is used to activate the relay; usually this pin one end is connected to 5Volts whereas another end is connected to the ground.

Pin2 (End 2): This pin is used to activate the Relay.

Pin3 (Common (COM)): This pin is connected to the main terminal of the Load to make it active.

Pin4 (Normally Closed (NC)): This second terminal of the load is connected to either NC/ NO pins. If this pin is connected to the load then it will be ON before the switch.

Pin5 (Normally Open (NO)): If the second terminal of the load is allied to the NO pin, then the load will be turned off before the switch.

Features

- Normal Voltage is 5V DC
- Normal Current is 70mA
- AC load current Max is 10A at 250VAC or 125V AC
- DC load current Max is 10A at 30V DC or 28V DC
- It includes 5-pins & designed with plastic material
- Operating time is 10msec
- Release time is 5msec
- Maximum switching is 300 operating per minute

The relay opens or closes switch contacts using the current supply. Typically, a coil is used to magnetise the switch contacts and draw them together when the switch is engaged. As soon as the coil is not strengthened, a spring pushes them independently.

There are primarily two advantages to employing this approach. The first is that less current is needed to activate the relay than is needed to switch the relay contacts. The other advantage is that there is no electrical connection between the contacts and the coil because they are both galvanically isolated.

4.6. ESP32 CAMERA

Figure.52. ESP camera

An ESP32-S microprocessor and a camera module are combined on the development board known as the ESP32-CAM to create a potent platform for creating Internet of Things (IoT) projects that can capture and transmit images and videos.

With a dual-core processor, Wi-Fi and Bluetooth connectivity, and a variety of peripheral connectors, the ESP32-S chip is a potent microcontroller. It supports up to 4 MB of flash memory and 520 KB of SRAM, and it can run at up to 240 MHz clock frequency.

A tiny camera module that can record photos and videos with resolutions as high as 1600x1200 pixels is included with the ESP32-CAM. Additionally, it offers infrared (IR) illumination for use in low-light conditions and includes a built-in lens.

The ESP32-CAM includes a variety of interfaces, including UART, SPI, I2C, ADC, DAC, and PWM, for integrating peripherals and sensors. Along with a USB interface for programming and debugging, it also contains a microSD card slot for storing photos and videos.

The Arduino IDE, which has a user-friendly interface and a sizable library of pre-built functions and examples, can be used to code the ESP32-CAM. Additionally, it supports C and C++ programming and may be combined with other development tools like ESP-IDF and Micro Python.

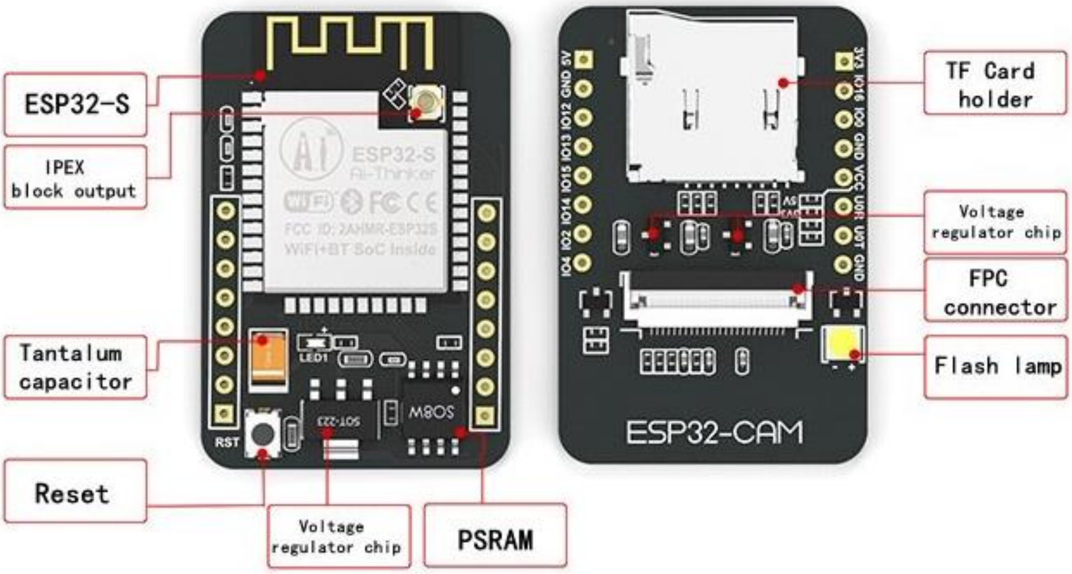


Figure.53. ESP camera blocks

Power management features on the ESP32-CAM optimise power usage and increase battery life. Deep sleep modes are supported, and it has the ability to wake up from sleep in response to predetermined triggers such button presses or sensor readings.

