GSJ: Volume 9, Issue 4, April 2021
ISSN 2320-9186

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Global Scientific JOURNALS

GSJ: Volume 9, Issue 4, April 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

Control of Limnological Parameters for IoT-based Mussel Cultivation

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A Design Project Submitted to the College of Engineering in Partial Fulfillment of the Requirements for the Degree in Bachelor of Science in Electronics Engineering

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GSJ: Volume 9, Issue 4, April 2021
ISSN 2320-9186

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October 2019

APPROVAL SHEET

This is to certify that **Engr. Ronnie S Conception** have supervised the preparation of and read the paper prepared by **Abdulkader, Saleh Ali , Jorge Benito, Eyimi Ayingono, Saeed, Adil Ahmed And Saeed, Khalid Idris** entitled **Control of Limnological Parameters for IoT-based Mussel Cultivation** and that the said paper has been submitted for final examination by the Research Committee of the College and Panel Members.

Engr. Ronnie S Conception
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As members of the Oral Examination Committee, we certify that we have examined this paper and hereby recommend that it be accepted as fulfillment of the practicum requirement for the Degree **Bachelor of Science in Electronics Engineering.**

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ACKNOWLEDGEMENT

The proponents would like to give their sincere gratitude and appreciation for the help and support that are extended to the following people who have contributed in making this proposal possible:

The proponents would like to give their deepest gratitude to **GOD** for providing them more than enough knowledge, winsome privilege in the further study of their course Electronics Engineering through the proposal.

The proponents would also like to thank their **families**, specially their **parents** for their spiritually support they provided them while preparing their proposal.

The proponents would also like to thank their advisors **ENGR. Ronnie S. Concepcion,** and **ENGR. Jerry Turingan** for their continuous support, patience and his guidance that helped us during the proponent’s proposal.

And finally, the proponents would like to thank their friends and colleagues for the support while they were doing this proposal.

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Abstract

The study of the condition of limnological parameters has always been one for a study. Scientists have researched endlessly on ways to balance the Aqua level to make it suitable for marine lives. Many studies have shown how researchers introduce techniques on developing technologies that help monitor and stabilize water environments. Significance has been placed on the study of water quality and condition of marine lives to determine their safety for consumption. This paper, however, examines the limnological parameters such as pH level, temperature, electrical conductivity, and oxygen level as basis for preserving the lives of mussel cultivation. It is a general knowledge to group all these thoughts together as intents to improve aquaculture. Aquaculture in this case is regarded as a method of cultivating and rearing plants and animals in a controlled marine environment such as ponds, rivers and so have you. Technological advancement has highly improved this idea of aquaculture by giving the scientist of farmer the obscure ideas such as the parametric data that would be gotten from this study.

Keywords: Limnological Parameters, Monitor, Control, Mussel.

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CHAPTER 1

INTRODUCTION

This chapter covers the discussion about the study of mussel cultivation taking all the objective and specific study regarding the protecting of the mussels outside the aqua environment to analyze and use IoT for controlling limnological parameters to ensure that the mussel will not be polluted or get contaminated by other factors will discussed about it in this chapter.

1.1 BACKGROUND OF THE STUDY

The purpose of this study is to develop and design a controlled system device that is capable of monitoring and control the temperature, PH and electrical conductivity of an artificial seawater using IoT to cultivate healthy mussels. Also, the implementation of this controlled system device is specifically configured to match the needs of farmers, growers and agricultural organizations that are facing problem in growing healthy mussels because of the pollution and the global warming that is changing drastically the weather. Besides the plastic pollution has become a major concern in Indonesian coast and marine environment today. It occurs because 14% of the solid waste (SW) components in this country is plastic, and the SW management (SWM) infrastructure and services are still limited. The objectives of this article are to discuss the improper SWM and its impact to plastic pollution in Indonesia. (Yulinah Trihadiningrum, 2019).

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As the Philippines economically is an agricultural state, this study will serve as a progress in the agricultural and electronic field, providing data that can be collected with the help of installed sensors. Such data like weather condition, temperature, etc. Data is stored in one place, and farmers can easily check it and analyze to make the right decision.

This study makes it possible to avoid challenges and remove all issues that may arise during farming processes. So, the quality of the product is growing and consumers get a good product of high quality.

The evolution and the growth of the cites and the town are primary dependent on many factors expanding the geographic location for the earth and decreasing the water bodies and changing of the physical shape of the environment making and the increasing of the pollution the presence of the aqua environment in danger , for instance in the population of the Philippines in 1995 was 69 million and in this year shows huge increase to 108 million as stated in based on World meters elaboration of the latest United Nations data.(worldmeter,2019). Farming mussels is really useful for the aquaculture environment since it helps cleaning the water and its play a major role in this environment because the modify aquatic habitat, making it more suitable for themselves and the other organisms. One of the valuable functions performed by mussels is capturing organic matter from the water column when they siphon, processing it to build body and shell, excreting nutrients that are immediately available to plant life and then depositing the remaining organic material to the sediment making it available for other invertebrates and fish to consume.(department of mussel resource,2019).

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On the other hand the IoT solution for monitoring the weather condition of a certain or particular place and make information value the technology behind the internet of things is efficient to connect it with a certain parameter the data can be accessible especially for agriculture zone but the main problem it is difficult to monitor and control the weather parameter during weather hazard to overcome this problem we should use network sensor to monitor and control the weather parameter it is implemented in cultivation in small area. (R.Suresh Babu, et l ,2018).

In case of mussel farming there are many methods, one of the most familiarized method is single drop mussel, the sock is hung in the longline, the longline will be either on the surface of the water or below. mussel spat is loaded in socking material and each individual length is hung from longline and the length of each sock will be dependent on the depth of the water being farmed and as the mussel grow, they move outside the socking material. And the second farming technique called rope culture and that used in Rhode Island collecting baby mussel seed on ropes near the shore. the seed goes into a sock around a long rope on the water the socks with the rope is connected to buoys , dropped into the water and left grow in the ocean for at least a year after that time juicy mussel are bursting through the socks , they are collected , packed on ice and finally ready to sell . and there is also continues socking its used in Irish industry involving the manual cutting of mesh and rope and packing of young mussel by hand. The continuous system allows the packing collector mesh and grow rope –a far more efficient method.

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Climate change can affect and weakness the ability of the ocean and coasts to provide critical ecosystem services such as food, carbon storage, oxygen generation as well to support nature-based solution to climate change adaption (gattuso j –p et al.2015).

1.2 STATEMENT OF THE PROBLEM

The mussel's growth depends on different factors like PH coming from the air after increasing the carbon dioxide the ocean will absorb and make the seawater more acidic caused by the uptake of additional carbon dioxide from the atmosphere which is dissolved in seawater Mussels are very sensitive to a decline in pH in early life stage.

In this area the proponents suggest constrain remote sensing based on an environment information like (water depth and wind speed) and other environmental information data like temperature and organic carbon to verify and ensure the problem will minimized and limited (Guido Benassai,et l ,2018) and one of the research scattering system using different type of spices of saltwater developed and tested using vector machine.(Paul L. D. Roberts;et l,2011). In our project since the problem shall be focused on containment the mussel cultivation from all factors that can minimized the quality and cultivation of the mussel like temperature changing, global warming and increase of the pollution therefore increase of human demand.

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1.3 GENERAL OBJECTIVE

The main objective is to design and implement a control system of limnological parameters for IoT based mussel cultivation

1.4 SPECIFIC OBJECTIVES

Specifically, this study aims the following:

1. To set all the inputs used pH, temperature, conductivity and dissolved oxygen sensors to the fuzzy logic controller.

2. To make use of the fuzzy logic helping us to make the system operate.

3. To monitor the limnological parameter and control it using three outputs.

4. To test the functionality and precision of the sensors by monitoring the collected values of data parameters within the period of time that the mussels are being cultivated.

1.5 SIGNIFICANCE OF THE STUDY

The final output of this study will redound to the benefit of certain groups in our society. Considering that the design of the mussels-controlled system device is completed and it works as planned. The benefits they may be able to get is as follows:

STUDENTS. In this study the students will identify the importance of the use electronic devices and how they can be associated with other fields, and also the data will help them to understand the use of some electronic sensors and their performance.

TEACHERS. The teachers can also gain significance in this study. For their, they would assess the needs of the students and compare and contrast the use of this device in the agricultural field.

FUTURE RESEARCHERS. this study would help the future researchers to be aware and knowledgeable of the processes involved in the Mussels controlled system device. It would help them to be a better analyst and it can be a help as a future reference for more studies related to this one, and it will help them to improve it more.

INSTITUTION. This study will help the institution to provide an environment of learning, encouraging students to conduct researches related to the electronics and agricultural field. It will also be a stepping stone to improving over what is already existing to solving real-life problems relevant to the time at which they intend to improve their ideas.

AQUAFARMERS. Through this study the aqua farmers of the Philippines will be able to mix electronics and agriculture to collect all information together and manage it efficiently to get grow healthy mussels. The aquafarmers will indubitably be able to monitor and regulate the parametric data in making sure that the aqua environment is at its optimal level with no concept of technology whatsoever.

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THE RESEARCHER. The researcher can also gain significance in this study. They would improve their skill, strategy, and knowledge in engaging research. The knowledge entailed in this research will also enhance the researchers in realizing the in-depth idea of monitoring and controlling these frameworks using commonly-known microcontrollers.

1.6 SCOPE

This study aims to design and to develop a controlled system data logging and monitoring system. It covers the monitoring of the water limnological parameters for the growth of the mussels and saves the data and information in Microsoft Excel by the use of sensors. To analyze the changing in certain parameter. The proposed smart farm data logging and monitoring system is expected to gather data that covers the temperature, dissolved oxygen, PH and electrical conductivity by the use of sensors. And These sensors are capable to provide an accurate, precise and reliable data. The researchers will have an experimentation for placing the sensors strategically in order to monitor the data values of the said parameters to provide more accurate and precise information. for comparing the different rate of cultivation outside and inside the seawater.

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1.7 LIMITATIONS

The study is limited only on monitoring, reports on the system and logging all the data observed by the sensors. The logged data will be integrated by the researchers into a single controlled system, which will cover effective monitoring. This system will be simulated and executed using network wireless sensor and internet of things, which serves as the main control unit.

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CHAPTER 2:

RELATED LITERATURE

This chapter covers all of the related studies and literature which were used as reference for this study, including the overview of the current technology wherein a comparison table of the existing studies and products to the proponents' prototype was shown and briefly discussed.

2.1 LITERATURE SURVEY

Cultivate Mussels

Improvements in stocking strategy and management could increase the yield of mussels that are on-grown from harvested wild seed mussel resources and thereby enhance the sustainability of this shellfishery. A field experiment was undertaken to ascertain shell characteristics (compression strength and thickness) of seed mussels grown at different shore heights, whether these characteristics changed after a period of growth under identical conditions, and if these characteristics reduced predation losses by crabs and birds. Results indicated that mussels grown at higher shore levels attained shell characteristics beneficial to predation resistance and that these were maintained after a period of growth at a lower shore level. A novel management plan for mussel cultivation was formulated from the results of this study by manipulating shore position according to the attainment of these predator resistant shell attributes and the spatial distribution of the main natural mussel predators (crabs and birds). This technique was expanded to address the mussel cultivation problem of low natural seed settlement. (Beadman, H. et, 2003).

Growth of Mussels

M. viridis is a fairly widely distributed species along the coastline of India. In Goa, rich beds of this mussel are found in inshore waters and estuaries. Rope culture of green mussel in Goa has been started in 1974. Mussel seeds are transplanted from the natural bed at Velsao to Dona Paula, about 20 km away, and are allowed to grow on nylon ropes suspended from floating rafts. Environmental conditions both at Velsao and Dona Paula are almost similar. Growth of mussels on ropes is much faster than in natural beds. Mussels grow at a rate of about 8 mm/month on ropes and attain marketable size in approximately 5 months. The most difficult period for mussel culture is the monsoon season, when because of turbulent sea conditions, the rafts require constant attention. Total caloric content of cultured mussels is higher than those from the natural beds. Fouling of mussels on ropes by bryozoans and barnacles is common. Annual production of mussels is of the order of 23 kg mussel meat per rope or approximately 1150 kg of mussel meat per raft. In terms of yield in area, it works out to be 480 tons of mussels/ha/year approximately. Cost of production is about Rs. 2500/raft and the value of mussels produced is about Rs.6900. Rope culture thus gives high rate of returns of about 181%. Various constraints and advantages of mussel culture have been indicated and the potential of mussel farming in Goa has been compared with that of the other regions of the world where mussel culture is being practiced. For the production of high-quality protein food, mussel culture is perhaps the simplest and the easiest form of farming. (Alhambra M.Cubillo et l . 2012).

Artificial seawater

Crowding conditions in bivalve populations cause intra specific competition processes, resulting in individual growth reduction. In aquaculture, density is usually maximized to obtain a greater commercial yield. Commercial farms provide an ideal scenario for studying the effect of density on mussel growth in suspended culture systems. In this study, different growth indicators for Mytilus galloprovincialis (growth rates, length and weight growth curves and size frequency distributions) were measured along a cultivation density gradient. Ropes cultured at different densities (220, 370, 500, 570, 700, 800 and 1150 ind/m) were hanged from a commercial raft and growth indicators were monitored monthly over the second phase of traditional culture in Galicia, from thinning-out to harvest (April to October 2008). A negative effect of density on individual growth was observed. Individuals cultured at lower densities presented higher growth rates and consequently reached greater weight and length values at the end of the experimental period than those cultured at higher densities. Differences in growth related to the cultivation density may suggest differences in intraspecific competition for limiting resources (space/food). Effects of density on growth started after 4 months of culture (August) when individuals reached sizes around 66 ± 1.3 mm. The increase in size of individuals in a population implies an increment of their food and space requirements, which in turn intensifies intraspecific

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competition. This fact should be considered in aquaculture management, since higher densities could be supported without effects on growth performance if cultured mussels are limited to a lower size. (Maria P. Papadopoulou et, 2010).

wireless sensor networks

Recent developments in processor, memory and radio technology have enabled wireless sensor networks which are deployed to collect useful information from an area of interest. The sensed data must be gathered and transmitted to a base station where it is further processed for end-user queries. Since the network consists of low-cost nodes with limited battery power, power efficient methods must be employed for data gathering and aggregation in order to achieve long network lifetimes. In an environment where in a round of communication each of the sensor nodes has data to send to a base station, it is important to minimize the total energy consumed by the system in a round so that the system lifetime is maximized. With the use of data fusion and aggregation techniques, while minimizing the total energy per round, if power consumption per node can be balanced as well, a near optimal data gathering and routing scheme can be achieved in terms of network lifetime. So far, besides the conventional protocol of direct transmission, two elegant protocols called LEACH and PEGASIS have been proposed to maximize the lifetime of a sensor network. In this paper, we propose two new algorithms under name PEDAP (Power Efficient Data gathering and Aggregation Protocol), which are near optimal minimum spanning tree-based routing schemes, where one of them is the power-aware version of the other. Our simulation results show that our algorithms perform well both in systems where base station is far away from and where it is in the center of the field. PEDAP achieves between 4x to 20x improvement in network lifetime compared with LEACH, and about three times improvement compared with PEGASIS. (Ian F. Akyildiz,2007).

