A WIRELESS SENSOR NETWORK (WSN) FOR REMOTELY MONITORING AN ARTIFICIAL AQUATIC ECOSYSTEM

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering
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for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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Approved:

____

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Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

September 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Muhammad Yazid Idzmir B Haslimalis

ABSTRACT

A Wireless Sensor Network (WSN) to remotely monitor an artificial aquatic ecosystem in this project was to discover a new technology using embedded devices. This new technology was implemented using Mote-IRIS 2.4GHz connecting to the network. Current methods used nowadays for monitoring aquatic ecosystems are less efficient and unable to solve the water quality expectation. Water with pollution became one of the biggest the world wide issued to lead for the fresh water supply. For solving these problems, a development with a new technologies using Mote-Iris for a proper of collecting data and for making data analysis can be make for the aquatic ecosystem. Sampled water will be collected to measured parameters that involved in collecting data are pH, Temperature and Humidity. All this parameter is crucial to identify the quality of the aquatic ecosystem. A proper set of tools and software need to be use in this project such as Transmitter, Receiver, Integrated Board (XM-300) and also sensor from MEMSIC company .The tools and software required to evaluate the parameters to be measure in the aquatic ecosystem. The analyze data will be recorded and data collection were made based on Water Quality Index (WQI) Method.

ACKNOWLEDGEMENTS

First and foremost I would like to express my humble gratitude to Allah S.W.T, because of His blessings and guidance to me throughout completing my final year project. I would also like to sincerely acknowledge for those who had assist me on this achievement of my project. My appreciation and gratitude goes to my supervisor, Dr. Azrina Abdul Aziz, for her sincere guidance and teaching me throughout this whole project. Not forgetting Dr Azlan Awang and Mr Abu Bakar Sayuti on assisting me to understand and completing my tasks throughout the whole year. Special thanks to my colleagues, Muhammad Asyraf, Shafiq Imtiaz and Nurul Ashikin for their cooperation to help me during my difficulties on accomplishing this project. I would like to express my gratitude to my university, Universiti Teknologi PETRONAS especially the Electrical and Electronic Engineering Department for equipping me with essential theories and skills for self-learning. Its well-rounded graduate philosophy has proven to be useful in the industry.

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WSN Wireless Sensor Network

WQI Water Quality Index

Ph.   Potential Hydrogen

DO   Dissolved Oxygen

Chapter 1
INTRODUCTION

1.1 BACKGROUND OF STUDY

Wireless sensor network is one wireless technology application which consists of sensor nodes that communicate each other to collect and transmit data from surrounding environment as stated in IEEE Standard Dictionary of Electrical and Electronic Terms, IEEE Standard 100, 1984. Wireless sensor network for monitoring an aquatic ecosystems using Mote-IRIS in this project is to focus on monitoring the change in the water quality with additional external multi probe system, PH sensor to a cost efficient lab develop sensor cluster. This probe been placed in the water tank as to measure the water quality. The purpose of this project is to investigate the effectiveness of wireless sensor network by studying the characteristics the change of water quality.

1.2 PROBLEM STATEMENT

Due to economy development and improvements may changes, resulting speed-up of contamination and damaged to the water environment, so a new technologies have been developed nowadays to monitor and sense aquatic environments such as Wireless Sensor Network (WSN).To prevent this problem there are many factors that need to be considered to make sure the effectiveness of networking monitoring such as appraisal of the monitoring objectives, locations sampling, suitable frequencies sampling, selection of water quality variable and budget. For this project, aquatic ecosystem monitoring been developed as an alternate methods for water resource management and controlling water contamination , so that it can be use nowadays are much indispensable and improved the monitoring system.

1.3 OBJECTIVES

Understanding to build a wireless Sensor network has been proposed for monitoring the change in the ecosystem because it can operate unattended while providing fewer disturbances to animals than other conventional data logger method. However, deployment and implementation of WSN in rivers are challenging as the WSN has to be robust to climate change such as waterproof, has a reliable data delivery & must be able to conserve the limited energy supply. A working WSN that can also monitor with collecting meaningful data in the field is the cost of the equipment used to monitor aquatic environments. This project aims to use a WSN that meets these requirements for the purpose of investigating the change in the ecosystem.

1. To design a reliable and low power wireless sensor network to collect data

2. To design data collection method

3. To analyze the collected data and conduct appropriate analysis

4. To design a wet-proof case for the WSN for it able to work closely to water

1.4 SCOPE OF STUDY

The project starts by studying the development of Mote-IRIS and its components. Then, identifying related sensor as it is the primary element that will be measure and analyze throughout the project execution that need to be studied and understood first .The evaluation will not only based on the price of the components to be purchased, but also in terms of the features of the products, including parameters of the sensor that need to be obtain.

To commence the project, identifying the transmitter and receiver Motes 2.4GHz to be use in this project will create a pathway to recognize which product is better, design, install and assemble .Then, the methods of monitoring on how testing to be done and for data collection are identified and studied.

This project will comprise of hardware installation and coding .For hardware part, circuit design and assembly is required .While for coding or software part, it is to program using CrossBow- MoteWork to show the data at PC. Last but not least, this project will be conducted to investigate the actual range of data transmission and among nodes to the PC. The project prototype test execution will be divided into three environment categories; Temperature, pH, and dissolved oxygen.

CHAPTER 2
LITERATURE REVIEW

2.1 AQUATIC ECOSYSTEM

In aquatic ecosystem there are communities which rely on each other and also on their living environment consists in a body of water that are freshwater ecosystems and marine. Current method of aquatic ecosystems monitoring does by traditional ways by taking samples and bring to the lab are less efficient [1]. For Water Quality Index (WQI) parameters such as DO, BOD, COD, SS, AN, and pH were used for spatial water quality assessment, while in Mexico a man-made aquatic reservoir includes Electrical Conductivity (EC), Turbidity, Ammonia Nitrogen and Phosphorus was taken into consideration for measuring Water Quality Index (WQI) [6],[7].

The wireless monitoring capabilities which contribute a lot to environment systems by identifying the presence of foreign chemicals over air or in the water system. This kind of application is suitable for WSN compared to larger size of other wireless devices . [5] .

IRIS mote offer much efficient rather than current method that been used for monitoring aquatic ecosystem. WSN should been applied widely nowadays with a lot of advantages such low cost,collection of a variety parameters and high detection accuracy compared to currently method done by taking the samples and bring to the lab to analysis.The measurement of all the parameters takes a lots of times to analyze and to get the results,so it might harm the aquatic life and all organism [8].

2.2 WIRELESS SENSOR NETWORK (WSN)

WSN communicates using sensor nodes that consists three main parts; base station, gateways and sensor nodes [2].According to research paper, mostly the wireless nodes have limited range from 15 meters length up to 30 meters to communicate. So, in fact to make a wide distance communication, the sensor nodes need to communicate from gateways to transmit data to the base station and then the gateways will forward those data to the base station and vice versa [4].