The ESP32-CAM can be used for a variety of Internet of Things (IOT) applications that need image and video processing, including security cameras, smart doorbells, robotics, and systems for monitoring the environment. It is perfect for battery-powered projects because to its tiny size and low power consumption. The ESP32-CAM is a robust and adaptable development board that offers an affordable and simple platform for creating Internet of Things (IOT) projects with image and video capabilities.

4.7 ESP32 Camera PINOUT

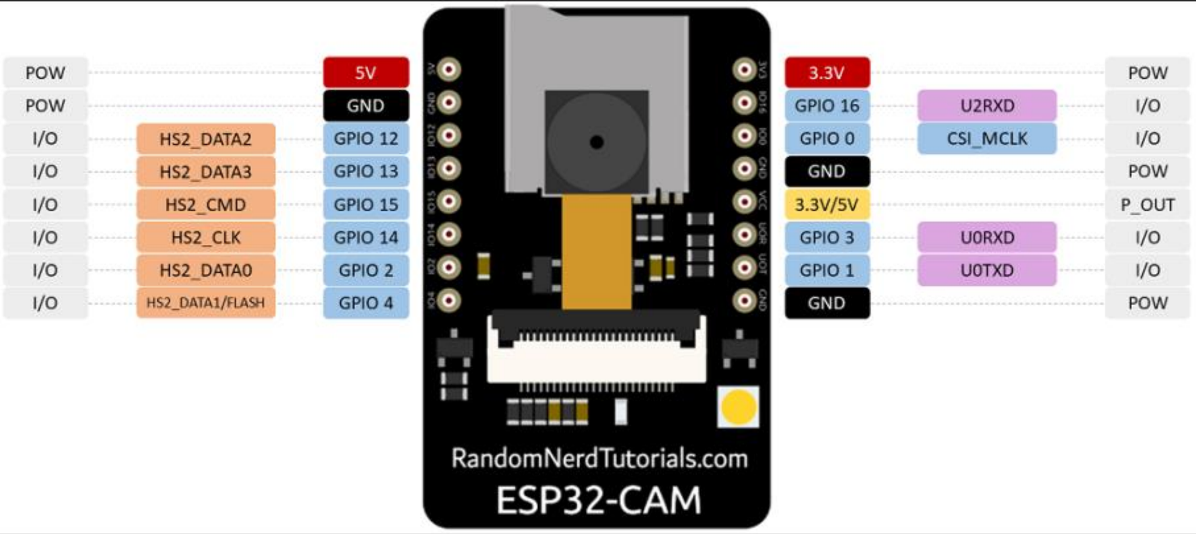


Figure.54. ESP camera pinouts

To make the camera working first need to connect the programmer to the camera module since the module doesn’t have a inbuilt programmer, this is done by the designers to make the camera module compact. The programmer needs to be connected while programming the Module as well as after programming since the RX and TX needs to be powered. To program the module, we first make the connections in the way VCC of programmer is connected to 5V input of module and GND of programmer to GND of the module. The transmission and reception of data is done via RX and TX pins. RX and TX needs to be connected oppositely in the way TX is connected to RX and RX to the TX pin. Most important is to short ground to the Io1 pin while programming the board, after the programming is done the jumper is removed and reset button on the module needs to be pressed.

In the Arduino IDE the IP address will appear after opening the serial monitor. The code required for this is taken from Arduino example codes the webserver camera. Make sure that In the code WIFI SSID and password is added, This will connect the Camera to the WIFI and if one connects the to the server with the IP address the camera view will be seen with different control settings.

4.8. Cloud server and real-time data

In the proposed architecture we have used 3 sensors i.e., temperature (DS18B20), pH (SKU: A75), TDS (Grove SKU: 765936) sensor. Every sensor is connected to Esp32 with the help of different pins. The Esp32 is connected to internet. The real time data from the sensor is directly uploaded on the ThingSpeak server.