Design of wireless sensor networks

Aquaculture is moving toward an intensive controlled environment production with a significant increase in production, but at a cost of increased risk of catastrophic loss due to equipment or management failures. In addition, managers of intensive production facilities need accurate, real-time information on system status and performance in order to maximize their potential. This work has developed and deployed low cost short-range modules of wireless sensor network based on ZigBee standard and virtual instruments technology in order to monitor and control an aquaculture system in real time. The system consists of smart sensor nodes, coordinator/gateway node and personal computer (PC). The smart sensor nodes monitor environmental parameters such as dissolved oxygen, water temperature, pH and water level using relevant sensors, transmit this information to the coordinator/gateway node through ZigBee network and receive control signals for actuator control. The coordinator/gateway node receives data acquired and sends command to PC in order to achieve human–computer visualization interface. The graphical user interface (GUI) was designed by Lab Windows/CVI software platform so that users can observe, investigate and analyze the related scientific and accuracy of parameters in aquaculture environment. We have implemented our method for two sensor network nodes deployed in fish ponds and monitored the results for six months indicating that the power management and networking solutions adopted to work in practice, lead to maximize monitoring, control as well as the recording of the aquaculture system. It effectively reduces the probability of high risk of fish mortality through enabling constant monitoring of the critical parameters in the aquaculture environment. This situation in effect increases economic benefit for aquaculture, consumer confidence and safety while reducing labor cost and energy consumption (Daudi S.Simbeye et al ,2014).

Ocean acidification

Increasing absorption of carbon dioxide into world's oceans has caused seawater to become more acidic and warmer. In addition to many other consequences this will potentially have an impact on the propagation of sound in the ocean. Increasing acidity in seawater is bound to decrease the attenuation of sound and will result in better propagation conditions for sound. It has been observed that increased shipping has caused an increase in the ambient noise levels in the ocean and lower attenuations caused by ocean acidification could magnify this increase in noise levels. Increasing noise levels in the world's ocean and its impact on marine environment including marine mammals will continue to attract the attention of underwater acousticians. (Gopu R. Potty,2009).

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Seawater activation

A seawater-activated power cell for low power, long life undersea missions is under development. The cathode uses dissolved oxygen in seawater as a reactant. The anode is a selected magnesium alloy which limits self-discharge and extends cell life. The cell displays an open circuit voltage of about 1.6 volts. Under a load that would be equivalent to that required for a typical one-year mission, e.g., 2 to 3 watts, this power cell displays a working potential of 1.3 to 1.4 volts and has a total weight of about 32 kg. No pressure compensation is necessary since the structure is totally open to the seawater. Tests to date in selected ocean environments show that the cell operates well in low salinity water and in oxygen-depleted areas where other systems generally fail. Ocean tests have also shown that this power source can provide in excess of 700 Wh/kg for months. It has also been shown to operate both under ice and in fresh water. (E.S. Buzzelli et l ,1990).

Oxygen diffusion rate

Bucket experiments were conducted to measure the rate of diffusion of oxygen into sea water, stripped of dissolved oxygen to about 1 mg/l, of "homogeneous" salinity of 26-30 0 / 00 and with a "stable" temperature gradient. In five successive tests, the water required about 60 hours, under calm laboratory conditions, to exceed 7 mg/l at all depths in the bucket. Results of these tests indicated input of oxygen to be much more rapid than expected from molecular diffusion of the Fiskian type giving a diffusion coefficient of 6 ×

10 -3 cm 2 sec -1 compared to 2 × 10 -5 cm 2 sec -1. It is suggested that evaporation in the thin water layer at the air/water boundary increases the salinity sufficiently to initiate the transfer of oxygen from the atmosphere into sea water by convective movements, even in the presence of a stable temperature gradient and in the absence of turbulence (M. Waldichuk,1980).

Mussel farming

Eva Galimany, a marine biologist with the Institute of Sciences of the Sea in Barcelona and a member of the team working on the NOAA project in New York, noted the sheer abundance of saltwater mussel species (many more than oysters and distributed in intertidal zones throughout much of the world) means that mussels are adaptable to a wide range of conditions. “From my experiments, they are great survivors, barely get sick, and can cope with many types of weather issues and toxins,” she said. And since they can cope with difficult conditions it’s hoped that mussels could make it in places like the Bronx and theoretically be harvested and ground up for fish food, assuming they did not contain large quantities of toxics. (Yale Environment 360 How Mussel Farming Could Help to Clean Fouled Waters. (PAUL GREENBERG,2013).

Combine effect growth

The combined effects of salinity and temperature on survival and growth of larvae of the mussel Mytilus edulis L. were studied. The effects of salinity and temperature are significantly related only as the limits of tolerance of either factor are approached. Survival of larvae at salinities from 15 to 40‰ is uniformly good (70% or better) at temperatures from 5° to 20°C, but is reduced drastically at 25 °C, particularly at high (40‰) and low (20‰) salinities. Larval growth is rapid at a temperature of 15 °C in salinities from 25 to 35‰, at 20 °C in salinities from 20 to 35‰. Optimum growth occurs at 20 °C in salinities from 25 to 30‰. Growth decreases both at 25° and 10 °C; the decline is most drastic at high (40‰) and low (20‰) salinities. (Brenko A. Calabrese,1996).

Conductivity measurement

A set of microcontroller-based seawater conductivity measurement system is introduced, which is a part of the Expendable Conductivity, Temperature, Depth profile measurement equipment in the domestic research at present. In the hardware and software design, temperature compensation and low temperature drift rectifier filtering techniques are used to overcome the impact on the sensor and circuit, because of 40 degrees temperature changes in seawater. At the same time, under the DDS principle, a configuration is made on the microcontroller to output high-stability sine wave. The experiment proves that the accuracy for the seawater conductivity measurement system reaches ±0.077 mS/cm.

(Fan Hanbai et l ,2010).

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Internet of Things

Progresses in the marine research heavily rely on gathering data about species physiology, mobility, and their habitat to understand the environmental changes and its effects using bulky bio loggers and sensory networks that are invasive in nature. In this paper, we demonstrate an advanced lightweight compliant environmental monitoring system: "Marine-Skin" with enhanced sensing and logging capabilities, having soft-packaging and endurance up to a depth of 2 km in highly saline Red sea water for multiple weeks. Unlike invasive bio loggers, we demonstrate a unique non-invasive attachment strategy by designing a wearable jacket from soft-polymers that can be adhered to any species irrespective of their skin type. We have successfully deployed the feather-light (Sohail Faizan Shaikh et l ,2019).

Water quality

In recent years, ultraviolet-visible spectroscopy has been widely used for measurements of water quality in seawater, because full spectrum contains large amounts of information. NO3 can be detected in 220-230 nm, and chemical oxygen demand (COD) and total organic carbon (TOC) can be detected in 280-290 nm. In visible spectrum, water color, turbidity and total suspended solids (TSS) can be measured. We presented a water environmental multi-parameter sensor developed for the simultaneous measurement of these parameters. In order to research their absorptive characteristics and explore the detection methods, we sampled the absorption spectra of artificial seawater solutions of NO3, COD and turbidity. (Yingtian Hu et l, 2016).

Temperature sensors

Previous researchers have used freshwater mussels as biological sensors by monitoring the rhythmic opening and closing of their valve (gape). However, these mussels were tethered. Our goal is to use mussels as untethered sensors. Here we describe the Hall-effect sensing, and wireless communication electronics that are housed in a mussel backpack. We present experimental results demonstrating that one can measure untethered mussels' gape for extended periods. (J.J. Niemeier et l, 2013).

Mussel benefit

Mussels are found worldwide. Some live in the sea. Others inhabit freshwater streams and lakes. Inside their double-valved shell lies a soft body that is covered with a skin like organ called a mantle. As is the case with all mollusks, the mantle forms the shell by mixing calcium and carbon dioxide, which are extracted from the creature's food and the surrounding water. To match that ability, we humans would have to eat rock fragments, process them inside us, and then release them as prefabricated building materials that automatically make walls and roofs! But it is not the shell that is exciting researchers; it is the marine mussel's foot. (Barnhart,2001).

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Network topology

Topology control algorithm for wireless sensor networks is of great significance to save nodes' energy and prolong the lifetime of the network. Nowadays, there are two ways for wireless sensor networks to save energy: hierarchical topology control and power control; In this paper, we propose a new topology control method, Sleep-supported and Cone-based Topology Control method (SCTC), which integrates periodic sleep and topology control. The simulation results show that SCTC can save energy consumption and extend the lifetime of the network obviously.(Qianbin Chen et l , 2008)

Environmental Science

Water is an essential and a life sustaining drink to humans and is also important for survival of most other organisms and hence its quality needs to be monitored regularly to assure that it's safe to use. Potable water is a cause of concern in many developing countries including India. Presently we have fine and accurate quality assessment techniques as far as the chemical parameters of water quality are concerned but when it comes to the bacteriological parameters, we are still way behind from some of the other countries. Escherichia coli, is the most common serotype of enter hemorrhagic bacteria that are responsible for numerous food borne and water borne infections globally. This paper deals with detection of e coli bacteria in per ml water sample for which we have made a system comprising of an incubator chamber required for optimal growth of bacteria, (Meet Poladia,2016).

2.2 MOST CITED JOURNALS

The most cited and popular documents obtained from the digital library IEEE Explorer database regarding the combined search of the keywords "water quality" AND "Internet of Things" AND "aquaculture" AND "Wireless Sensor Network" are presented below and ordered by the number of citations in descending manner.

AUTHOR, PUBLICATION DATE	NUMBER OF CITATIONS	MAIN CONTRIBUTION	REMARKS
ShaoHua Hu, 2015	11	This study is concerned on the implementation of a dynamic system based on a wireless sensor network of internet of things that can monitor the quality of the water using the services in the internet of things.	Mussel cultivation needs to be farmed in a clean water for the harvest a healthy mussel. Using Internet of Things, we can detect all parameters affected by the water quality
Cesar Encinas et al., 2017	9	This study is concerned on a prototype and proof of concept of a distributed monitoring system of the most important variables in aquaculture water quality. The system proposed in this study monitors the water quality based on wireless sensor networks and on the	The major problem that can face the mussel is the quality of water and the project is aimed to monitor and control using the IOT technology to come up with a solution that can be useful for

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		Internet of Things (IoT). This information is important for the development of this area, since it allows sharing the different conditions in the breeding of aquatic organisms between different breeders and organizations.	the development of a product
M. Manju et al., 2017	8	This study is concerned on a system that can be made use of to produce organic food to match the ever-growing demand for food in the world. Since, the system implemented in this study continuously recycles the water used, the quality of water must be constantly monitored at regular intervals. Manually doing this task can be very tiring. Hence, Internet of Things (IoT) can be used as an effective application for this purpose. The system proposed in this study here consists of continuous	Aquaponic system concern about the junction of the aquaculture and hydroponics and its quite similar to specific mussel cultivation in water quality but the difficulty found in monitoring in a regular time but using internet of things to reduce human intervention and used an effective method to improve growing mussel species.

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		monitoring of the water quality and the plant's environment by using different sensors. The information collected by the sensors are accessed remotely by using the Internet of things.	
Duangchak Manyvone et al., 2018	8	This study is concerned on the water quality monitoring IoT Beat Sensors. The interval times of ID code transmitted wirelessly from Beat Sensor nodes correspond to amount of salinity, water levels, and pH, so that receivers can acquire these parameters from many sensor nodes in agriculture and aquaculture fields.	The proponents used this method of storing data collected from sensor in cloud such as water level, amount of salinity and pH level and that will help farmers to get more information regarding the water quality. Using the sensors to collect data and information of the water this data will be send to a microcontroller then WSN will transfer the data to the mobile
N. Hari Kumar et al., 2016	2	This study is concerned on the showcase of how to build an efficient Internet of	The variety and combination of the traditional method

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		Things (IoT) application for aquaponics in order to create an autonomous, self-regulating system with the help of Wireless Sensor Network (WSN). The designed aquaponic system of this study is composed of sensor devices that can sense and collect information of the various dimensions of the water quality involved and store it in a cloud database. This means that the human intervention would be considerably less when compared to the traditional methods of aquaponics.	required a human intervention and the wireless network sensor technology which helps aquaculture system and make the next generation to collect data and gather information easily.
T. Abinaya et al., 2019	2	This study is concerned on designed Internet of Thing (IoT) system based on for monitoring and controlling the water parameters in the aquaculture. The system in this study can detect and control the parameters such as temperature, pH value, dissolved oxygen, water	Focusing of the main problem can help all the different method to be specific on their work. the water quality is the major role to have a healthy aquaculture free from all the pollution parameter.

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		level, foul smell detector and ammonia in the water. The measured values from the sensors used in this study are also sent to the cloud using wi-fi modem and can be viewed in the control room. Also, the values are sent as short messages to the concern person using GSM modem.	
Bassirou Ngom et al., 2019	1	This study is concerned on water quality monitoring system through LoRa transmission. This study is claimed to be a low-cost infrastructure composed of a remote station for real-time data collection and a web platform for visualization and exploitation. To evaluate the reliability and efficiency of the system of this study, they performed some performance tests and the results are also presented in the study.	Water quality is the most important factor that affects aquamarine species and implementing technology on it can be very important for the growth and health of those species. This study focusses on a remote monitoring pool that can observe the quality of the water for future study of aquatic species

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Muhammad Niswar et al., 2018	1	This study is concerned on a design and implementation of a water quality monitoring system for crab farming using IoT technology to give awareness to a farmer for maintaining acceptable levels of water quality in the pond. Hence, this study contributes to increase the survival rate of crab and achieve higher yield of soft-shell crab.	Farming in south Asian it comes with difficulty since the quality decrease the IoT is a perfect solution to make sure the harvest and quality of the mussel not getting affected lacking some of the limnological parameters.
Vinay Vishwakarma et al., 2018	1	The study is concerned on the implementation of an electronic instrument that can measure water parameters like temperature, pH, turbidity and Dissolved Oxygen. to check the suitability of water. This study it has a great contribution in the growth of the aquatic organisms and also analyses the conduciveness of environment needed for certain types of aquatic	The increasing of the urban city and population required an equality with respect to water and also the quality of the limnological parameters and to meet all the human needed the technology using IoT with specific parameter sensor by collecting the information using

		organisms. It is also possible to create a database of periodic changes occurring in the water quality. The instrument sends the data of different parameters wirelessly to the offshore central server remotely using Internet of Things concept.	WSN to check the suitability of water

Table 1. Cited journals using the keywords "water quality" AND "Internet of Things" AND "aquaculture" AND "Wireless Sensor Network"

2.3 MUSSEL CULTIVATION

Mussel culture has played greater role in meeting the increasing protein demands of the human population. Bivalves such as oyster, mussel and clam are the most important cultivable organisms all over the world. Of these, mussels such as P.viridis and P.indica forms the most dominant cultivable species. The Central Marine Fisheries Research Institute (CMFRI) has developed eco-friendly techniques for mussel culture. Recently, CMFRI has taken up efforts to popularize mussel culture in all coastal districts of Kerala.