As example, WSN had been used on variety of sensing input as a medium for collecting data such as lightning condition, noise levels, temperature, PH, pressure, humidity or absence of an object, direction and size of an object. The reason for choosing WSN because of it broadly applications which it only requires transmission of small power signals. The cooperative capabilities are by contributing a lot to environment monitoring application which usually used as pollution monitoring system by identified the presence of foreign chemical over air or in the water. This kind of application is suitable for WSN compared to larger size of other wireless devices [3].

With main capability, WSN sensor nodes can collaborative each other and sending data to the remote monitoring center by the base station using GPRS. Furthermore, if any sudden change in water quality it is also able to compute back simple computation in order to get back the data and to reduce data traffic in transmission by transmitting the only necessary processed data or data that needed for more higher level computation [3] .

WSN design comes in small size, battery power consumption and capabilities, computation capabilities and the memory storage are limited. It gives more accurate result as the higher number of sample data been collected with the sensor node capabilities, a dense deployed are possible unlike other wireless communication, such as blue-tooth and Infrared the WSN sensor nodes better in data packaging, collect data, more efficient in operating linearization, parameter memorizing and routing to a base station [3] .

The technique to cover larger collectable data area, the sensor nodes must be between the base station and other further reachable sensor nodes that will transmit data with multi-hop communication. It is because the transmission range of each sensor node is very small due to frequencies rate and length of transmission rate. So to overcome this problem, the multi-hop communication will surpass the range of point-to-point communication with very effective data transmission [3].

2.3 WATER QUALITY INDEX (WQI)

Based on journal article, the quality of water in any ecosystem can be simply reflect as a simple numeric expression known as a Water Quality Index (WQI).There are two steps to carry out data analysis; by performing for each of the variable using analysis of variance (ANOVA) and WQI method. To consider each variable for ANOVA, a factorial treatment design 12 * 3 which factor A with 12 levels (the sampling hours) and three different level depth (0.1 m, 0.3 m and 0.5 m) as a factor B with level of significant 0.05 (α= 0.05).For WQI with a general mean of 2.1,is indicating the water in excellent quality [1]. The following Equation show how WQI was calculated.

$$\text{WQI} = \frac{\sum_{i=1}^{n} Pi*Wi}{\sum_{i=1}^{n} Pi} K \qquad [1]$$

where:

WQI = water quality index.

Wi = specific weight of each variable (1-4)

Parameters	Units	Wi*	Pi*	Range Tolerance
pH	-	4	1	6.5 - 8.5
			2	<6.5
Humidity	%	2	1	>100
			2	<100
Temperature	˚C	3	1	20 - 25
			2	<20
			2	>25

Table 1. Value Assigned for water quality parameters

In this experiment, three variables that to be measured; potential hydrogen (pH), temperature (T) and humidity (φ) measured with Ph-BTA Probe sensor from Vernier Software and Technology Company. The pH level is measured in pH units, Humidity in % and Temperature in Celsius degree (˚C).The scale for the assessment and analysis of water quality shown in the table below.

Value of WQI	Classification	Water Quality
95 - 100	I	Excellent
80 – 94	II	Good
65 – 79	III	Quite Good
45 – 64	IV	Poor
0 – 44	V	Polluted

Table 2. The scale for the assessment of water quality by WQI

2.4 HARDWARE AND SOFTWARE

A. MIB520 USB Interface Board

MIB520 is a base station for Wireless Sensor Networks; USB Port Programming for IRIS/MICAz/MICA2 Hardware platforms and USB Bus Power. The MIB520CB provides USB connectivity to the IRIS and MICA family of Motes for communication and In-system programming. Any IRIS/ MICAz /MICA2 node can be function as a base station when mated to the MIB520CB USB interface board .In addition to data transfer, the MIB500CB also provides a USB programming interface [7].

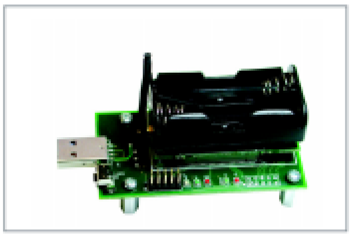


Fig. 1 MIB520CB with attached Mote [7]

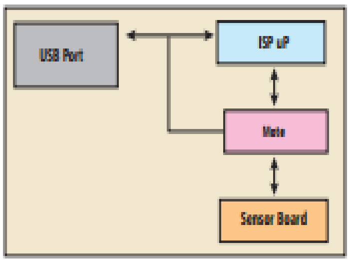


Fig. 2 MIB520CB Block Diagram [7]

The MIB520CB offers two separate ports; one dedicated to in-system Mote programming and a second for data communication over USB.USB Bus power eliminates the need for an external power source.

B. MDA300 Data Acquisition Board

MDA300 board is a multi-Function Data Acquisition Board supported via MEMSIC's MoteView user interface with Temp, PH and Humidity as a sensor which suitable for environmental data collection, general data collection and logging [5].

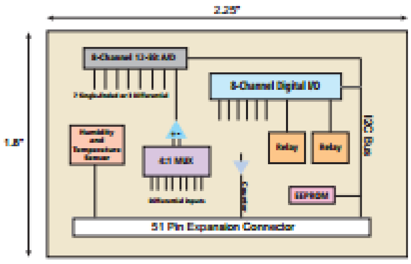


Fig. 3. MDA300C Block Diagram [5]

The MDA300's easy access micro-terminals also make it an economical solution for a variety of applications and a key component in the next generation of low-cost wireless weather stations as part of a standard mesh network [5].

C. MoteView 2.1 Software

MoteView is developed to be an interface between a user and a deployed network of wireless sensors. MoteView provides the tools to simplify deployment and monitoring. It also makes it easy to connect to a database, to analyze, and for graph sensor readings [6].

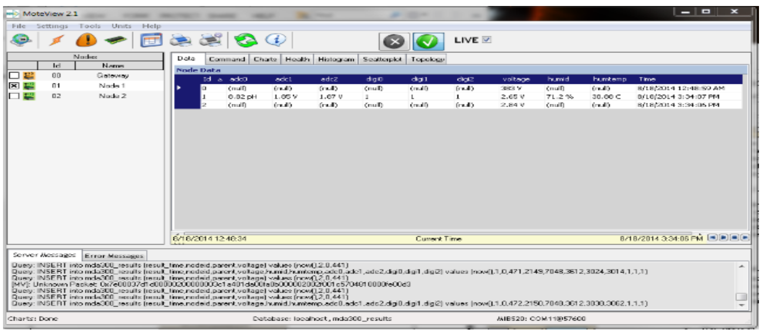


Figure 4. MoteView 2.1 Software Setup

The framework to deploy a sensor network is divided into 3parts; Mote layer to program with XMESH/ TinyOS for tracking asset, instruction detection and monitoring; Server for data logging and as for sensor readings to base station MIB510 board and MDA300 and Tier as the third part for interpret sensor data and software tools to provide visualization, monitoring and analysis tools [6].