The real-time data were stored in the ThingSpeak IOT server. This is a free cloud server for permitting to gather and store sensor information in the cloud and create IOT applications. [3].

4.9. Uploading the data on ThingSpeak Server

An application platform for the Internet of Things is called ThingSpeak. You can create an application using Things peak that uses sensor data. Real-time data collecting, processing, visualisations, apps, and plugins are among the features of ThingSpeak.

A Things peak Channel serves as the foundation of ThingSpeak. You send your data to be stored through a channel. Each channel has 8 fields for any kind of data, 3 fields for locations, and 1 field for status. You can publish data to a ThingSpeak Channel, have ThingS peak process the data, and then have your application retrieve the data.

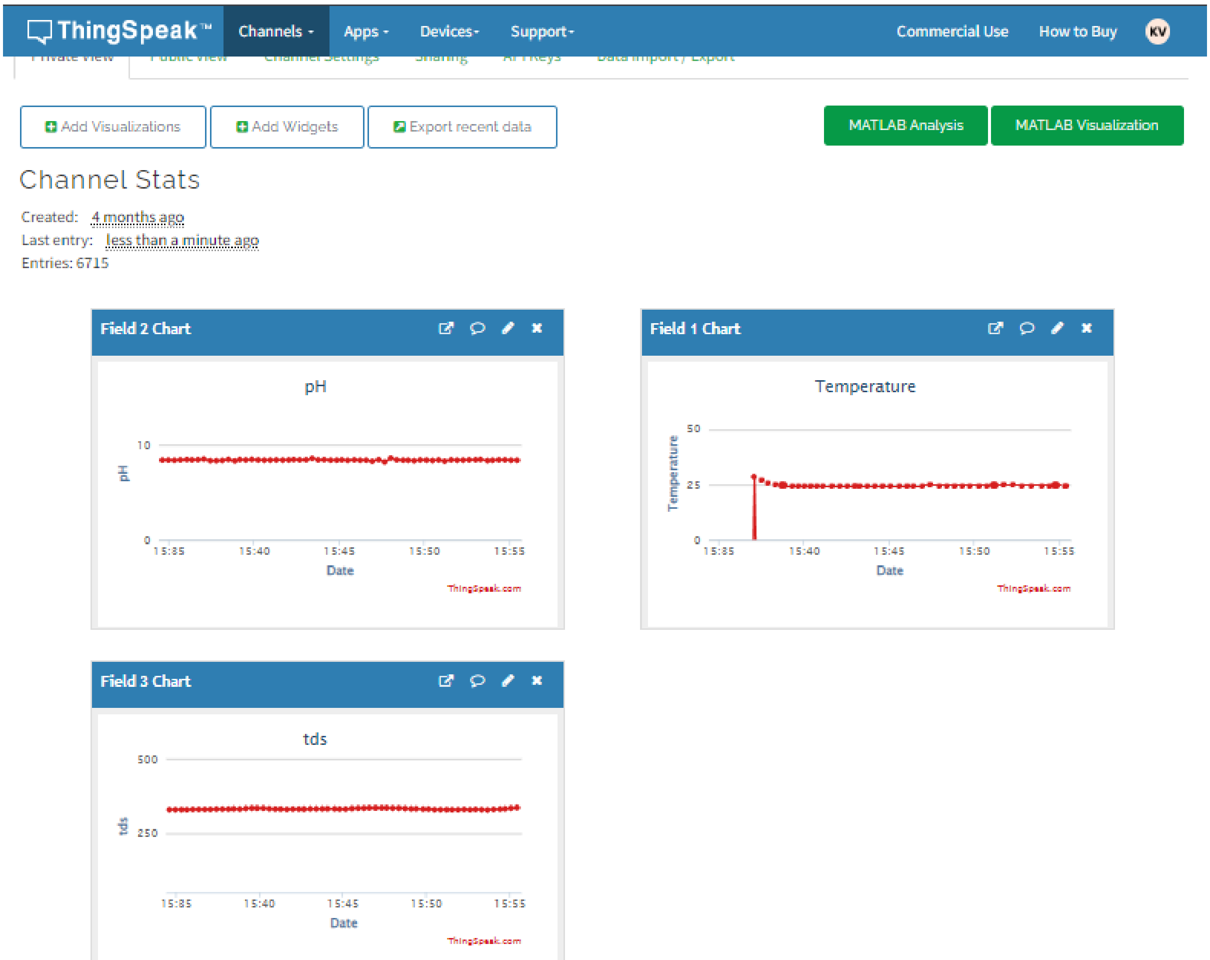


Figure.55. ThingSpeak server

CHAPTER 5

DATA COLLECTION

5.1. Data Acquisition

The sub final part in this project is the data acquisition phase in which there is the acquisition of enough data for further processing and to have meaningful insights from it. Data acquisition is the process of collecting parameters from which we can get meaningful insights and information from it. Data can be in many forms in terms of numerical values, images, etc. Creating a quality data set is very important to get proper insights from the data which is being collected. In the case of our project, as the design of the Recirculatory Aquaculture system is completed in addition to it we integrated the IOT system to it, Now the entire system is in control, with the fish in the tank ready to grow. The final goal is to determine how much the growth in the fish is over a course of time using machine learning techniques. To identify how much is growth in the fish we need to have a huge collection of past and present data, the comparison of both the data set is done with machine learning algorithms to come to a final conclusion. In order to enable data-based decision-making in fish farming, precision fish farming is a novel idea in aquaculture research and industry that combines modern technologies and data processing techniques. The notion is based on automatic monitoring, based on using contactless techniques, of fish and the environment. For constant individual care, biomass estimation, and fish status determination, it is very necessary to identify individual fish of the same species within the group. Fish body patterns can be used to identify specific individuals, although there is no automated system for doing this. The trend is towards more automation. The advancement of new techniques for digital cameras and machine learning has made it possible to automate a number of tasks in the uncertain environment of fish farming.