Green mussel shows a rapid growth rate by length of 8mm-13.5mm per month. Under average culture conditions, green mussel and brown mussel attain a length of 80-88mm with 36.5-40g weight and 65mm with 25-40g in 5 months respectively. The farmed mussels give a better meat yield compared to mussels from the natural bed. The average edible portion of the meat yield is 27.2%- 33.3% of the total weight. Growth by length and weight are probably the most important criteria for assessing the success of the culture system. The growth of mussel is influenced by a number of environmental factors such as water quality, food availability, settling density, water current and tidal exposure.

Harvest will be done when the mussels reach marketable size and condition index is high, i.e., before the spawning and onset of monsoon. Normally harvest season is from April to June. Mussel rope is collected manually and brought to the shore for harvest and washed thoroughly using jet wash to remove grit and silt. The mussels separated from the ropes are maintained in re- circulating seawater for 24 hrs. and washed again in fresh seawater. This method of depuration is effective in reducing the bacterial load of the mussel meat by 905. Depurated mussels are then mainly sold through local market as live shell-on mussel. At present processing units use only a small quantity of cultured mussel. New strategies need to be developed to fully exploit the domestic market. Meat from depurated mussel can be shucked in fresh condition or after boiling or steaming. Further processing of the mussel meat can be done after blanching in 5% salt solution for 5 minutes.

2.4 ARTIFICIAL SEAWATER

Microbiologists have concocted an artificial seawater medium that can be used to successfully cultivate abundant marine microorganisms, many of which have not been genetically characterized before.

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Artificial sea water is primarily used in marine biology and allows the easy preparation of media appropriate for marine organisms. Marine artificial media are used when critical studies cannot be conducted using a natural seawater base, so artificial seawater medium is used to minimize or exclude known contaminants for the purpose of studying trace elements. The Artificial sea water recipe consists of mineral salts, some anhydrous salts that can be weighed out, and some hydrous salts that should be added to the artificial seawater as a solution. There are many formulas, each with its own characteristics. The quality of a brand of sea salt is dependent on the formula, the quality of the raw materials and the uniformity of the blending. The salinity is the sum of all of the dissolved ions. All the salts present in the medium provides organic source of growth nutrients. Vibrio and Halobacterium are common survival under conditions of hyper osmolarity.

Artificial seawater (abbreviated ASW) is a mixture of dissolved mineral salts (and sometimes vitamins) that simulates seawater. Artificial seawater is primarily used in marine biology and in marine and reef aquaria, and allows the easy preparation of media appropriate for marine organisms (including algae, bacteria, plants and animals). From a scientific perspective, artificial seawater has the advantage of reproducibility over natural seawater since it is a standardized formula. Synthetic seawater is also known as artificial seawater and substitute ocean water.

The tables below present an example of an artificial seawater (35.00‰ of salinity) preparation devised by Kester, Duedall, Connors and Pytkowicz (1967). The recipe consists of two lists of mineral salts, the first of anhydrous salts that can be weighed out, the second of hydrous salts that should be added to the artificial seawater as a solution.

Table 2. Gravimetric salt values

Gravimetric salts		
Salt	**Molecular weight**	**g kg^{-1} solution**
Sodium chloride (NaCl)	58.44	23.926
Sodium sulfate (Na2SO4)	142.04	4.008
Potassium chloride (KCl)	74.56	0.677
Sodium bicarbonate (NaHCO3)	84.00	0.196
Potassium bromide (KBr)	119.01	0.098
Boric acid (H3BO3)	61.83	0.026
Sodium fluoride (NaF)	41.99	0.003

Table 3. Volumetric salts values

Volumetric salts		
Salt	Molecular weight	mol kg−1 solution
Magnesium chloride (MgCl2.6H2O)	203.33	0.05327
Calcium chloride (CaCl2.2H2O)	147.03	0.01033
Strontium chloride (SrCl2.6H2O)	266.64	0.00009

While all of the compounds listed in the recipe above are inorganic, mineral salts, some artificial seawater recipes, such as Goldman and McCarthy (1978), make use of trace solutions of vitamins or organic compounds.

2.5 LIMNOLOGICAL PARAMETERS

The parameters analysed to assess the water quality are broadly divided into:

Physical parameters: Colour, Temperature, Transparency, Turbidity and Odour.

Chemical parameters: pH, Electrical Conductivity (E.C), Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Hardness, Calcium Hardness, Magnesium Hardness, Nitrates, Phosphates, Sulphates, Chlorides, Dissolved Oxygen (D.O), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Fluorides, Free Carbon-di-oxide, Potassium and Sodium.

Heavy metals: Lead, Copper, Nickel, Iron, Chromium, Cadmium and Zinc.

Biological parameters: The biological parameters involved the qualitative analyses of planktons (zooplankton and phytoplankton).

Field measurement: The field parameters measured include pH, conductivity, dissolved oxygen and temperature.

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Temperature

Impinging solar radiation and atmospheric temperature brings about spatial and temporal changes in temperature, setting up convection currents and thermal stratification. Temperature plays a very important role in wetland dynamism affecting the various parameters such as alkalinity, salinity, dissolved oxygen, electrical conductivity etc. In an aquatic system, these parameters affect the chemical and biological reactions such as solubility of oxygen, carbon-di-oxide-carbonate-bicarbonate equilibrium, increase in metabolic rate and physiological reactions of organisms, etc. Water temperature is important in relation to fish life. The temperature of drinking water has an influence on its taste.

PH:

The effect of pH on the chemical and biological properties of liquids makes its determination very important. It is one of the most important parameters in water chemistry and is defined as -log $[H^+]$, and measured as intensity of acidity or alkalinity on a scale ranging from 0-14. If free H^+ are more it is expressed acidic (i.e. pH<7), while more OH^- ions is expressed as alkaline (i.e. pH> 7).

In natural waters pH is governed by the equilibrium between carbon dioxide/bicarbonate/carbonate ions and ranges between 4.5 and 8.5 although mostly basic. It tends to increase during day largely due to the photosynthetic activity (consumption of carbon-di-oxide) and decreases during night due to respiratory activity. Waste water and polluted natural waters have pH values lower or higher than 7 based on the nature of the pollutant.

Conductivity

Conductivity (specific conductance) is the numerical expression of the water's ability to conduct an electric current. It is measured in micro Siemens per cm and depends on the total concentration, mobility, valence and the temperature of the solution of ions. Electrolytes in a solution disassociate into positive (cations) and negative (anions) ions and impart conductivity. Most dissolved inorganic substances are in the ionised form in water and contribute to conductance. The conductance of the samples gives rapid and practical estimate of the variation in dissolved mineral content of the water supply. Conductance is defined as the reciprocal of the resistance involved and expressed as mho or Siemen (s).

Dissolved Oxygen

Oxygen dissolved in water is a very important parameter in water analysis as it serves as an indicator of the physical, chemical and biological activities of the water body. The two main sources of dissolved oxygen are diffusion of oxygen from the air and photosynthetic activity. Diffusion of oxygen from the air into water depends on the solubility of oxygen, and is influenced by many other factors like water movement, temperature, salinity, etc. Photosynthesis, a biological phenomenon carried out by the autotrophs, depends on the plankton population, light condition, gases, etc. Oxygen is considered to be the major limiting factor in water bodies with organic materials. Dissolved oxygen is calculated by many methods.

2.6 INTERNET OF THINGS

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

How IoT works

An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.

Benefits of IoT

The internet of things offers a number of benefits to organizations, enabling them to:

- Monitor their overall business processes;
- Improve the customer experience;
- Save time and money;
- Enhance employee productivity;
- Integrate and adapt business models;
- Make better business decisions; and
- Generate more revenue.

2.7 WIRELESS SENSOR NETWORK

A Wireless sensor network can be defined as a network of devices that can communicate the information gathered from a monitored field through wireless links. The data is forwarded through multiple nodes, and with a gateway, the data is connected to other networks like wireless Ethernet.

WSN is a wireless network that consists of base stations and numbers of nodes (wireless sensors). These networks are used to monitor physical or environmental conditions like sound, pressure, temperature and co-operatively pass data through the network to a main location.

Types of WSNs (Wireless Sensor Networks)

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Depending on the environment, the types of networks are decided so that those can be deployed underwater, underground, on land, and so on. Different types of WSNs include:

- Terrestrial WSNs
- Underground WSNs
- Underwater WSNs
- Multimedia WSNs
- Mobile WSNs

Under Water WSNs

More than 70% of the earth is occupied with water. These networks consist of a number of sensor nodes and vehicles deployed under water. Autonomous underwater vehicles are used for gathering data from these sensor nodes. A challenge of underwater communication is a long propagation delay, and bandwidth and sensor failures.

Under water WSNs are equipped with a limited battery that cannot be recharged or replaced. The issue of energy conservation for under water WSNs involves the development of underwater communication and networking techniques.

Limitations of Wireless Sensor Networks

- Possess very little storage capacity – a few hundred kilobytes
- Possess modest processing power-8MHz
- Works in short communication range – consumes a lot of power

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- Requires minimal energy – constrains protocols
- Have batteries with a finite life time
- Passive devices provide little energy

2.8 STATISTICAL ANALYSIS

Table 4: Descriptive statistics of water quality parameters in the southern Caspian Sea (Mazandaran coast) during four seasons

PARAMETERS	SPRING	SUMMER	AUTUMN	WINTER	YEARS
TEMPERATURE (C)	17.42	27.23	20.58	11.79	19.26
CONDUCTIVITY (μmos/cm)	15.92	19.58	17.33	14.18	16.78
DISSOLVED OXYGEN (mg/l)	9.49	8.68	9.17	10.6	9.48
PH LEVEL (μg/l)	8.23	8.42	8.07	8.06	8.19

Adapted from K. Raghu Sita Rama Raju, et al, (2017)

Water quality is a critical factor while culturing aquatic organisms. This work focus on the monitorization of the quality of the parameters of the water, such as the temperature, dissolved oxygen, ammonia, pH, salt, nitrates etc. The key question remains in the utilization of the artificial water, all the above-named parameters can be controlled by any microcontroller, but can be better if the water parameters are provided by the proponents. The proponents therefore analyzed the best way to produce their own artificial seawater for a better performance of the sensors.

Adapted from Flordeliza L. Valiente, et al. (2018).

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The purpose of this study is to create an automated aquaponics system using Nile Tilapia and Romaine Lettuce with access and control of pH level and temperature through Internet of Things (IoT). Intel Edison is used as the microprocessor which continuously sends information of the aquaponics' status and adjusts them if the parameters falls below their optimal levels. It is important to address that the parameters of the water are very important when it comes to farming aquatic organisms, therefore controlling the pH level of the water will not ensure the growth of healthy fishes. The this study the proponents investigated the important of the growth of healthy mussels, therefore they implemented more parameters so that the farming of healthy mussels could be more efficient.

Adapted from Shih-Pang Tseng et, al. (2016)

Aquaculture is one of the human important food sources. This study proposed the prototype of the framework, Sustainable Fish-Farming System (SFFS) using natural seawater, which can make the aqua-farming system more sustainable via applying the Internet of things (IOT) to reduce the need of energy for controlling the environment. Is important to address that From a scientific perspective, artificial seawater has the advantage of reproducibility over natural seawater since it is a standardized formula. Therefore, the proponents included the artificial seawater to with a standardized formula.

Adapted from Rakibul Hasan Rajib et, al. (2018).

Water quality parameters used in this work are Temperature, pH, Electrical Conductivity and Color. Sensor acquisition is conducted by Arduino and Raspberry Pi is used as data processing device as well as server. Photo acquisition is also performed by Raspberry Pi with the help of the smartphone camera to detect the color of the water. Is needed to clarify that the monitoring of the parameters of the water does not fix future problems, therefore the goals of the proponents' study are to monitor the parameters and control them in case of any abnormal state of the water.

Adapted from <u>Yuhwan Kim et, al. (2018).</u>

Most power companies are wasting hot water in the sea, which is called the wasted warm water energy. This research attempts to develop the thermal energy management system of warm water energy that is utilized in a fish farming system based on Internet of Things (IoT). The question is, why using the natural seawater if you can create your own artificial seawater. To avoid the wastes coming from the industrial companies, the proponents therefore make sure to create their own artificial seawater.

2.9 SYNTHESIS

In synthesizing the overall related studies, the proponents got too much information related to their proposal, and most of the previous studies were focused on the implementation of the IoT in a seawater farming. The proponents did not encounter such system which can control, monitor and automatically fix any issue regarding the parameters of the seawater, also the proponents did not encounter a system that controls, monitor the parameters of water using artificial seawater.

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CHAPTER 3

This chapter introduces and explains how the study was conducted. Also, it contains conceptual framework, the design considerations, the proposed methodology architecture of the study, and the steps that will be implemented for the future construction. Furthermore, this chapter represents the paradigm of the study which illustrates the parameters needed and shows how the proponents come up with the design and implementation of a control device of limnological parameters for IoT-based mussel cultivation. The proponents provide a general to detailed explanations of the study.

3.1 CONCEPTUAL FRAMEWORK

The proponents aimed to design and implement a Control device of Limnological Parameters for IoT-based Mussel Cultivation. In this study, the proponents provide different paradigms of the system that will help to understand and analyze the goal of the study and how the system will work. Furthermore, the proponents explain the general concept of the study in a comprehensive way.