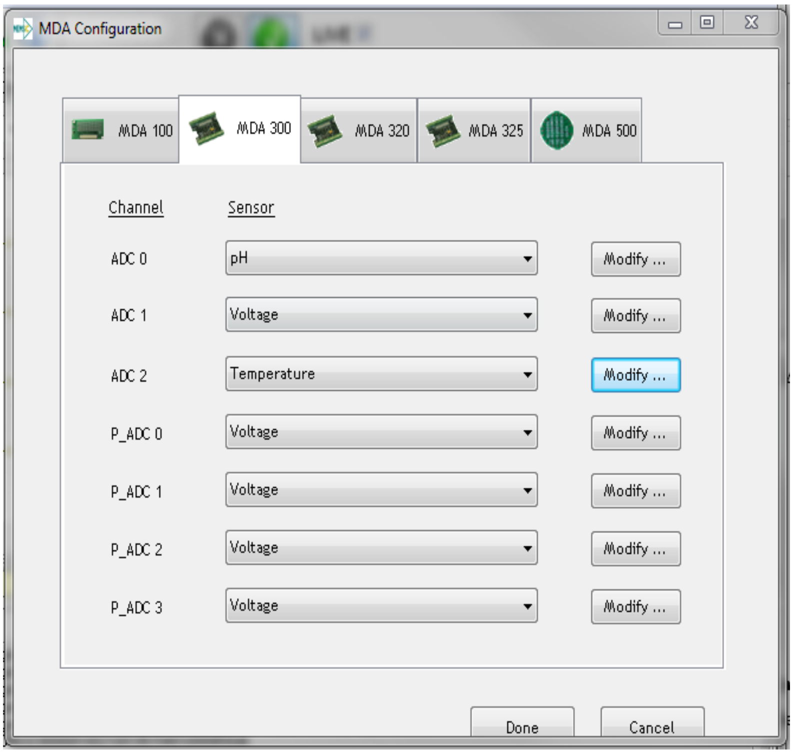


Figure 5. MDA300 Sensor Board Configuration

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

In order to achieve the objectives of this project, research and analysis being done on the MoteView 2.1 Software and MDA300 testing to create the program profile. Thus, the sensor nodes being implemented on the probe sensor to get the measure parameters.

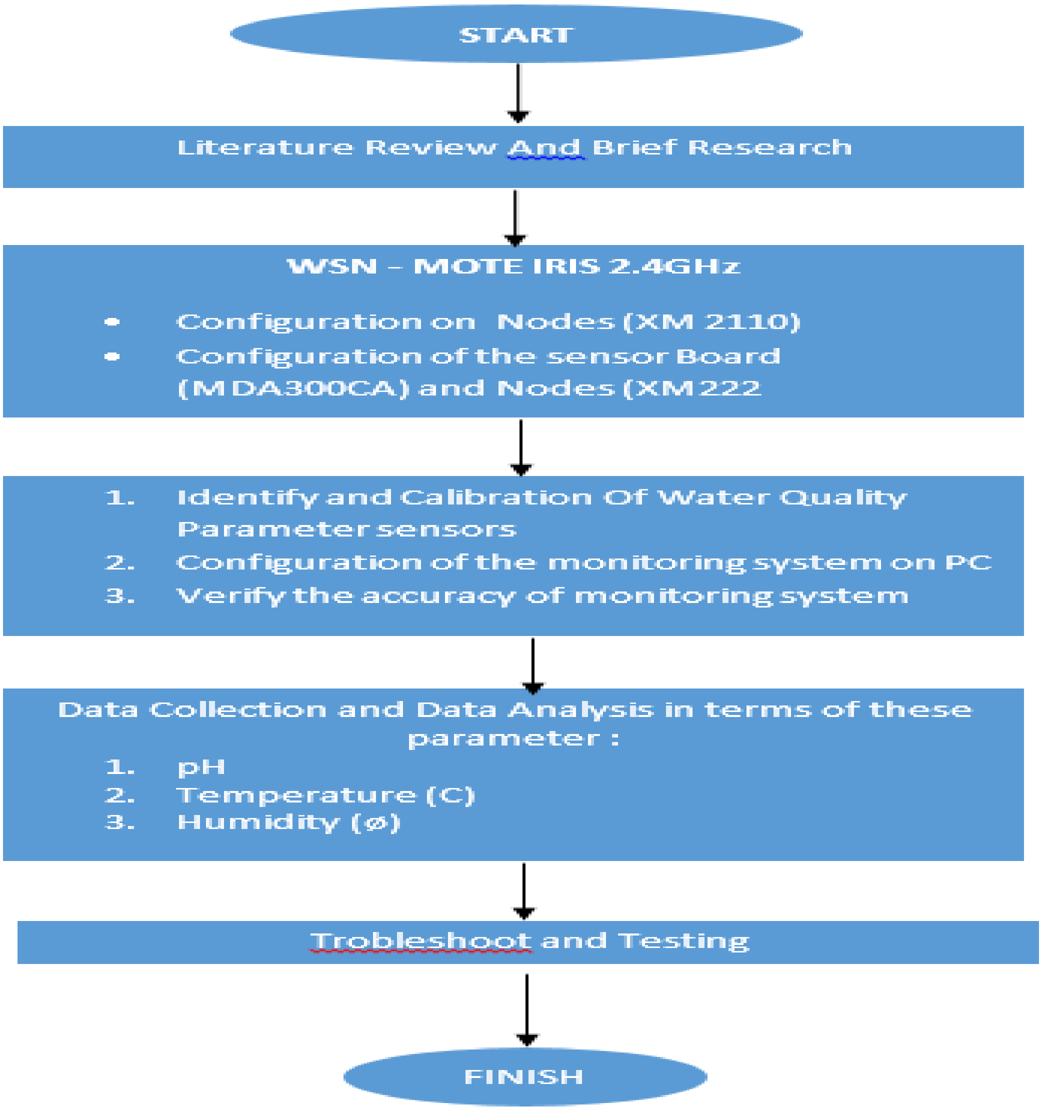


Figure 6. Research Methodology

3.2 KEY MILESTONE

Table 3: Key Milestone for Final Year Project 1

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Submission of final year project title selection form														
2	Submission of extended proposal														
3	Proposal defense														
4	Submission of interim draft report														
5	Submission of interim final report														

Table 4: Key Milestone for Final Year Project 2

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Submission of progress report														
2	Electrex														
3	Submission of Draft Report														
4	Final Report														
5	Viva														