The Data acquisition can be done in two types that is in-situ and ex-situ.

In-situ data acquisition is the practice of gathering information directly from the environment or a system under study without removing or otherwise altering the sample or system. In other words, in-situ measurements are made without taking the event or process out of its natural setting, right where it is happening. Since it enables researchers to examine a system's natural condition without interfering with it, this kind of data collection is very helpful in environmental and ecological studies.

In our project, we are heading toward the in-situ acquisition of data wherein we make use of a webcam to capture the images. While doing this there are problems that need to be handled simultaneously. Problems that will make us lose the quality of the data we gather are listed as follows. Losing quality in the sense the sharpness and details will be lost when there are wobbles and disturbances in the water.

Wobble in the water – To counter this problem taking short exposures is a crucial thing, taking $1/600^{th}$ or $1/1000^{th}$ will have very less wobble since the water is not moved much over this short time this infect causes another problem which is Light deficiency. When we go for short exposures, the light required is more because the camera sensor is exposed for a very short duration which is also known as short exposure. To solve both problems we go for the video frames, now the data acquisition is done with video frames. Taking video and extracting frames from it will solve both issues. The frame rate used in this process is 60 frames per sec. This is how the data acquisition is done in our project.

5.2. CAMERA

To Acquire the data on trial basis we first used the normal webcam to capture the images with different angles. For doing this we used a glass cylinder of length 600mm with a diameter of 60mm with a webcam inside it. The cylinder was immersed in the tank and video was recorded as the different fishes move in and around the camera. The camera is 5 megapixel vi-micro USB pc camera. The camera is shown below in the figure 56. The camera was interfaced to laptop using a driver software.

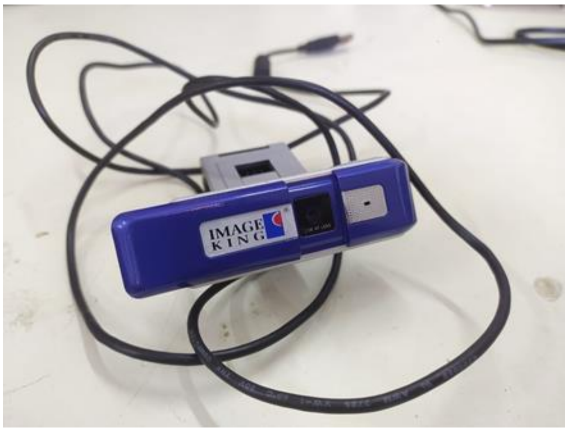


Figure 56. webcam.