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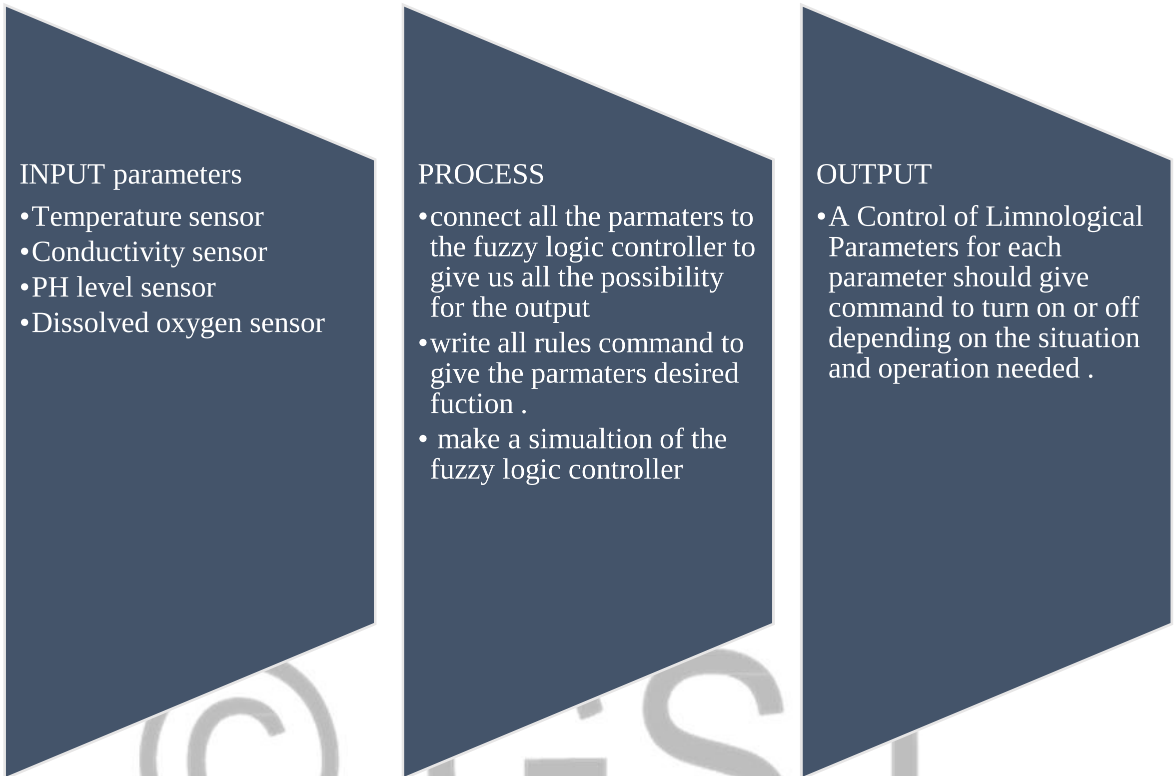

Figure 3.1. Conceptual framework

3.2 DESIGN CONSIDERATION

3.2.1 ECONOMIC

In this point view and considering the Philippines located in a narrow channel between Luzon and Santiago island that used to be filed with coral reef and supported a wide range of species we should consider that as a solution resource to meet or be at the same line with increasing the population, focusing on the best economical way and to increase the mussel farming cultivation . (Jianzhong Hao et l,2010).

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3.2.2 ENVIRONMENTAL

Farming of mussels in different levels of the seawater can face many disease like TBT it's an organic compound with an associated tin molecule and this compound can cause the most damage to marine environment with a high concentration can cause variety effect in different level of the seawater and reducing growth rate , shell thickening in oysters which reduce the size of the whole body , carb dioxide is being absorbed by the ocean by until it becomes acidic it is caused by pollution in the atmosphere from power plant ,car and other areas that destroys the ecosystem .

(Daphnis De Pooter,2013).

3.2.3 SOCIAL

The oyster farming industry has remained a relatively small industry in the Philippines. The same can be said for mussels. Part of the problem is the market. Unlike fish, mussel can't accommodate with families that would make it a part of their daily food unless if they are living in coastal areas. In 1995 a Korean company set up a large shellfish processing plant in Capiz province and other area that has minimize the demand of that area and the majority of mussel farmer has fishing as their other source of income in this matter this matter the proponents are provide the new idea to mussel cultivation that can be helpful expanding the growing rate.

3.2.4 POLITICAL

One of the major determinants of a successful aquaculture is governance, which includes not only the means of managing the industry but also the process by which decisions are made. On the other hand, the enabling and communicate with the farmers to figure out the new solution. The research is capable of providing the governing body with technology useful in improving the state at which they govern. It will be efficient in providing the best and reliable design that can easily be employed in solving life-long marine problems. Many countries as they were, are victims of polluted water environments which emanates from industrial waste and even from the public unsanitary condition. Majority of solid wastes are disposed into canals which lead to rivers: with this continuing, there will be a serious water pollution that ends up contaminating aquatic lives and become unfit for human consumption.

3.2.5 ETHICAL

The Ethical Matrix was changed in order to include the various aquaculture production stages separately. Like the environment, costumer and aquaculture organism it should have the flexibility to incorporate new data generated in the fast growing/continuous changing aquaculture sector in order to boost a new solution. (Kriton Grigorakis,2010). The roles of this prototype are practically for the purpose of water quality determination using sensors and microcontrollers. The proponents ensured that the prototype presented an ethical consideration by not going against the morals of individuals who read or make use of all or parts of this document for reasons related to the detecting and monitoring of limnological parameters.

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3.2.6 HEALTH AND SAFETY

One of the important issues when it comes to farming mussels is chosen the right place and be aware of the pollution factor that can make the ocean un safe to grow the mussel because the wrong kind of algae can make shellfish dangerous to eat. As demand for seafood continues to rise, worldwide aquaculture production now rivals that of fishing for some wild species. Understanding the local environment is an important component of ensuring that an aquaculture harvest is safe and sustainable. (Anderson, C.R., et al, 2009).

3.2.7 MANUFACTURABILITY

On this point we require a precise and reliable indicator of the pollutant of the recovery of a population from a pollution stress from with using a biomedical or electronics means to maintain and minimize the effect of the mussel providing valuable information about the level of pollution and the quality of the marine environment.

3.2.8 SUSTAINABILITY

The project will be covering a sustainable and reliable quality of the mussel by containing the mussel away from the seawater to make sure the mussel cultivation will not be hindered by the pollution parameters. The construction of the prototype will recognize this method when building the device in practical ways that meets the cost-efficiency while ensuring that the devices quality is reliable.

3.3 METHODOLOGICAL ARCHITECTURE

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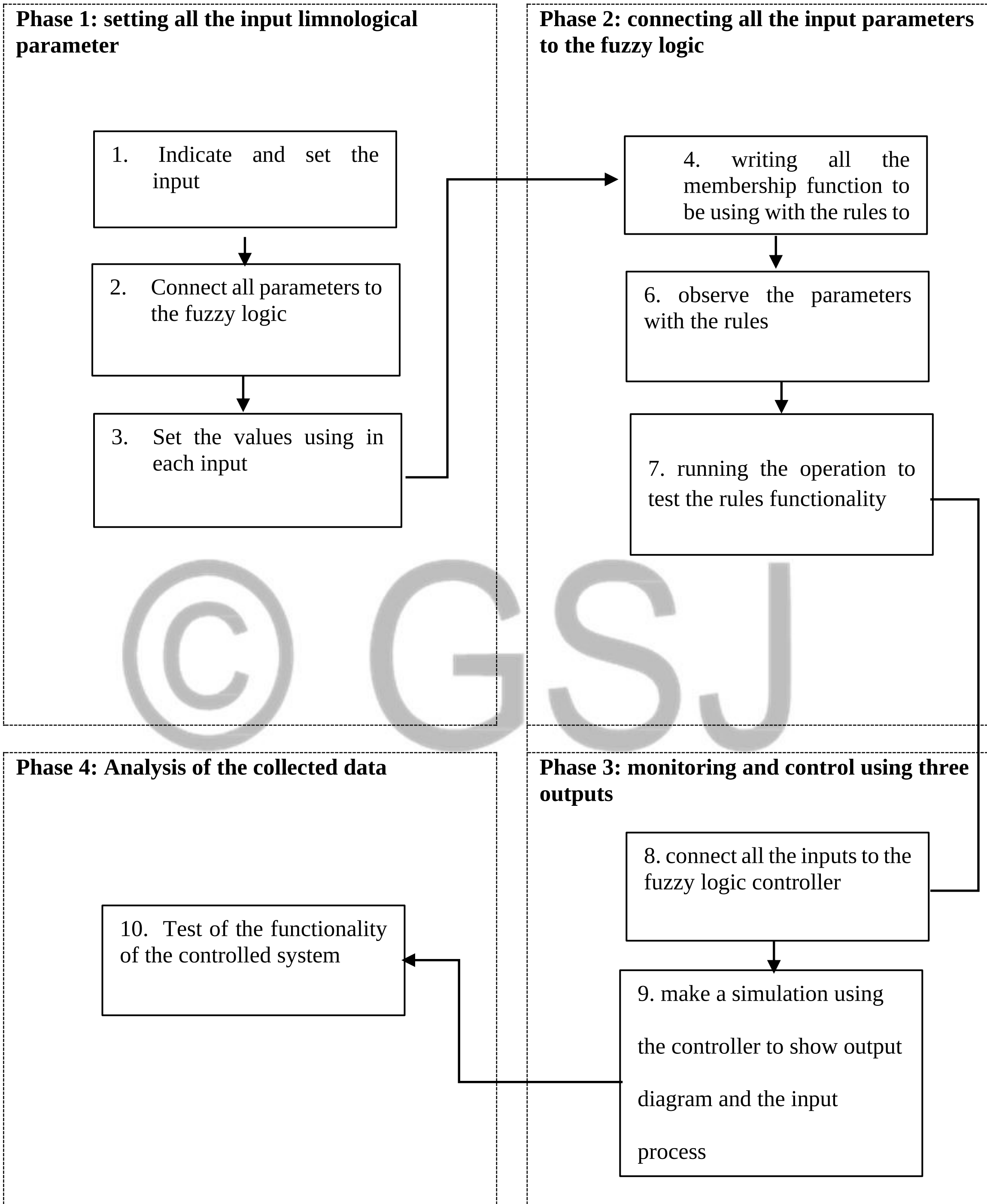

Figure 3.2. Methodological Framework

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3.4 PHASE 1: IMPLEMENTATION OF THE HARDWARE

In this phase the proponents will focus on the implementation of the Hardware in this study. As shown in the conceptual framework the proponents are working with four water parameters to be controlled, such as, temperature sensor, conductivity sensor, PH level sensor and the dissolved oxygen sensor. Those sensors will be providing data signal to the microcontroller, the said data will be sent and shown on a telephone or computer with the help of the wireless sensor network, that will be sending all the data gathered to the cloud and the electronic device.

3.4.1 STEP 1: CALIBRATION OF SENSORS

In the first phase the proponents will start calibrating all the sensor as it mentioned in the conceptual framework at the first thing the proponents will start with temperature sensor using DS18B20 sensors by plugging 5 kohm with the two sensor and connect that in the Arduino Uno to analyze the data , once the connected is set up the proponents will be calibrating the PH level sensor making sure or familiarized about the mussel environment and connect this also to the Arduino and electric conductivity sensor by depend on the temperature because as the temperature increased the conductivity may vary their value , dissolved oxygen consisting of two parts electrode and the sensor its better used for measuring a tank in order to calibrate this sensor we need to make sure in the saturated level of water in the locality and sodium sulfite.

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Figure 3.3: Calibration and set up the ph level and temparture sensors

3.4.2 STEP 2: DESIGN AND IMPLEMENTATION OF THE HARDWARE ARCHITECTURE

In this phase the proponents will be start working on the hardware part and since the project will be in the tank filled by artificial seawater all the sensors will be flooding or a side of the tank after the calibration of each sensor and connect all that to the Sintra board. This will prevent the sensors from becoming defective. The Sintra board will also make some part of the prototype to be buoyant, thereby, keeping only the harmless parts submerged in water. The device will be built to withstand mechanical damage, while the circuits also remain connected firmly in the same. Utilizing hot glue and other adhesives, some parts of the microcontroller can be fixed to the Sintra board. Components such as the heat sink, fan, and sensors which penetrates the Sintra board can be glued from both sides using heat and water-resistant glues to ensure that water does not go inside the secured box.

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3.5 PHASE 2: IMPLEMENTATION OF THE SOFTWARE

In this phase the proponents will be working on the software, the software in this study consist in two parts, the set up in the programming language of the microcontroller and the software connected to the wireless sensor network that will allow the information or data to be sent to the cloud. Embedded Software is the software that controls an embedded system. All embedded systems need some software for their functioning. Embedded software or program is loaded in the microcontroller which then takes care of all the operations that are running. For developing this software, a number of different tools are needed, these tools include editor, compiler, assembler and debugger.

3.5.1 STEP 3: DESIGN AND IMPLEMENTATION OF THE SOFTWARE ARCHITECTURE

In this step the proponents present the design for the programming language and other features in the software. The mobile application will be developed in Visual Studio 2015 in the C sharp language. It will be developed to read the serial port of the computer and to enable communication with the hardware. The application will be developed in

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Android studio for devices that have an operating system higher than Android 4.0.3 or equivalent.

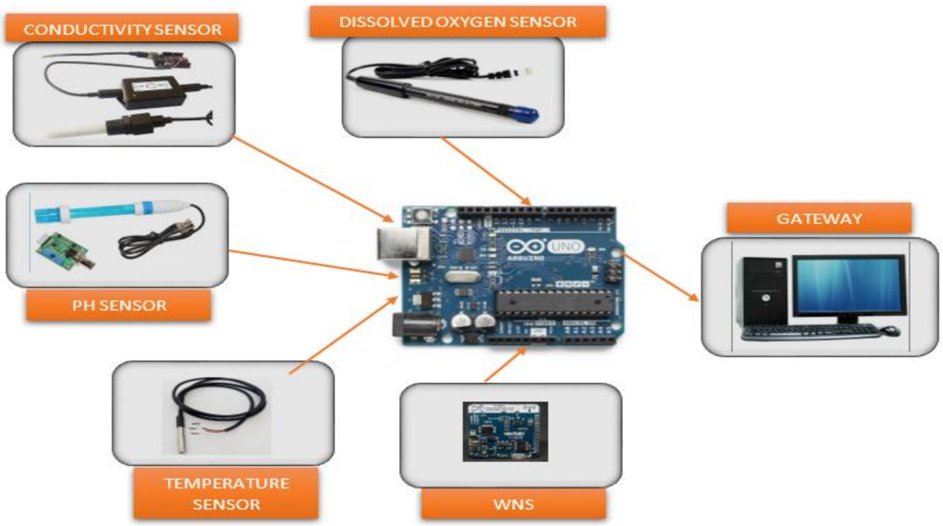

Figure 3.4. Design of the software architecture

3.5.2 STEP 4: INTEGRATION OF THE WSN AND THE MICROCONTROLLER

The proponents will be using a microcontroller with an open source embedded software that allows the communication between the sensors named previously and the system via WSN.