3.3 GANTT CHART

Table 5: Gantt Chart of Final Year Project 1

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Select & confirmation of project title														
2	Early research on the proposed topic														
3	Lab experiment														
4	Proposal defense														
5	Preparing interim draft report														
6	Preparing interim final report														

Table 6: Gantt Chart of Final Year Project 2

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Lab Experiment	■	■	■	■	■	■	■	■	■	■				
2	Preparing Progress Report						■	■							
3	Data Analysis			■	■	■	■	■	■	■	■	■	■	■	
4	Preparing Final Report								■	■	■	■	■	■	
5	Presentation Preparation									■	■	■	■	■	

3.4 Setup Experiment

A. Setup The Programming Using MoteView 2.1

README.txt | XMDA300M.nc | XMeshBaseM.nc

```
module XMeshBaseM {
     provides {
     interface StdControl;
     }
     uses {
     interface RouteControl;
     interface MetricStoreI;
     interface XCommand;
     interface Leds;
     interface BaseI;
//     interface XJoin;
//     interface XBaseJoin;
     interface StdControl as XMeshStdControl;
     interface HealthI;
     }
}

implementation {


   command result_t StdControl.init() {
      call Leds.init();
      call XMeshStdControl.init();
      return SUCCESS;
   }
   command result_t StdControl.start(){
//        call XBaseJoin.startBaseJoin();
      call XMeshStdControl.start();
      call BaseI.set_as_base(TRUE);
      return SUCCESS;
   }

   command result_t StdControl.stop() {
      return SUCCESS;
   }
```

(a)

README.txt | XMDA300M.nc | XMeshBaseM.nc

```
//start sampling  channels. Channels 7-10 with averaging since they are more percise.channels 3-6 make active excitation
record[0] = call Sample.getSample(0,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT | EXCITATION_50 | EXCITATION_ALWAYS_ON);

record[1] = call Sample.getSample(1,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT | EXCITATION_25 | EXCITATION_ALWAYS_ON);

record[2] = call Sample.getSample(2,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT | EXCITATION_33 | EXCITATION_ALWAYS_ON);

//record[3] = call Sample.getSample(3,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT | EXCITATION_33 | DELAY_BEFORE_MEASUREMENT);

//record[4] = call Sample.getSample(4,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT);

//record[5] = call Sample.getSample(5,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT);

//record[6] = call Sample.getSample(6,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT);

//record[7] = call Sample.getSample(7,ANALOG,ANALOG_SAMPLING_TIME,AVERAGE_FOUR | EXCITATION_25);// | EXCITATION_ALWAYS_ON);

//record[8] = call Sample.getSample(8,ANALOG,ANALOG_SAMPLING_TIME,AVERAGE_FOUR | EXCITATION_25);

//record[9] = call Sample.getSample(9,ANALOG,ANALOG_SAMPLING_TIME,AVERAGE_FOUR | EXCITATION_25);

//record[10] = call Sample.getSample(10,ANALOG,ANALOG_SAMPLING_TIME,AVERAGE_FOUR | EXCITATION_25);

//record[11] = call Sample.getSample(11,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT);

//record[12] = call Sample.getSample(12,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT);

//record[13] = call Sample.getSample(13,ANALOG,ANALOG_SAMPLING_TIME,SAMPLER_DEFAULT | EXCITATION_50 | EXCITATION_ALWAYS_ON);


//digital chennels as accumulative counter

record[17] = call Sample.getSample(0,DIGITAL,DIGITAL_SAMPLING_TIME,DIG_LOGIC | EVENT);

record[18] = call Sample.getSample(1,DIGITAL,DIGITAL_SAMPLING_TIME,DIG_LOGIC | EVENT);

record[19] = call Sample.getSample(2,DIGITAL,DIGITAL_SAMPLING_TIME,DIG_LOGIC | EVENT);

//record[20] = call Sample.getSample(3,DIGITAL,DIGITAL_SAMPLING_TIME,FALLING_EDGE);
```

(b)

Figure 7. MoteView 2.1 Programming for XMeshBase and XMDA300

Data had been received through base station will go into PC to analyze & develop the data and if still any hazard detected in the system, the alarm will alert the user with given an alarm notification shown in Figure 8. These processes require Mote View for setting the alert parameter.

Figure 8 . Mote View Alert Manager Notification

Figure 9 shown how each node transfer the number of byte through each packet and we can also determine the value of frequencies that been signal. MDA 300CA was built together in the sensors mote attached on top with connected on 15-pin slot up to 11 12-bit channels of analogue input.