The drawback of the camera is that the amount of noise and frame rate. The response of this camera as per the frame rate is not suitable for this purpose. As we have discussed earlier we need high frame rate with less ISO and lower the shutter speed since the wobble in the water may distort the images.

Secondly we used a GOPRO camera for the Data acquisition in the same fission and we acquired the satisfactory raw data with very less noise. Finally the Data acquisition on the trial bases.

CHAPTER 6

POWER CONSUMPTION

Whenever we develop a product it is very important to know its power consumption. Aquaculture systems, particularly those with recirculating systems, use a large amount of energy. Understanding an aquaculture system's overall power usage will help us accurately estimate your energy bills and keep track of your spending.

There are restrictions on how much energy aquaculture systems can consume in some regions. We can assure compliance with these requirements and prevent penalties or fines by being aware of the overall amount of power consumed.

Total Power Consumption in the project

Pump –100W

Air pump—100W

Esp32 – 5V X 240mA =1.2W

Temperature sensor—3.3V X 8.25uA =27.225 uW

pH sensor—9V X 0.004A =0.16 W

TDS sensor—5V X 6mA =0.03W

Total power usage—201.39W

CHAPTER 7

COST OF THE PROJECT

Knowing the overall cost will help us prepare for financing, budgeting, and cash flow management since aquaculture systems are big expenditures. We can decide whether to move forward with the project by calculating the payback period and return on investment using the overall cost information. The total cost of an aquaculture system comprises installation, maintenance, and operational costs in addition to the price of the materials and equipment at the time of purchase. Knowing the whole price will help us more properly predict your costs, spot areas for cost-savings, and manage your cash flow.

Total cost of the project

Tank cost—7300₹

Plumbing cost--1848₹

Filter cost—2775₹

Pump cost—4500₹

Air pump cost—8650₹

Fish cost—1400₹

Feed cost—200₹

IOT (esp32, cam, sensors, relay)-4846₹

Accessories cost—1050₹

Total cost ----32569₹

CHAPTER 8

RESULT AND CONCLUSION

The Project consists of two major parts which includes the IoT based RAS system development and Data acquisition. The RAS system is system which makes the suitable environment for the optimal fish growth. In the project we Implemented the IoT based RAS system which includes the main RAS system structure with different filters and circulatory systems, to which the IoT system is integrated. The IoT block consists of different sensors a camera interfaced to a microcontroller board with a WIFI over which sensor data is sent to the cloud and continuous monitoring is done.

The developed RAS system was used for rearing of seabass fishes and the different growth stages was observed. The images of the different growth stages were captured using a webcam and go pro camera and Database has been generated. The generated database was used for further processing , where indifferent Machine learning algorithms were tried.

FUTURE ADVANCEMENT

Now as the IOT based RAS system is completely ready, now it's time to take the project to a next level. The next part of the project will be image processing and machine leaning. For this there will be a need to collect the images of the fishes and create dataset. We can take the images of the fish at a certain interval of time. And then process the images and detect the fish, after which the features will be extracted. The features could be the outline of the fish ,etc. Once the fish is detected and the outline is obtained we can measure the length and width of the fish. After that we can use formula to calculate the biomass.[22] Same procedure can be done on different sets of images collected on different interval of time. And then the biomass of the fish on different intervals can be compared to estimate the growth of the fish.[21]