The main idea that the proponents want to transmit in this step is the intercommunication between the microcontroller and the WSN module, this second will be sending all the data gathered from the sensors to a device to be monitored and controlled

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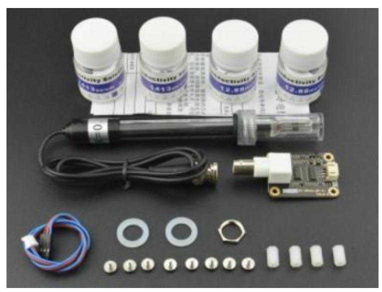
3.6. Bill of Materials

NAME OF MATERIAL	DESCRIPTION	PRICE	PICTURE
Dissolved Oxygen sensor	This is a dissolved oxygen sensor kit, which is compatible with Arduino microcontrollers. This product is used to measure the dissolved oxygen in water, to reflect the water quality. It is widely applied in many water quality applications, such as aquaculture, environment monitoring, natural science and so on.	12,500 PHP	
Water conductivity sensor	With this product, main control board (such as Arduino) and the software library, you can quickly build an electrical conductivity meter, plug and play, no welding. DFRobot provides a variety of water quality sensor products, uniform size and interface, not only meet the needs of various water quality testing, but also suitable for the DIY of multi-parameter water quality tester.	4,300 PHP	

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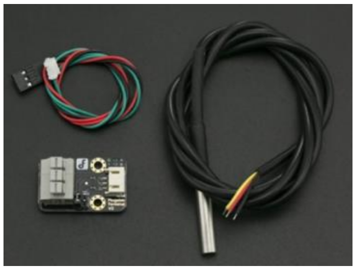
Temperature sensor	This waterproof temperature sensor kit is using the same probe—— DS18B20 probe AS. It contains a probe with a resister module. So, it is easy to connect on the Arduino board. The DS18B20 temperature sensor provides 9 to 12-bit (configurable) temperature readings over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor. Compatible with 3.0-5.5V systems.	850 PHP	
pH sensor	With this sensor we may now measure water quality and other parameters affordably. It also Arduino Compatible, especially designed for Arduino controllers to easily interface the sensor with practical connector. This will enable to extend your project to bio-robotics. It has an LED which works as the Power Indicator, a BNC connector and PH2.0 sensor interface. To use it, just connect the pH sensor with BND connector, and plug the PH2.0 interface into the analog input port of any Arduino controller. If	1,800 PHP	

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	pre-programmed, you will get the pH value easily.		
Arduino Due R3	The Arduino Due R3 ARM is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU (datasheet). It is the first Arduino board based on a 32-bit ARM core microcontroller. It has 54 digital input/output pins (of which 12 can be used as PWM outputs), 12 analog inputs, 4 UARTs (hardware serial ports), a 84 MHz clock, an USB OTG capable connection, 2 DAC (digital to analog), 2 TWI, a power jack, an SPI header, a JTAG header, a reset button and an erase button.	1,200 PHP	
Zigbee XBee 3 Module PCB Antenna	The XBee is a great interface between the Arduino and the XBee, which is a wireless communication module. The XBee Shield helps to reduce the clutter and hassle of having the XBee connected via a cable. The module communicates at distances of 100 feet indoors and 300 feet outdoors	1,600 PHP	

Table 5: Bill of the materials

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CHAPTER 4

INTERPRETATION OF RESULTS

1. DATA RESULTS OF THE SENSORS

The optimization parameters used in the design are highly effective when it comes to the project therefore we select more sensor to make sure we can reduce more obstacles we face in this aquatic environment so in order to choose the parameter carefully we saw first how each parameter can impact on the project alone and what is the advantages of using it.

Table 6. Data results of the sensors per trial

Time	Temperature	pH level
29/08/20 15:34	221.63	7.53
29/08/20 16:34	21.03	7.34
29/08/20 17:34	20.71	7.42
29/08/20 18:34	20.77	7.31
29/08/20 19:34	20.72	7.44
29/08/20 20:34	20.69	7.52
29/08/20 21:34	20.62	7.59
29/08/20 22:34	20.59	7.48
29/08/20 23:34	20.33	7.42
30/08/20 00:34	20.67	7.37
30/08/20 01:34	20.78	7.52
30/08/20 02:34	20.63	7.38
30/08/20 03:34	20.55	7.31
30/08/20 04:34	20.65	7.46
30/08/20 05:34	20.73	7.53
30/08/20 06:34	20.92	7.41
30/08/20 07:34	20.87	7.54
30/08/20 08:34	21.28	7.42
30/08/20 09:34	21.31	7.49

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30/08/20 10:34	21.57	7.4
30/08/20 11:34	21.47	7.38
30/08/20 12:34	21.54	7.56
30/08/20 13:34	21.32	7.51
30/08/20 14:34	21.12	7.53
30/08/20 15:34	20.84	7.46
30/08/20 16:34	20.78	7.52
30/08/20 17:34	20.92	7.35
30/08/20 18:34	20.79	7.31
30/08/20 19:34	20.88	7.39
30/08/20 20:34	20.82	7.47
30/08/20 21:34	20.54	7.58
30/08/20 22:34	20.74	7.32
30/08/20 23:34	20.67	7.54
31/08/20 00:34	20.49	7.37
31/08/20 01:34	20.65	7.58
31/08/20 02:34	20.69	7.43
31/08/20 03:34	20.65	7.56
31/08/20 04:34	20.75	7.43
31/08/20 05:34	21.19	7.6
31/08/20 06:34	21.26	7.37
31/08/20 07:34	21.41	7.41
31/08/20 08:34	21.38	5.49
31/08/20 09:34	21.43	7.57
31/08/20 10:34	21.65	7.31
31/08/20 11:34	21.47	7.44
31/08/20 12:34	21.56	7.38
31/08/20 13:34	21.42	7.52
31/08/20 14:34	21.11	7.35
31/08/20 15:34	21.18	7.49
31/08/20 16:34	21.24	7.36
31/08/20 17:34	20.92	7.31
31/08/20 18:34	20.87	7.39
31/08/20 19:34	20.97	7.53
31/08/20 20:34	20.82	7.42
31/08/20 21:34	20.87	7.48
31/08/20 22:34	20.54	7.34
31/08/20 23:34	20.78	7.56
01/09/20 00:34	20.72	7.59
01/09/20 01:34	20.69	7.41
01/09/20 02:34	20.61	7.55
01/09/20 03:34	20.73	7.38

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01/09/20 04:34	20.82	7.54
01/09/20 05:34	20.87	7.32
01/09/20 06:34	20.84	7.46
01/09/20 07:34	21.09	7.31
01/09/20 08:34	21.33	7.45
01/09/20 09:34	21.27	7.52
01/09/20 10:34	21.53	7.51
01/09/20 11:34	21.34	7.42
01/09/20 12:34	21.28	7.37
01/09/20 13:34	21.06	7.34
01/09/20 14:34	20.81	7.45
01/09/20 15:34	20.86	7.55
01/09/20 16:34	20.73	7.39
01/09/20 17:34	20.64	7.4
01/09/20 18:34	20.75	7.38
01/09/20 19:34	20.71	7.51
01/09/20 20:34	20.69	7.47
01/09/20 21:34	20.64	7.32
01/09/20 22:34	20.38	7.56
01/09/20 23:34	20.31	7.52
02/09/20 00:34	20.47	7.34
02/09/20 01:34	20.51	7.37
02/09/20 02:34	20.58	7.33
02/09/20 03:34	20.53	7.43
02/09/20 04:34	20.68	7.38
02/09/20 05:34	20.64	7.57
02/09/20 06:34	20.69	7.44
02/09/20 07:34	20.84	7.47
02/09/20 08:34	21.29	7.32
02/09/20 09:34	21.18	7.34
02/09/20 10:34	21.23	7.55
02/09/20 11:34	21.43	7.53
02/09/20 12:34	21.27	7.42
02/09/20 13:34	21.25	7.37
02/09/20 14:34	21.03	7.35
02/09/20 15:34	20.85	7.38
02/09/20 16:34	20.81	7.43
02/09/20 17:34	20.81	7.32
02/09/20 18:34	20.76	7.46
02/09/20 19:34	20.72	7.38
02/09/20 20:34	20.47	7.56
02/09/20 21:34	20.56	7.34

02/09/20 22:34	20.5	7.57
02/09/20 23:34	20.58	7.31
03/09/20 00:34	20.67	7.42
03/09/20 01:34	20.86	7.45
03/09/20 02:34	21.51	7.58
03/09/20 03:34	21.32	7.42
03/09/20 04:34	21.49	7.37
03/09/20 05:34	21.56	7.52
03/09/20 06:34	21.73	7.45
03/09/20 07:34	21.47	7.49
03/09/20 08:34	21.56	7.38
03/09/20 09:34	21.44	7.52
03/09/20 10:34	21.42	7.43
03/09/20 11:34	21.49	7.48
03/09/20 12:34	21.19	7.32
03/09/20 13:34	20.97	7.37
03/09/20 14:34	20.73	7.57
03/09/20 15:34	20.83	7.64
03/09/20 16:34	20.64	7.47
03/09/20 17:34	20.69	7.53
03/09/20 18:34	20.69	7.32
03/09/20 19:34	20.71	7.32
03/09/20 20:34	20.68	7.33
03/09/20 21:34	20.66	7.31
03/09/20 22:34	20.63	7.31
03/09/20 23:34	20.54	7.38
04/09/20 00:34	20.31	7.38
04/09/20 01:34	20.22	7.38
04/09/20 02:34	20.31	7.38
04/09/20 03:34	20.62	7.32
04/09/20 04:34	20.81	7.47
04/09/20 05:34	20.84	7.41
04/09/20 06:34	20.84	7.44
04/09/20 07:34	20.87	7.39
04/09/20 08:34	21.31	7.34
04/09/20 09:34	21.38	7.47
04/09/20 10:34	21.35	7.53
04/09/20 11:34	21.42	7.51
04/09/20 12:34	21.44	7.49
04/09/20 13:34	21.32	7.43
04/09/20 14:34	21.41	7.57

Table5: shows how the data for the set up varies for both sensors: pH level and temperature going to normal and to abnormal and that's how we can use this data to control whenever parameter goes to the abnormal state. The values are relevant to feed the AI on what triggers to execute when certain level of instability is reached. With these responses, the artificial water body can be regulated or stabilized to the desired state required for the cultivation of Mussels.

Table 7. Optimal values of the sensor

Sensor	Optimal Values	Status
Ph sensor	7.2 – 7.6	Neutral
Water Conductivity sensor	3 – 6	Neutral
Dissolved Oxygen sensor	0 – 5	Moderate
Temperature sensor	16 – 18	Moderate

2. DESIGN OF THE SYSTEM

Using MATLAB to design and simulate both the input and the output, at first focusing on the inputs which are the pH level , temperature , dissolved oxygen and electric conductivity and trying to control at the same time to maintain the process from decreasing or surpass the limit by using three different output for our parameters.

Selecting the fuzzy logic for the design can make it easier to deal with especially for controlling part and also the three output by connecting them with

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the parameters and start writing the command rules in order to make these parameters fully function.

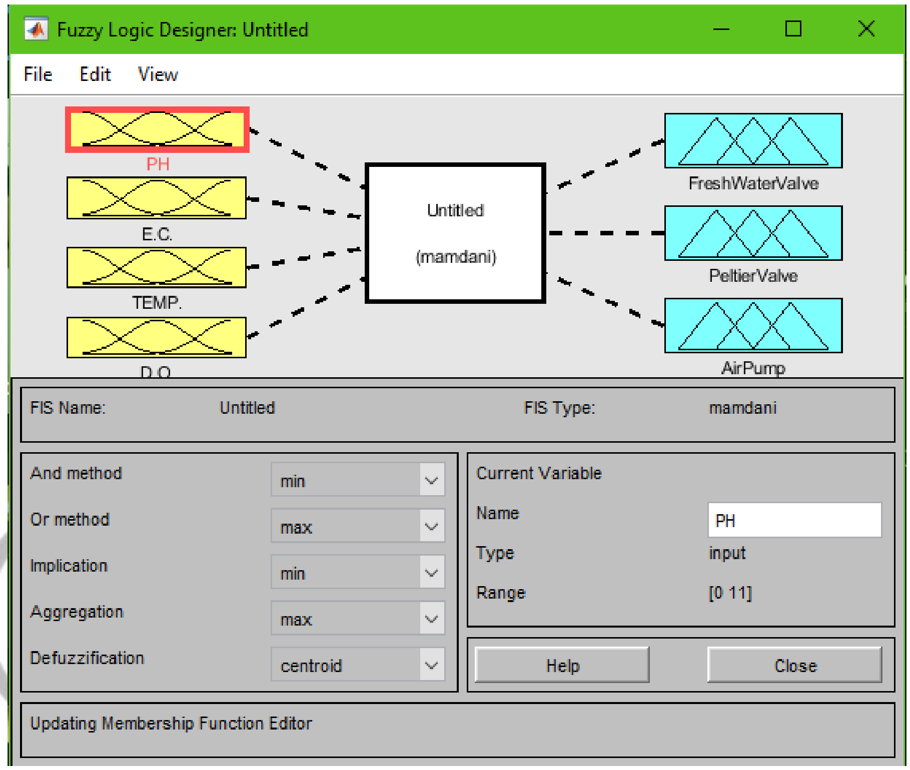

Figure 4.1. Fuzzy logic designer

The prototype was further carried out on actual sensors and components to generate actual data that can be used in the simulation process all over again. The prototype was designed using pH sensor for determining the pH level of the water and temperature sensor for determining the water temperature. There are also supporting components for the sensors to regulate their levels. Examples of these components are the heat sinks, and fan. They were used in stabilizing the conditions of the water container to make sure that the optimal levels are reached. This is further demonstrated using the MATLAB environment for simulating the behavior of these supporting components.

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3. DEVELOP THE SYSTEM BY COMBINING Ph PARAMETER

The pH parameter in the MATLAB simulation measures the acidity, neutrality or basicity of the water body in study. The values for neutrality ranges between 7.2 to 7.6. Where anything below 7.2 is considered acidic and over 7.6 is alkaline or basic.

These figures were computed employing the *fuzzy* software in MATLAB, where the initial numerical values were first presented to be within the range of [0, 11] as a guide to the corresponding membership functions which will be later used in the building of the *RULES*.

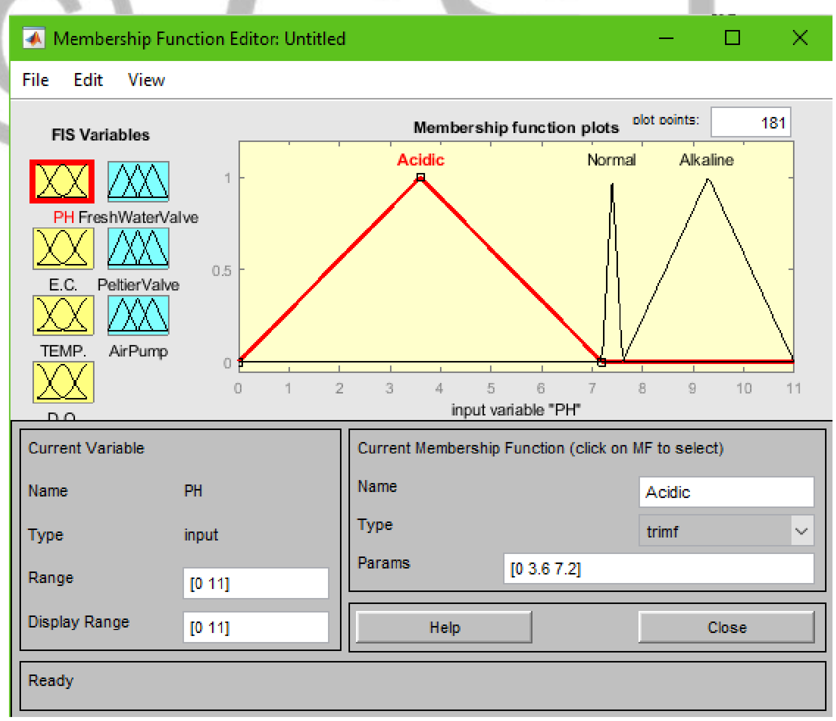

Figure 4.2. Membership function for acidic level of pH

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4. DEVELOP THE SYSTEM BY COMBINING ELECTRICAL CONDUCTIVITY PARAMETER

Electrical conductivity parameter can be insinuated to be dependent on the pH of the water. As it were, the electrical conductivity is greater when the water is acidic and vice versa. Their relationship is directly proportional, and makes it easier to determine with a single output element. Furthermore, study finds that pure water is not a very good conductor of electricity with sea water at 5 S/*m*, drinking water at 0.005-0.05 S/*m*, and ultra-pure water at $5.5 \times 10^{-6}\ S/m$. [31].