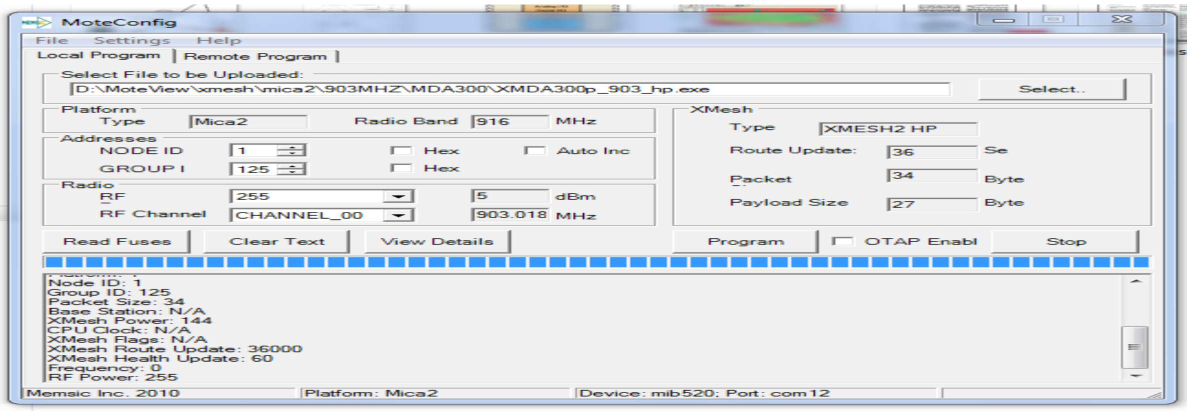


Figure 9 Mote Config Reading Data

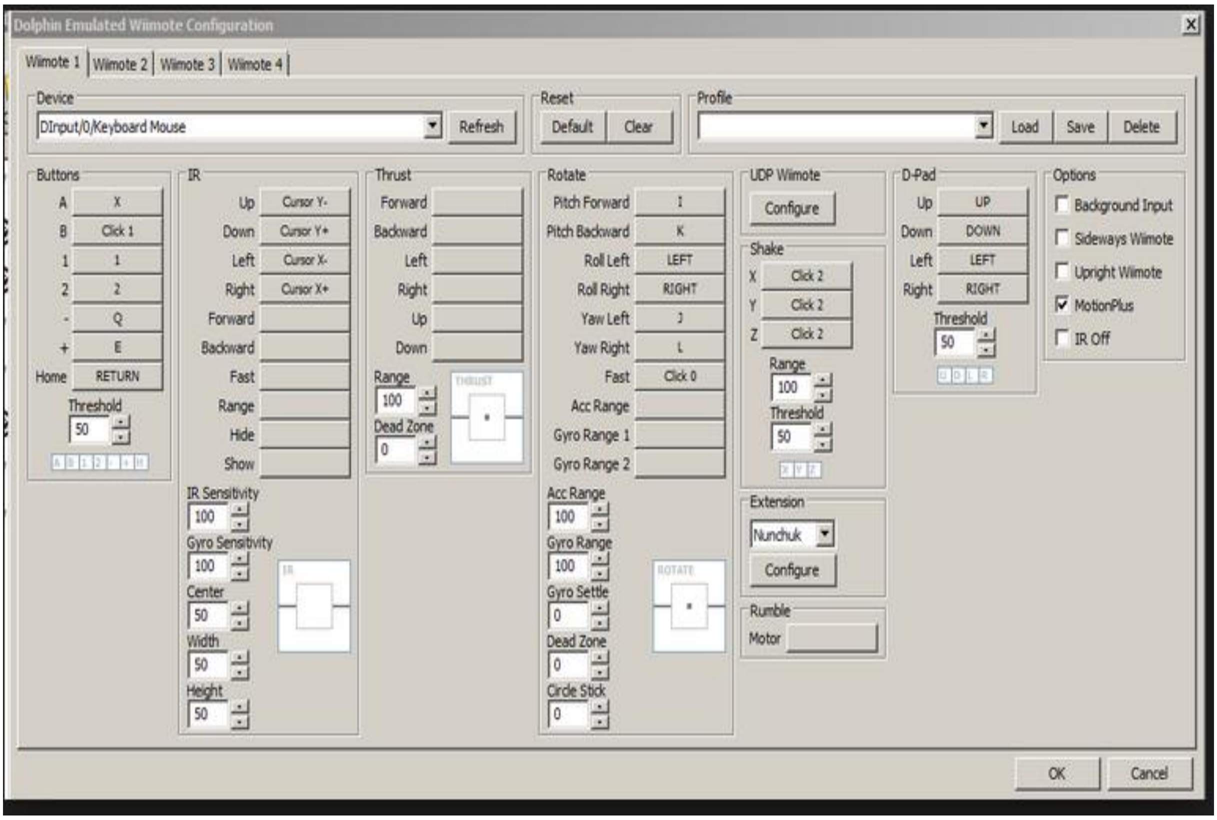


Figure 10 . Mote Config setting For Each Node

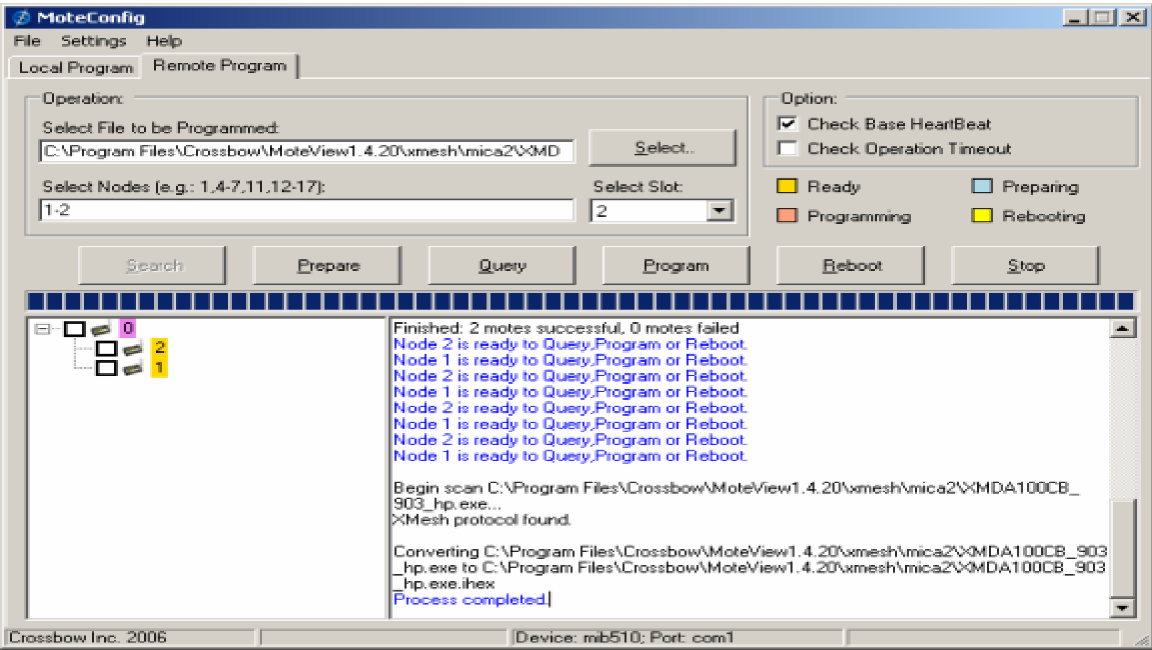


Figure 11 . Nodes Been reading and Running OTAP Image

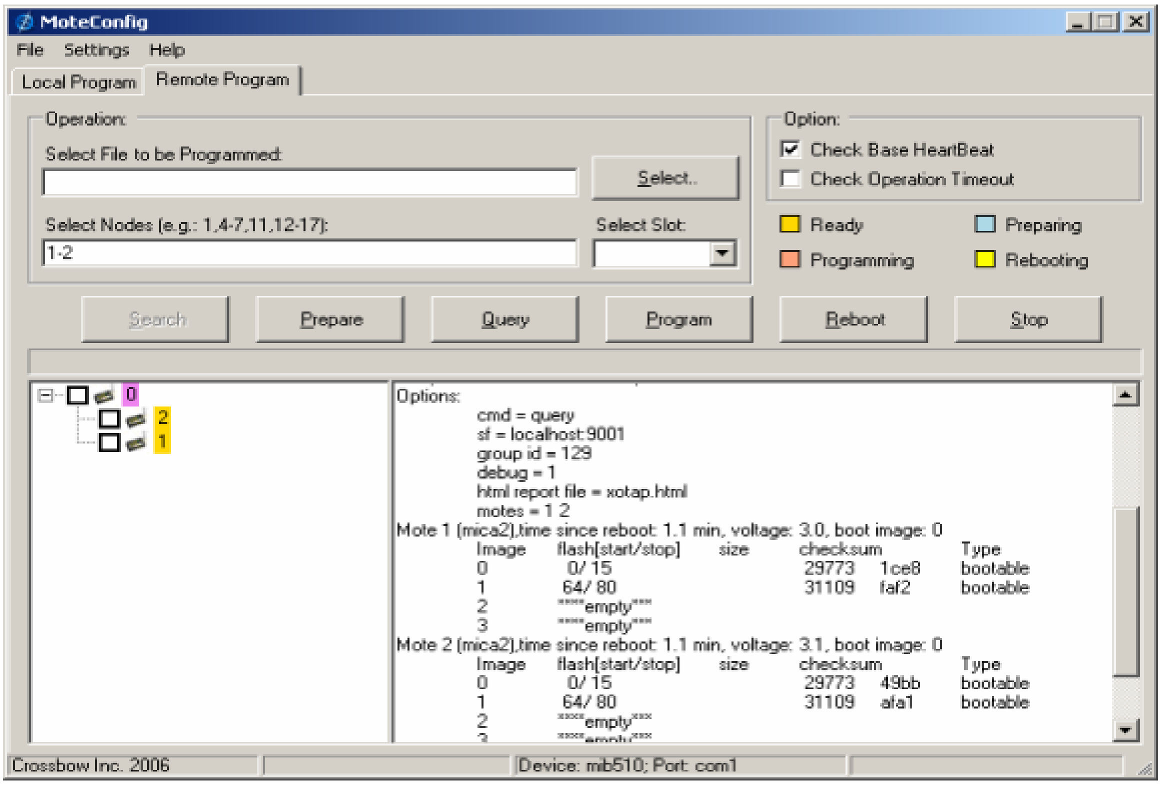