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APPENDIX

```
#include <WiFi.h>

#include <OneWire.h>

#include <DallasTemperature.h>

#define TdsSensorPin 34

#define VREF 3.3

#define SCOUNT  30

int analogBuffer[SCOUNT];

int analogBufferTemp[SCOUNT];

int analogBufferIndex = 0;

int copyIndex = 0;

float averageVoltage = 0;

float tdsValue = 0;

float temperature = 25;

const int potPin=A0;

const int oneWireBus = 4;

float ph;

float Value=0;

OneWire oneWire(oneWireBus);
```

```
DallasTemperature sensors(&oneWire);

 String apiKey = "7QTHISEG76TY8746"; // Enter your Write API key from ThingSpeak

const char *ssid = "Airtel-MyWiFi-AMF-311WW-C16A"; // replace with your wifi ssid and
wpa2 key

const char *password = "1bc657ee";

const char* server = "api.thingspeak.com";



WiFiClient client;

int getMedianNum(int bArray[], int iFilterLen){

  int bTab[iFilterLen];

  for (byte i = 0; i<iFilterLen; i++)

  bTab[i] = bArray[i];

  int i, j, bTemp;

  for (j = 0; j < iFilterLen - 1; j++) {

    for (i = 0; i < iFilterLen - j - 1; i++) {

      if (bTab[i] > bTab[i + 1]) {

        bTemp = bTab[i];

        bTab[i] = bTab[i + 1];

        bTab[i + 1] = bTemp;
```

```
      }
    }
  }
  if ((iFilterLen & 1) > 0){
    bTemp = bTab[(iFilterLen - 1) / 2];
  }
  else {
    bTemp = (bTab[iFilterLen / 2] + bTab[iFilterLen / 2 - 1]) / 2;
  }
  return bTemp;
}
void setup() {
  Serial.begin(115200);
  pinMode(potPin,INPUT);
  sensors.begin();
  delay(1000);
  Serial.begin(115200);
  pinMode(TdsSensorPin,INPUT);
  Serial.print("Connecting to ");
```

```
  Serial.println(ssid);

  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {

    delay(2000);

    Serial.print(".");

  }

  Serial.println("");

  Serial.println("WiFi connected.")

}

void loop() {

Value= analogRead(potPin);

Serial.print(Value);

Serial.print(" | ");

float voltage=Value*(3.3/4095.0);

ph=(3.5*voltage);

Serial.println(ph);

delay(5000);

     sensors.requestTemperatures();

     float temperatureC = sensors.getTempCByIndex(0);
```

```
  if(temperatureC<=26.00)
  {
     pinMode(2,OUTPUT);
     digitalWrite(2,LOW);
  }
  else
  {
     pinMode(2,OUTPUT);
     digitalWrite(2,HIGH);
  }
    Serial.print(temperatureC);
    Serial.println("ºC");
    delay(5000);
 {
 static unsigned long analogSampleTimepoint = millis();
 if(millis()-analogSampleTimepoint > 40U){     //every 40 milliseconds,read the analog value
from the ADC
   analogSampleTimepoint = millis();
```

```
    analogBuffer[analogBufferIndex] = analogRead(TdsSensorPin);
analogBufferIndex++;
    if(analogBufferIndex == SCOUNT){
      analogBufferIndex = 0;
    }
  }
  static unsigned long printTimepoint = millis();
  if(millis()-printTimepoint > 800U){
    printTimepoint = millis();
    for(copyIndex=0; copyIndex<SCOUNT; copyIndex++){
      analogBufferTemp[copyIndex] = analogBuffer[copyIndex
      averageVoltage = getMedianNum(analogBufferTemp,SCOUNT) * (float)VREF / 4096.0;
      //temperature compensation formula: fFinalResult(25^C) = fFinalResult(current)/(1.0+0.02*(fTP-25.0));
      float compensationCoefficient = 1.0+0.02*(temperature-25.0);
      float compensationVoltage=averageVoltage/compensationCoefficient;
      tdsValue=(133.42*compensationVoltage*compensationVoltage*compensationVoltage - 255.86*compensationVoltage*compensationVoltage + 857.39*compensationVoltage)*0.5;
      //Serial.print("voltage:");
      //Serial.print(averageVoltage,2);
```

```
      //Serial.print("V   ");
      Serial.print("TDS Value:");
      Serial.print(tdsValue,0);
      Serial.println("ppm");
    }
  }
}
if (client.connect(server, 80)) // "184.106.153.149" or api.thingspeak.com
   {
      String postStr = apiKey;
      postStr += "&field1=";
      postStr += String(temperatureC);
      postStr += "&field2=";
      postStr += String(ph);
      postStr += "&field3=";
      postStr += String(tdsValue,0);
      postStr += "\r\n";
```

```
    client.print("POST /update HTTP/1.1\n");
    client.print("Host: api.thingspeak.com\n");
    client.print("Connection: close\n");
    client.print("X-THINGSPEAKAPIKEY: " + apiKey + "\n");
    client.print("Content-Type: application/x-www-form-urlencoded\n");
    client.print("Content-Length: ");
    client.print(postStr.length());
    client.print("\n\n");
    client.print(postStr);
  }
}
```