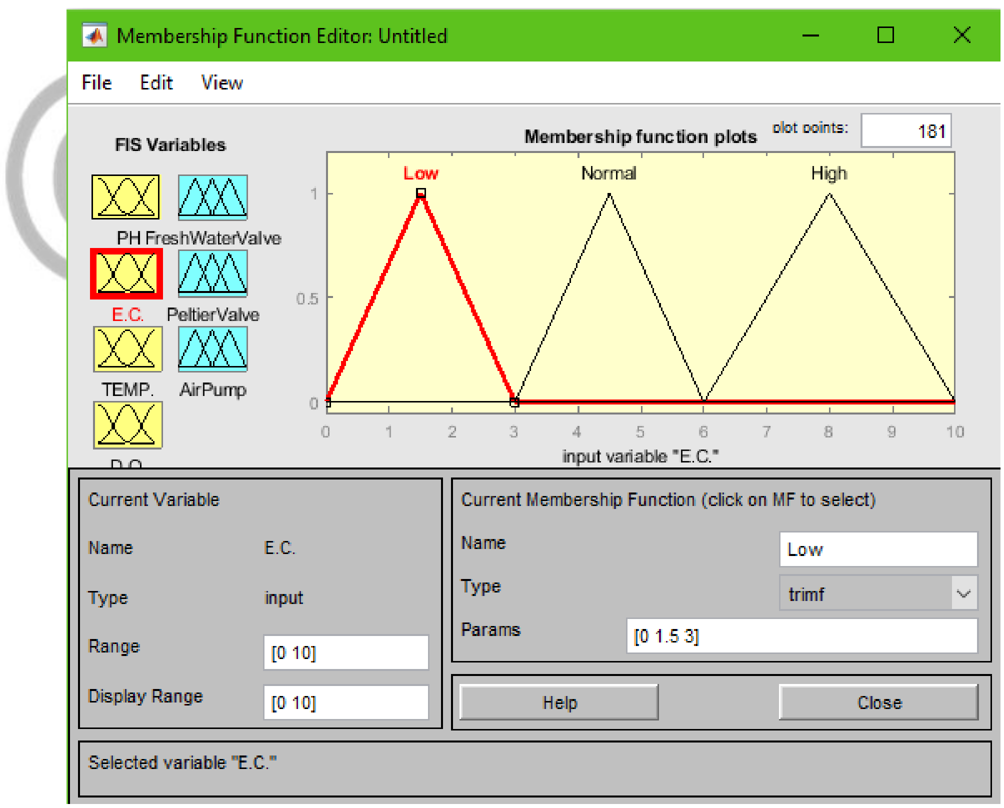

Figure 4.3. Membership function for Electrical conductivity when low

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5. DEVELOP THE SYSTEM BY COMBINING TEMPERATURE PARAMETER

The temperature parameter under the observation of the water body is defined in the said context as the hotness, coldness, or neutrality of the water body. The water environment is stable at temperatures between 16ºC and 18ºC, where the condition stated during the simulation suggests that values below 16ºC are cold and values above 18ºC are hot.

These temperature values were computed employing the *fuzzy* software in MATLAB, where the initial numerical values were first presented to be within the range of [0, 40] as a guide to the corresponding membership functions which will be later used in the building of the *RULES*.

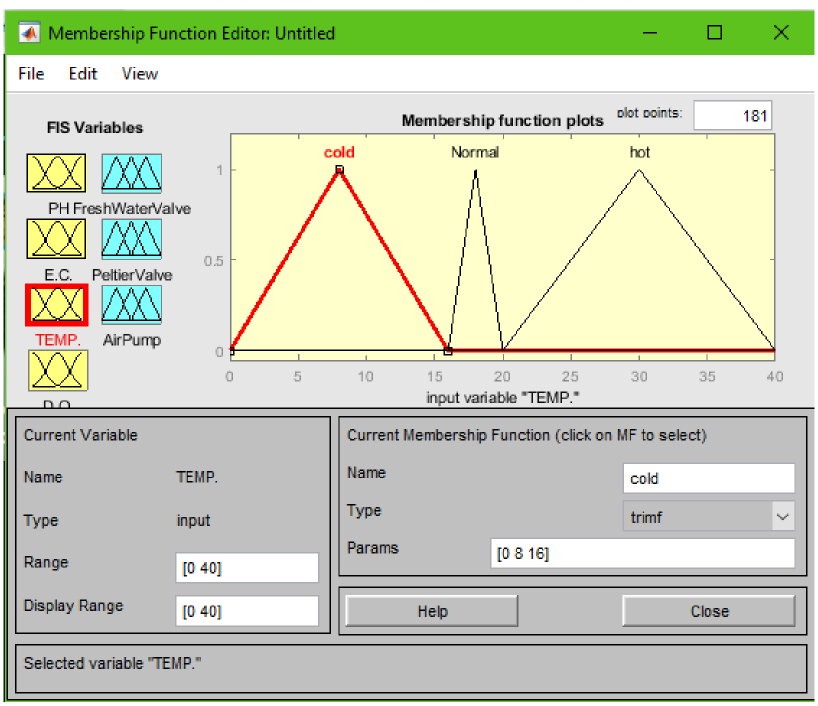

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Figure 4.4. Membership functions for temperature parameter

6. DEVELOP THE SYSTEM BY COMBINING DISSOLVED OXYGEN PARAMETER

Dissolved oxygen is a parameter that indicates the amount of oxygen in water. Ordinarily, oxygen is more in colder water than it is in warmer water environment. The amount of oxygen is represented to be at its minimal when it is within the value of [0, 5]. Low oxygen will prompt the air pump to turn on, while higher oxygen level will prompt the air pump to reduce the amount of oxygen.

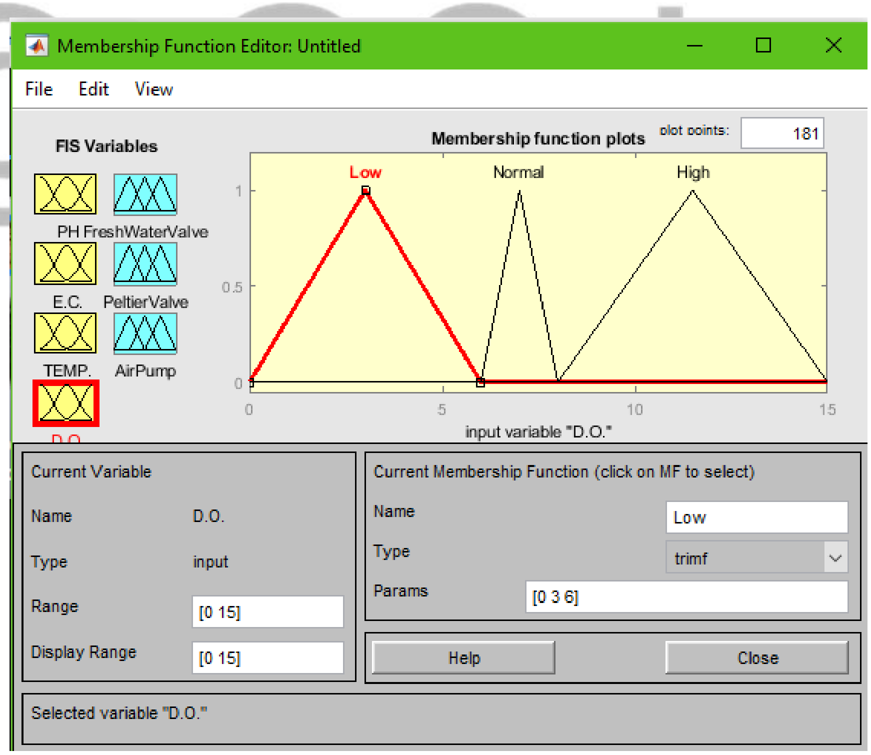

Figure 4.5. Membership functions for DO

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7. EVALUATION OF THE SYSTEM CONSIDERING;

A. Output value from Fresh Water Valve

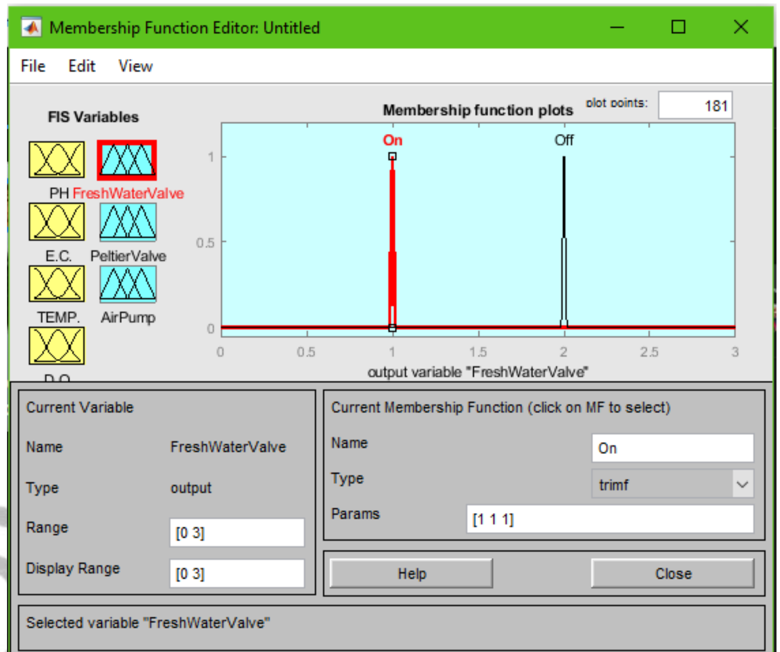

Figure 4.6. Membership Functions for Fresh water valve

The figure above shows the values of the output for pH and electrical conductivity parameters. The first membership function indicates that it will come on when the pH is low or acidic and when the electrical conductivity is high. The "ON" means that water valve will open when the input variation is met and vice versa.

B. Output value from Peltier Valve

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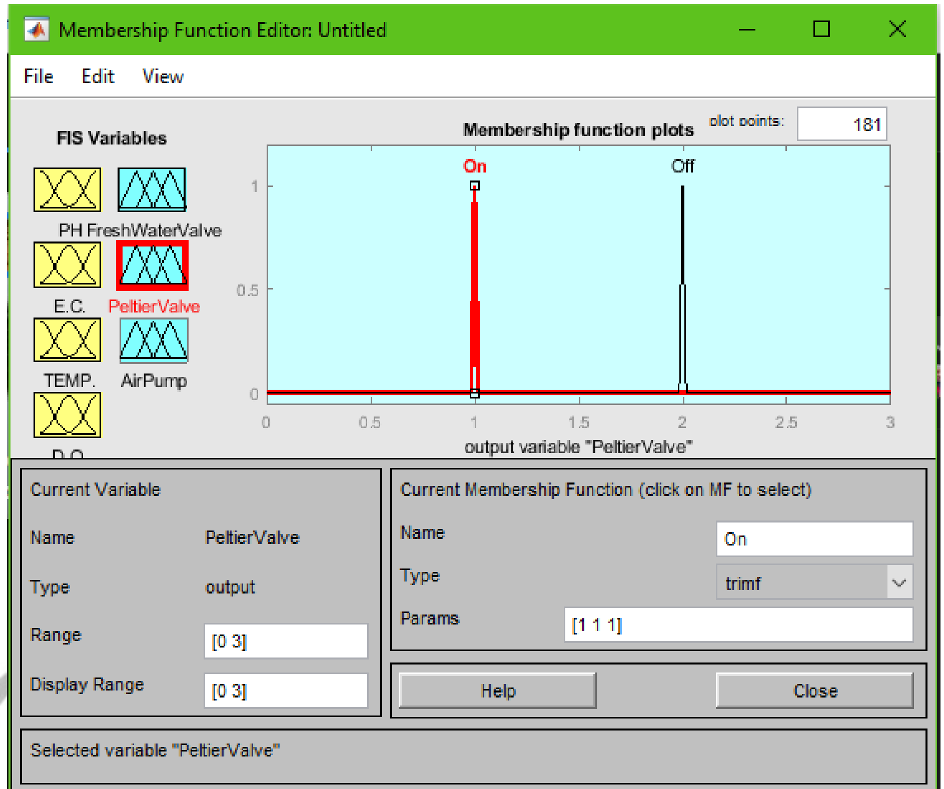

Figure 4.7. Membership function for Peltier valve output

Peltier valve as stated in section 5 above will initiate a cooling effect when the temperature is high. According to the figure above, the valve is either “on” or “off”. When it is “on”, the valve is cooling and otherwise when it is off. The process is dependent on the temperature difference of the water environment and is automatically activated based on the response from the input, in this case, the temperature change. This feature is used to ensure that the temperature of the system is stabilized at all times.

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C. Output value from Air Pump

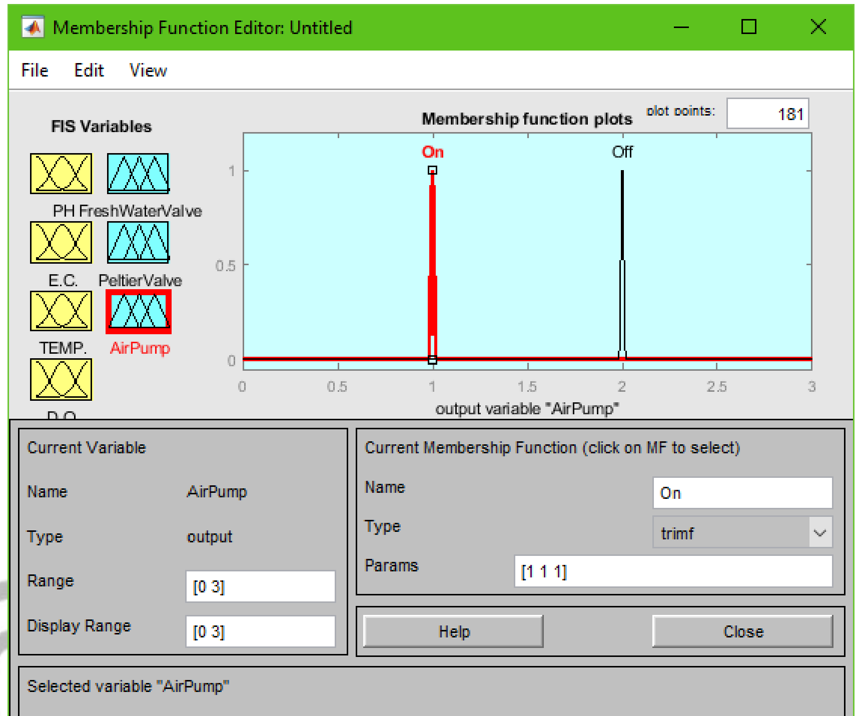

Figure 4.8. Membership functions for air pump

The above figure is a representation of the feedback of how the dissolved oxygen parameter responds to low or high oxygen content in the water environment. As seen in the figure, the first membership function is “on” when the oxygen level falls below the moderate value ([0 5]), and is “off” when the moderate amount of dissolved oxygen is reached. The response from the output is dependent on the level of dissolved oxygen.