Figure 12 . Nodes collecting for Information

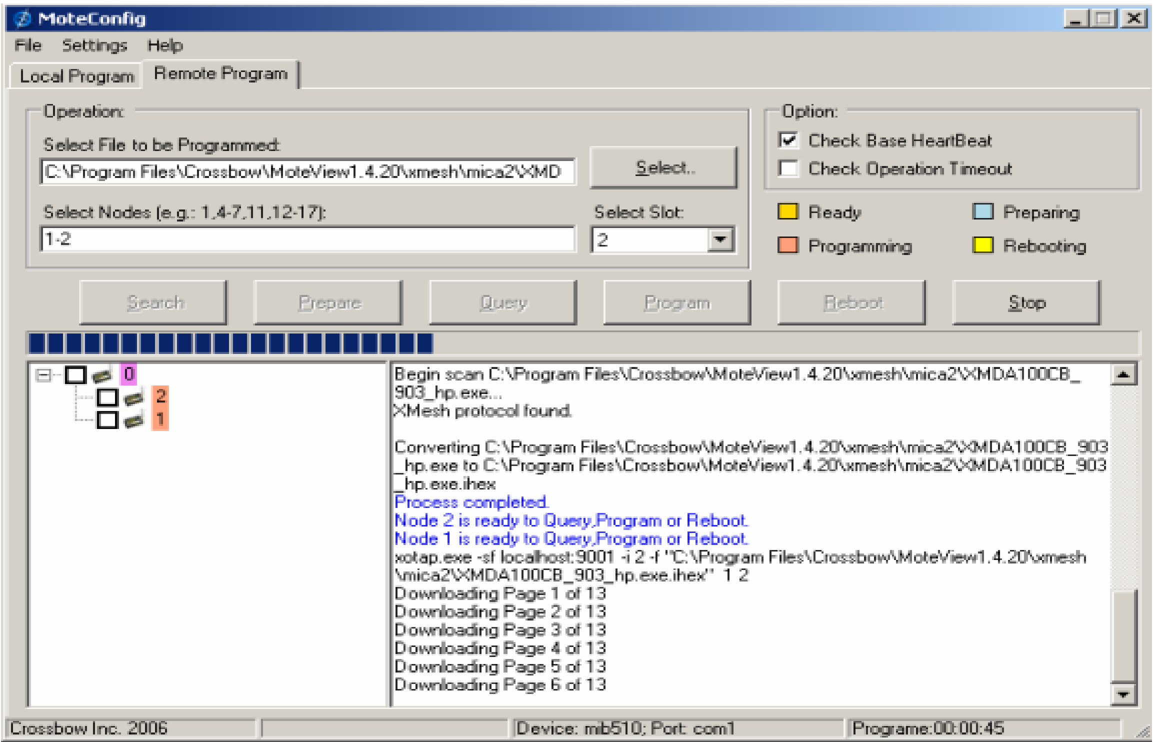


Figure 13 . Programming the nodes in the network via XOTAP

3.5 Preliminary Work

Author develops C language source code to support the microcontroller as desired. The compiled source code was simulated with the MoteConfig 2.0 software.