8. SET UP THE SENOR WITH THE SYSTEM

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Figure 4.9. Placing the hardware in the box

The construction of the prototype involved a systematic process of carefully placing the delicate components, especially the microcontrollers in a Sintra board, to avoid damage by water. As seen in the photo above, the Raspberry Pi is carefully glued to the Sintra board to provide safety to it against mechanical damage. While that is done, it is also connected via connecting wires to other peripherals such as the sensors and other microcontrollers. In this way, they are firmly and safely distributed inside the Sintra board while indubitably carrying out their various roles.

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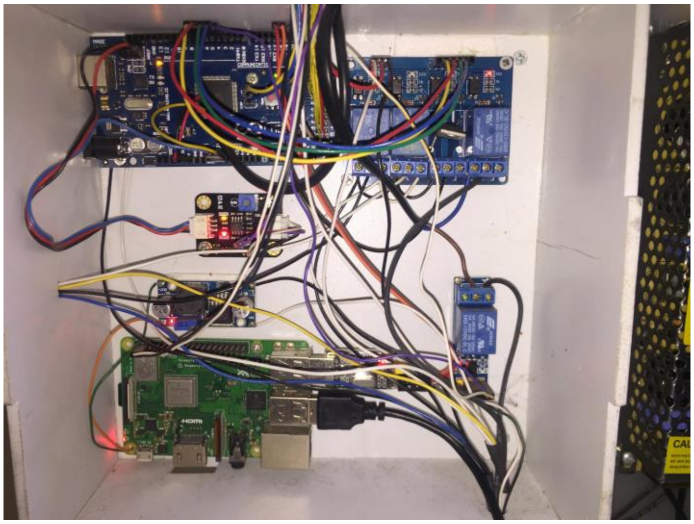

Figure 4.10. Connecting the wires with the hardware components

The image above is a representation of the hardware components been connected together using connecting wires. These components are responsible for the data behavior such as, length at which the data will be retrieved, treated, and stored. While the Sintra board provides safety from water damages, the components can operate unruffled for as long as possible.

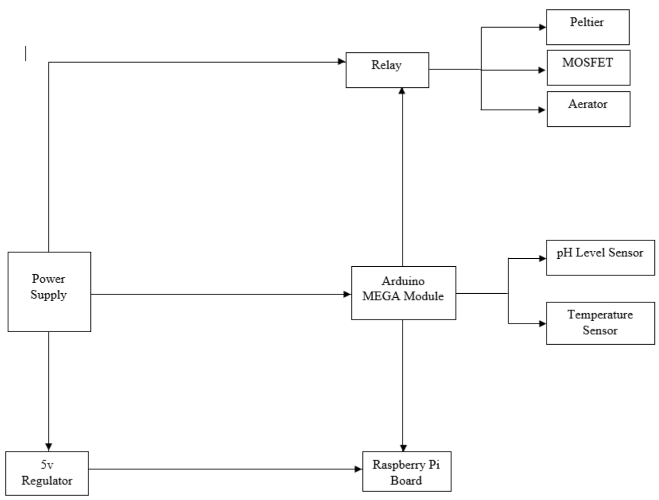

Figure 4.11. Circuit Diagram of the connected components.

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The figure above is the circuit diagram of the connection made between the microcontrollers (Raspberry Pi and Arduino Mega Module) and other components (Sensors and supporting components).

Figure 4.12. pH level sensor floating in the water to get data

pH sensor in this figure above has about 10% of its length body submerged inside the water to prevent the delicate circuit board from been damaged by water through bridging and rusting. As seen in the figure, the Sintra board holds it firmly to a fixed position to ensure that it stays steady while it measures the pH level of the water. Additionally, the reading can be directly read from the LCD display attached to it. However, to generate consistent and unattended data retrieval, the microcontrollers pull the relevant data and stores it relatively.

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D. Efficiency

The efficiency of the device is dependent on its ability to maintain a sustainable and reliable outputs. The outputs from the MATLAB simulation which include the freshwater Valve, Peltier Valve, and Air pump, are gotten from the several combinations of probable occurrences that might occur in the water body. These occurrences are regarded to as RULES. These rules are used to determine the efficiency of the prototype, which successfully can be calculated utilizing the formula below;

Actual Rule (R_{act})

Theoretical Rule (R_{theo})

$$\eta = \left| \frac{Ract}{Rtheo} \right| x\ 100\% \qquad \text{.... (4.2)}$$

E. Cost Analysis

The cost analysis describes the efficiency and relationship between the cost of manufacturing the model and maintaining it. In order to utilize an intelligent device in monitoring, it is vital to ensure that while the device can effectively carry out the basic operations, the cost producing and maintaining them are balanced for the advantages of having more sales due to low cost and continual usage due to quality of material.

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Mathematically, the formulas for determining the interest of investment and salvage value are shown in the formulas below based on the study of engineering economy;

Interest of Investment = $\left(\frac{1}{number\ of\ useful\ years}\right)(Initial\ cost)$ …. (4.3)

The salvage value is represented also as;

Salvage Value = $P(1\text{-}i)^{n}$ …. (4.4)

Where;

n = number of useful years

P = initial cost

I = depreciation rate

The depreciation cost can be calculated using the following formulas;

$Depreciable\ asset\ ds = Initial\ Cost - Salvage\ value$ …. (4.4)

$Depreciation\ cost = (i)\ (ds)$ …. (4.5)

The cost of production and maintaining the device is estimated to be favorably better than other studies. This will ensure that aquaculture is sustained with inexpensive developments.

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F. Result and Discussion

The following figures were obtained from the simulation on MATLAB, each figure represents the steps involved during the entirety of the simulation.

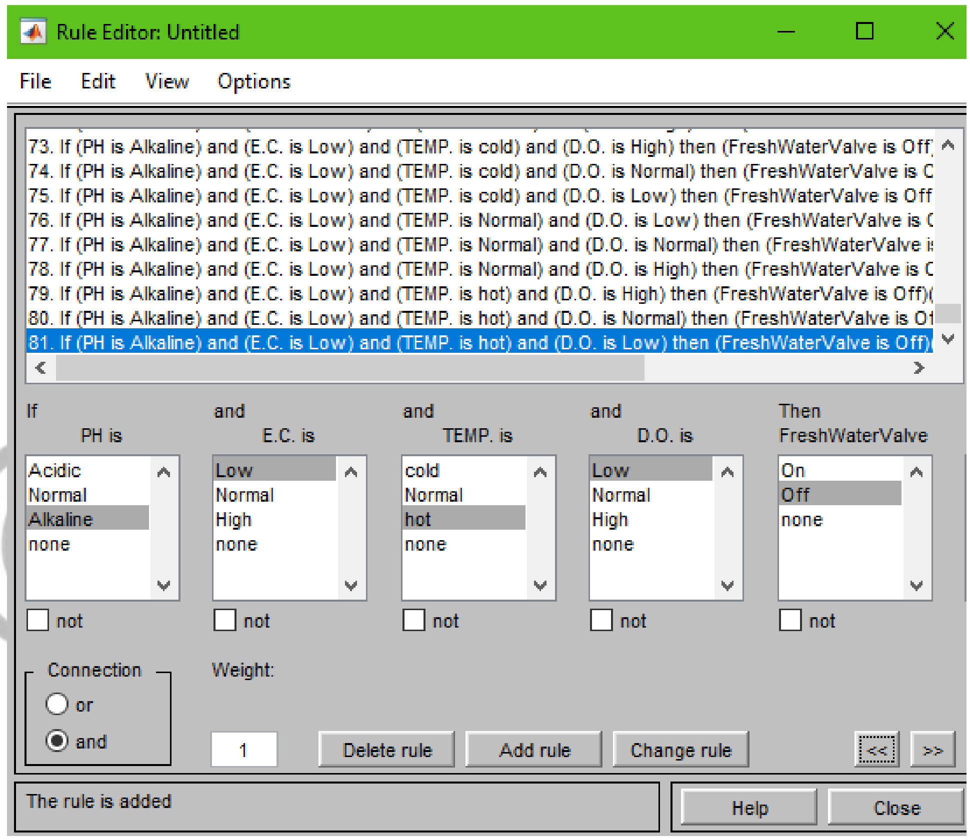

Figure 4.13. MATLAB Rule editor

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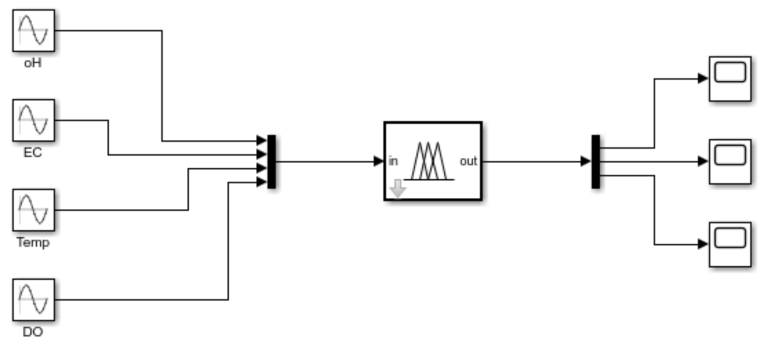

Figure 4.14. Simulink design model

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The completion of the software simulation led to the actual prototype development which involved hands-on engagement in design of the system for measuring pH and temperature parameters of the study medium. The proponents employed pH level sensor and temperature sensors to measure the above parameters respectively: While making use of Raspberry Pi and Arduino microcontroller to control the command input and the data retrieval which were measured over a couple of days. The circuit used in the construction of this device is as represented below.

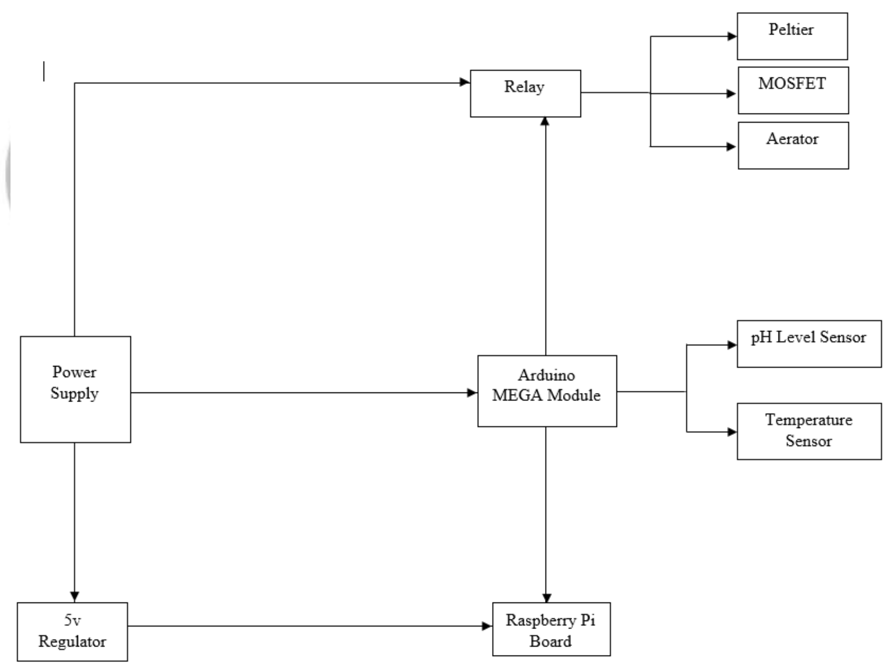

Fig. Circuit Diagram

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G. Synthesis

Synthesis describes the section of the simulation prototype design that involves the understanding of the results and the mode of obtaining them.

The data obtained from the actual prototype is represented in a graphical format below. The graphs show the behavior of each parametric data gotten from the sensors as they progressed with time. These representations are visual approach to determining the consistency of the data and their reliability in a situation when the prototype will be used in a real-life scenario.

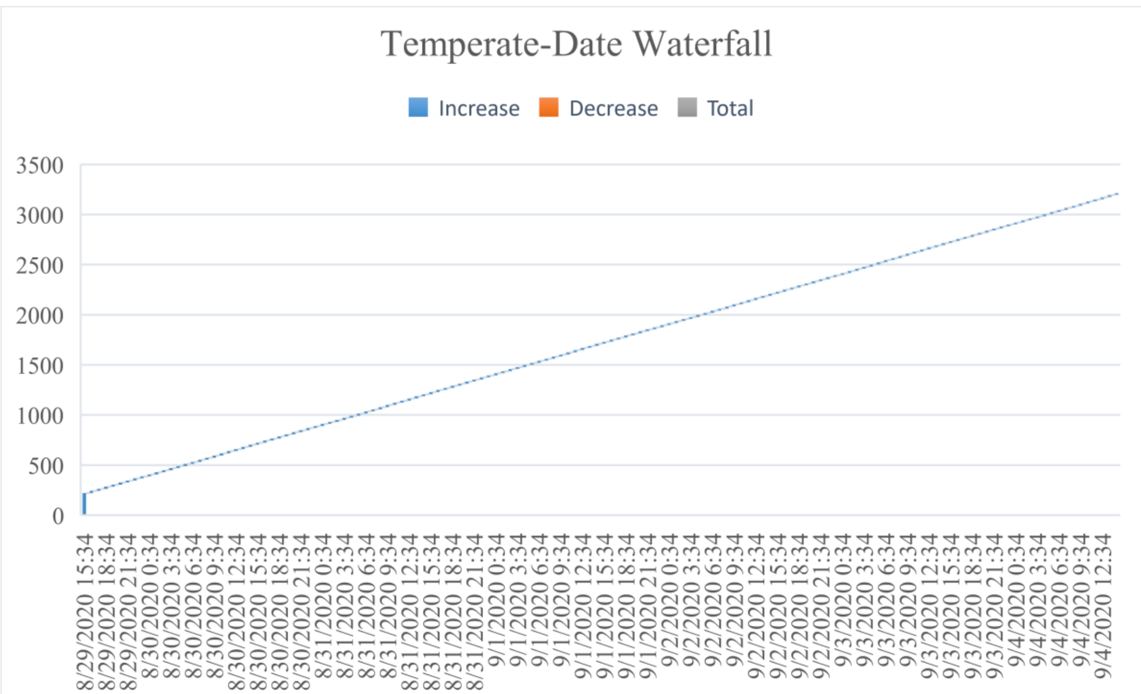

Figure 4.15. Temperature-date waterfall

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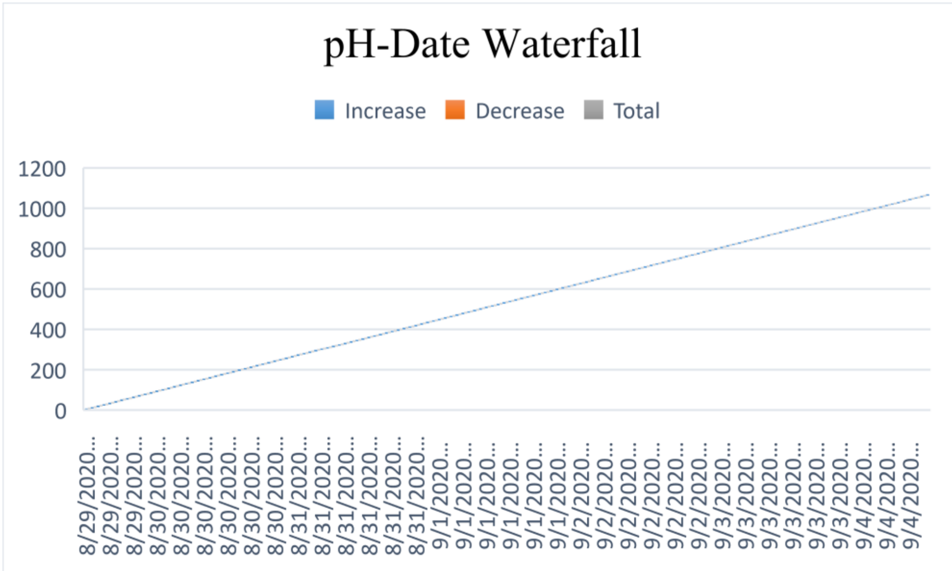