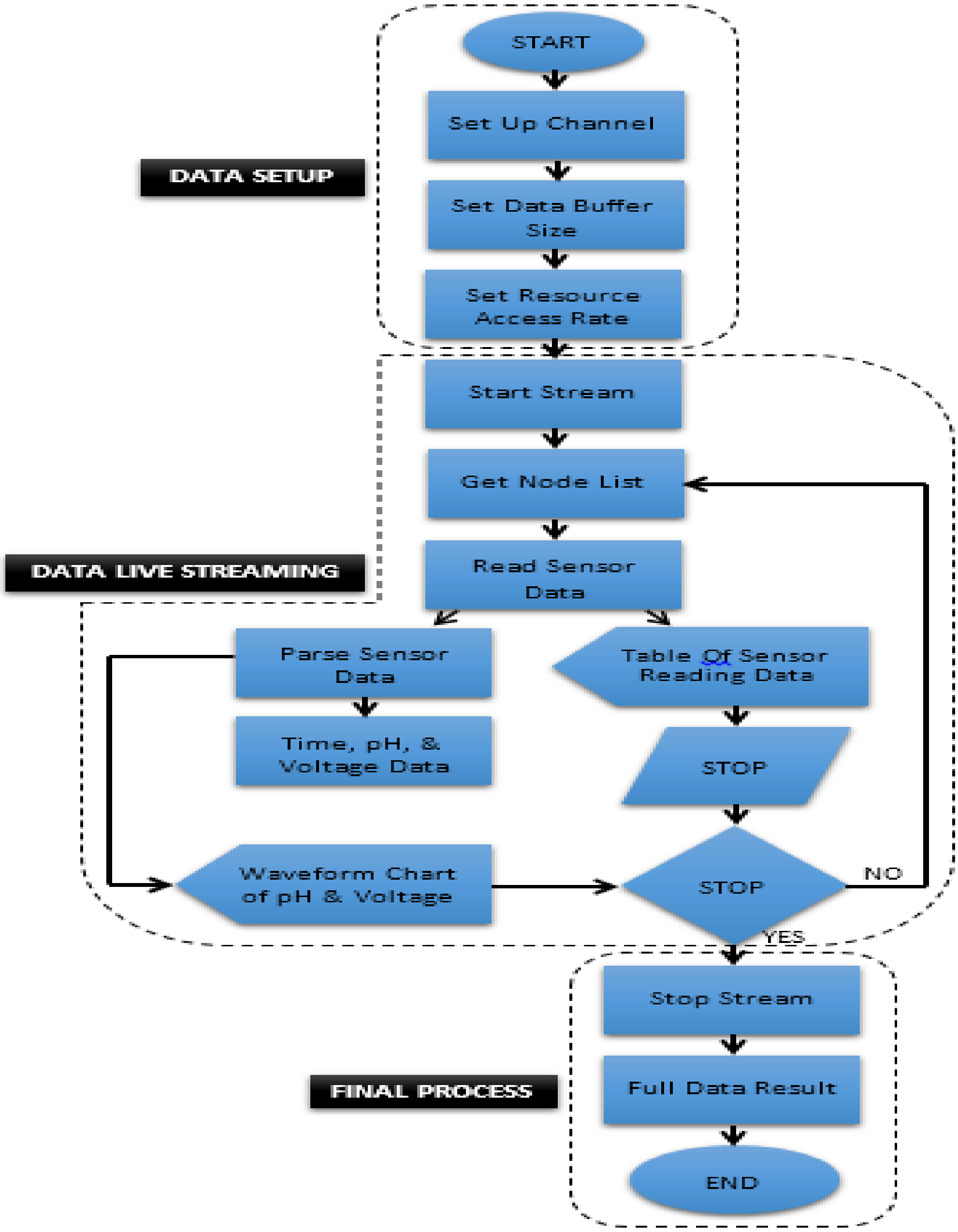


Figure 14. Program Flow Chart

CHAPTER 4
RESULTS AND DISCUSSION

The graph below proved that from all the parameter setup and all data reading were correct according to the Water Quality Index (WQI) where three different samples of water taken from different PH value. All this data were measured using MoteView 2.1 data logger that were built inside the software. Figure 12 shows the UTP Lake Water Quality Index (WQI) in three different depth.

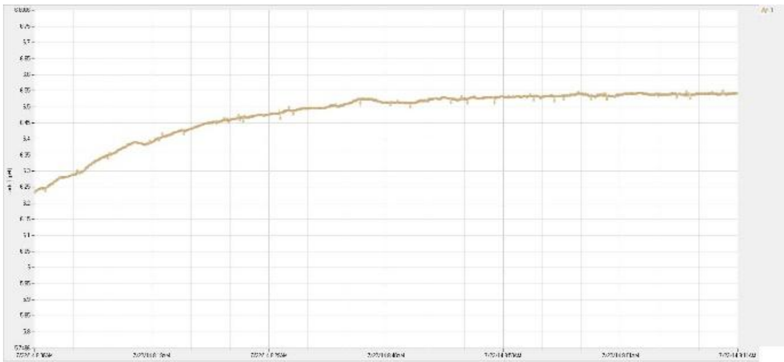


Figure 15. Result for Chlorine Water (PH 7)

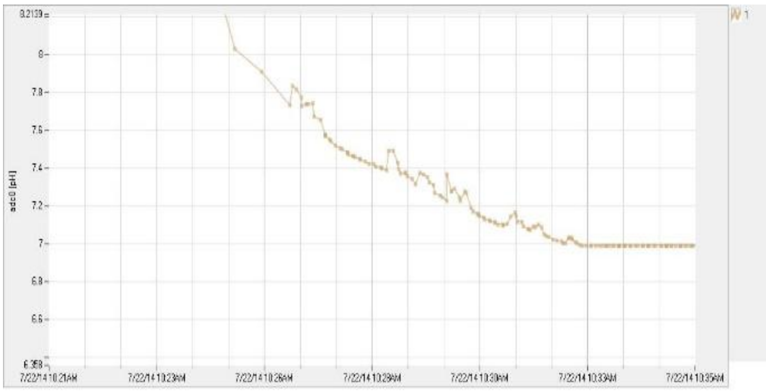


Figure 16. Result for Chlorine Water (PH6.5 to PH7).

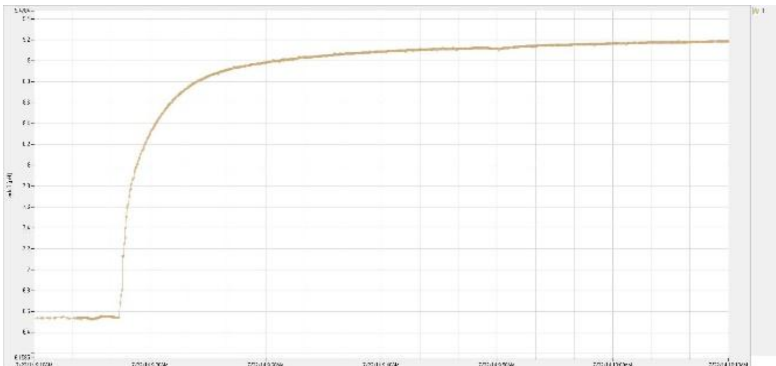
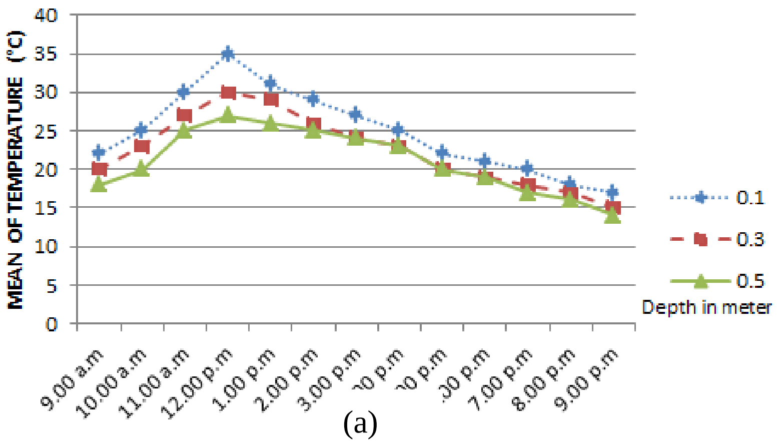
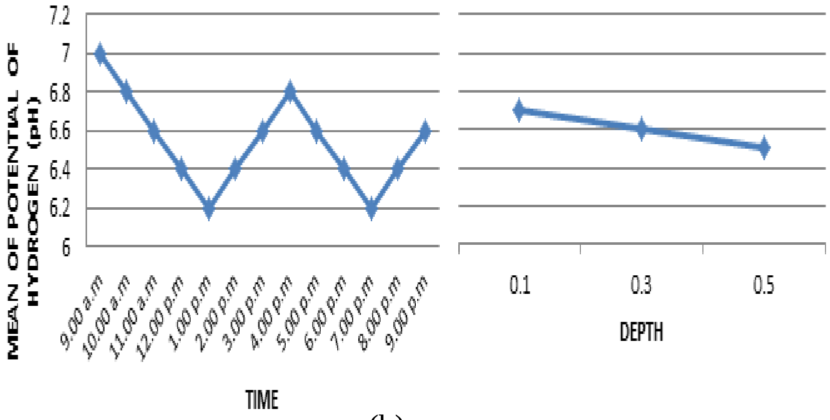