Figure 4.16. pH-date waterfall

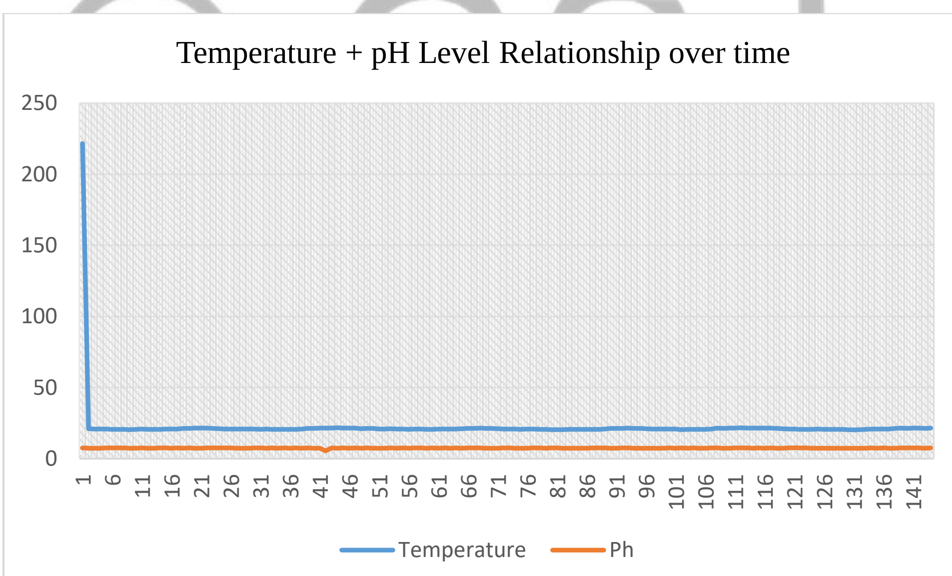

Figure 4.17. Temperature + pH Level Relationship with Time

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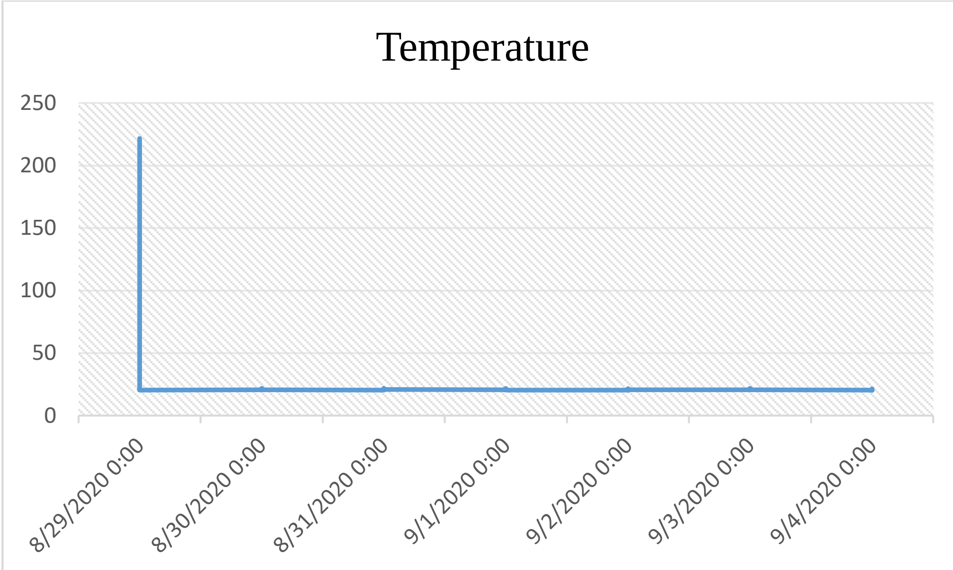

Figure 4.18. Temperature data behavior over time

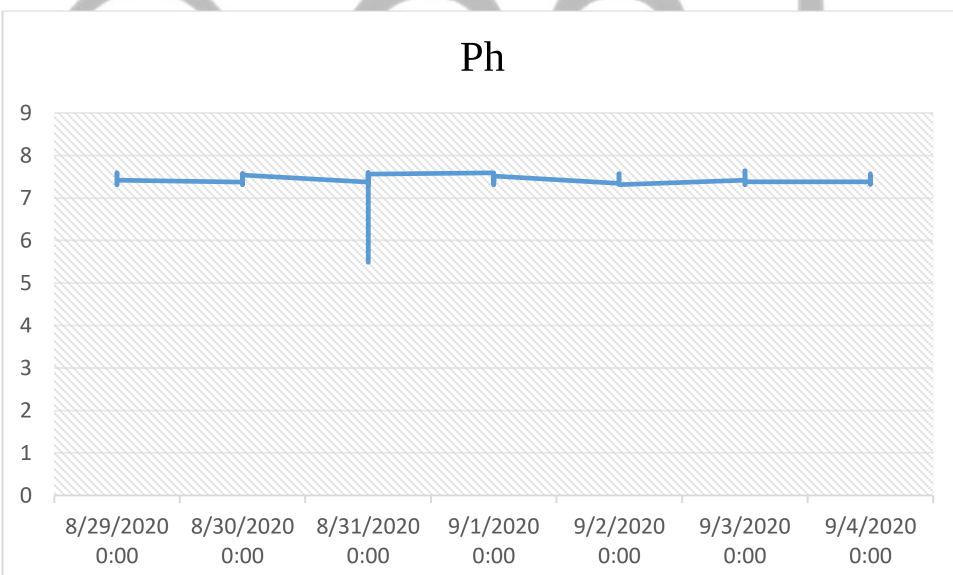

Figure 4.19. pH level data behavior over time

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The above diagrams showcase the slight instabilities in the data retrieved by the sensors. Their levels seem closely like they are barely varying, which is actually affirmative because of the water under study. The water substance has not been changed since data retrieval and in that case hasn't been affected by any inconsistencies brought about by pollution. Although, trace presence of heavy metals which already exist in the water and from the atmosphere, affects the pH level. While the temperature difference can significantly be caused by the drop and rise of ambient temperature.

However, it is important to note that these values may differ between study environments because of the factors listed earlier. The presence of heavy metals may increase in a river closer to a manufacturing industry than in a remote river with little or no human activities. The temperature differences may be higher or colder depending on the location of the water body. For example, the water temperature may be higher in a river closer to a volcanic activity and lower in places where heat from the sun is the only underlying factor.

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CHAPTER 5

CONCLUSION

The proponent's final experimental contribution to the project followed a successful implementation of Peltier modules as a mediator between heat and electrical energy generation. The Peltier modules as we know are temperature differential modules that causes electrical energy to be generated while maintaining a cold and hot opposite interface. The researches in this attempt, aimed to light up a led display using the electrical energy generated from the perfectly connected Peltier module whose source of heat and coolness comes from air conditioner and heat sinks respectively. The following chapter explains the various steps, materials used, and other practical involvements during the experimentation procedure. Additionally, the researchers also made reference to online tools and guidelines on the perfect components that are required and sufficient for the lighting up of the led display board. Although the experimentation took a little overtime and improper deployment due to the existing ECQ, which became a challenge. In order to facilitate the process, the researches utilized other source of heat to test the model, and in practical results, showed a working process of how Peltier module can successfully light up the led display board. The researchers also included the SPST switch which could control the on and off of the circuit board when not in use. In that case, the circuit turns off at appropriate time when needed. This will give the user a better option to interfere with the operation of the model. In subsequent experiments, the model could interject with other developments such as utilizing the model for domestic and industrial use.

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RECOMMENDATION

The proponents recommend a wider range of parameter observation to improve the water quality level, such as the detection and treatment for heavy metals and turbidity. It is a common criterion to find water environment with opaque surfaces, and these are mostly the ones with disturbance from human activity and aquatic life. Heavy metals are possibly seen in water environments like this, especially the one nearer to factories, dumpsites, or in general, places with high chances of pollution.

The researchers would also like to find new solution and prospective regarding the mussel's life by using different type of parameters and trying to test that in the same ideal environment to come up with a new thought because mussels are playing a role model in filtering and cleaning the ocean.

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APPENDICES

A. SHORT NARRATIVE OF THE INTERVIEW

The researchers were unable to carry out certain apportionments such as carrying out interview and actual deployment of device in supposed site under study due to the ongoing pandemic and Government stay-home regulation. However, in order to continue with academic requirements, the researchers were prompted to undergo a virtual simulation of the proposed prototype by utilizing MATLAB IDE in testing the and accomplishing the objectives of the project. The researchers also utilized other online tools such as tutorials from past researches in making sure that the objective of the thesis is met with full possibility for success. This privilege also gave the proponents the chance to utilize the powerful features of MATLAB to provide rules for each parameter that were helpful in the final simulation test of the program.

B. RESEARCH LOCALE

The researchers were unable to carry out certain apportionments such as carrying out interview and actual deployment of device in supposed site under study due to the ongoing pandemic and Government stay-home regulation. However, in order to continue with academic requirements, the researchers were prompted to undergo a virtual simulation of the proposed prototype by utilizing MATLAB IDE in testing the and accomplishing the objectives of the project. The researchers also utilized other online tools such as tutorials from past researches in making sure that the objective of the thesis is met with full possibility for success. This privilege also

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gave the proponents the chance to utilize the powerful features of MATLAB to provide rules for each parameter that were helpful in the final simulation test of the program.

C. DOCUMENTATION PICTURES

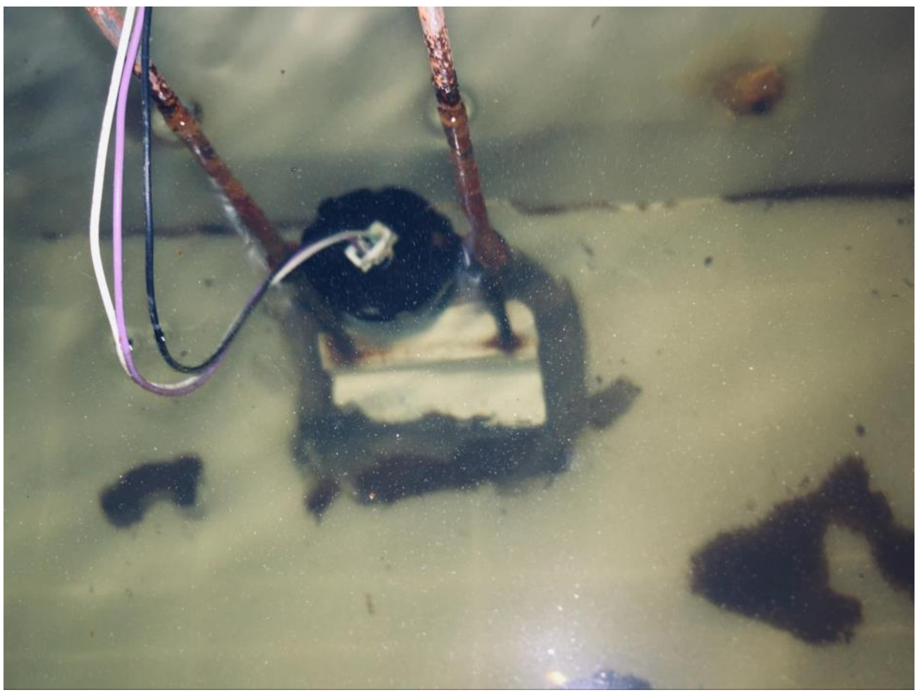

Figure 5.1. Sensor submerged in water

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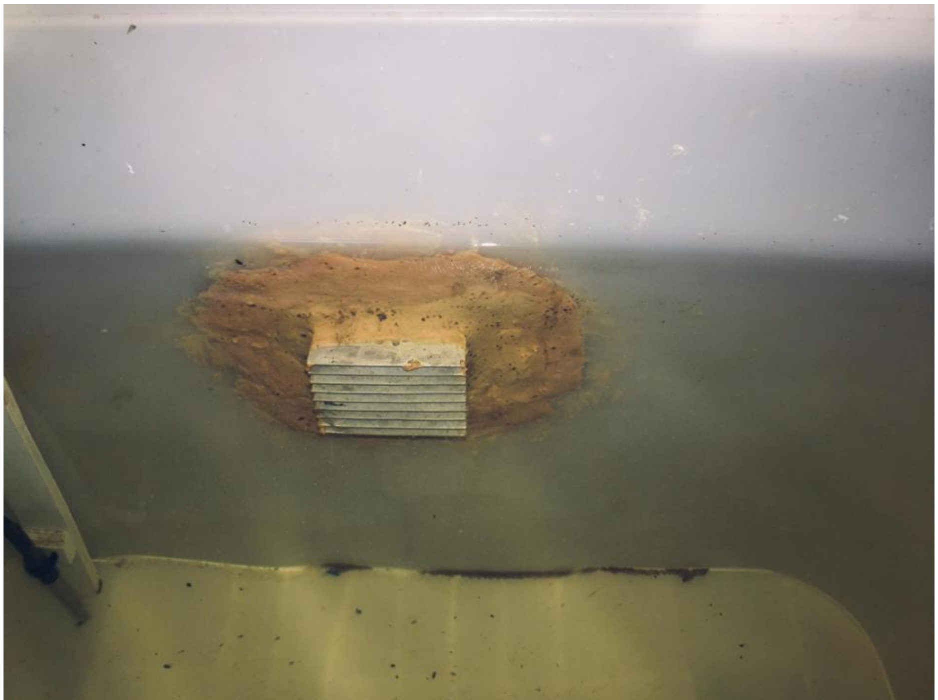

Figure 5.2. Heat Sink for temperature regulation

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Figure 5.3. Power Supply

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Figure 5.4. Fan.