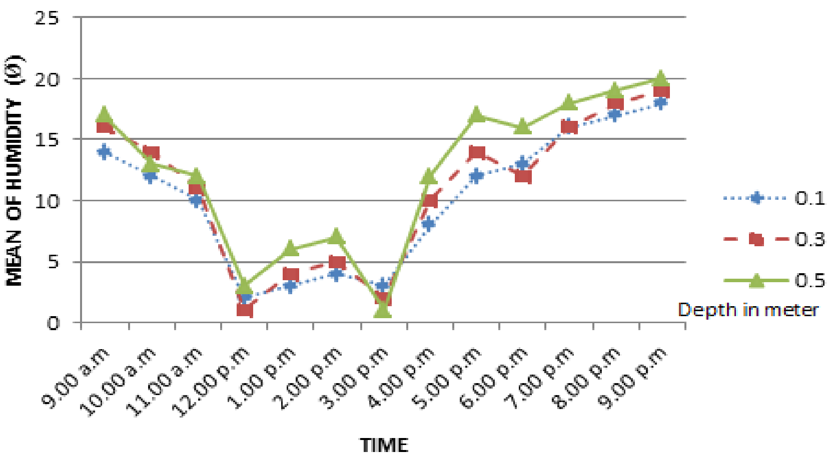
Figure 17. Result for Graph of Alkaline Water (>PH 7).



(a)



(b)



(c)

Figure 18. Levels of Parameters Temperature (a), pH (b) and Humidity (c) value in water samples from the UTP Lake Water

Hours	WQI*	Water Quality
0900	3.19	Excellent
1000	2.84	Excellent
1100	2.74	Good
1200	2.77	Good
1300	1.42	Good
1400	1.38	Poor
1500	1.37	Poor
1600	2.02	Poor
1700	2.00	Good
1800	2.04	Good
1900	2.10	Good
2000	2.10	Good
Average	**2.15**	**Good**

Table 7. WQI values per 12hours at UTP Lake Water from 0900 Hour to 2000 Hour

The calculated WQI determined excellent water quality for the morning, good quality for afternoon and night and poor for evening. The results show that the water of this ecosystem can be used without any problem for ecological purposes as well as for artificial aquatic ecosystem. It is highly recommend to continue monitoring water and to employ other methodologies like the WQI using additional variables.

CHAPTER 5
RECOMMENDATION AND CONCLUSION

The main goal of this project is to develop a network connection using the IRIS mote of functional Wireless Sensor Network (WSN) through a new technique by tackle with the problem of the efficiency of the technologies for environments monitoring system. The monitoring using wireless sensor network hopes that it will contributes a useful feedback such as more large monitoring coverage, flexibility to configure, low power consumption, small damage to the natural environment and low cost product.

Finally, the main part is only to focus on investigating the effectiveness of Motes-IRIS 2.4 GHz transmitter and MicaZ receiver with multi-probe sensor to determine the parameter to give better understanding and explore for a new design of water environment monitoring system, based on a WSN. The monitoring system thus promises broad applicability such proved that it can transmit the signal within the range of five to ten meters. The prototype were designed and built inside a wet-proof transparent case where it will be easy to monitor, replace the batteries and for it able to work closely to water and the test for the all the parameter with probe PH-BTA were implement to put near the water.

The calculated WQI determined excellent water quality for the morning around 3.19, good quality for afternoon with range 2.0-2.5 and night and poor for evening as the average shows 1.37. The results show that the UTP lake water of this ecosystem can be used without any problem for ecological purposes as well as for fishing, agriculture and livestock production of average (WQI) 2.15. It is highly recommend to continue monitoring water and to employ other methodologies like the WQI using additional variables.

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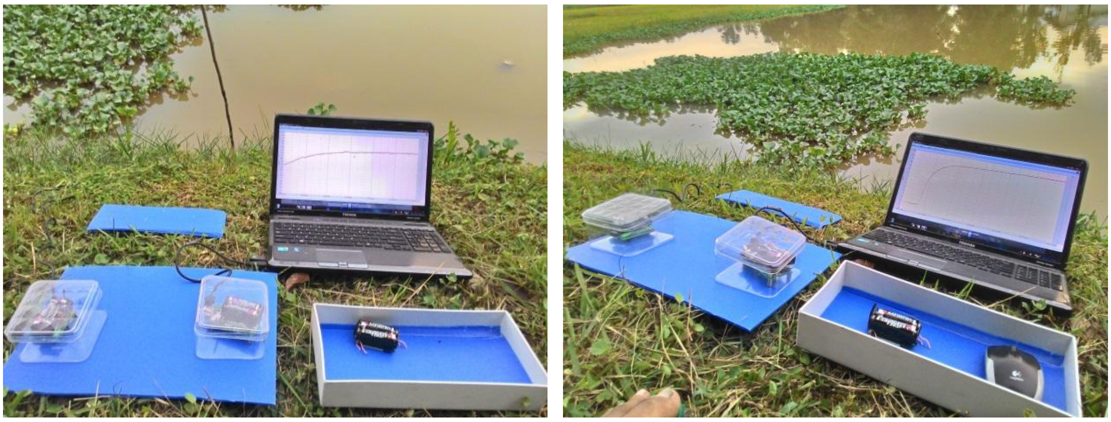
APPENDICES

The Appendix below shows the setup connection for the available value in the manual. I show that the setup connection is done at UTP Lake and II shows that the probe connection is done by attached inside the water with different depth.

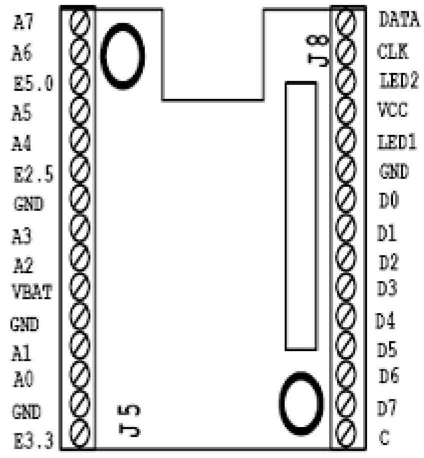


(I)

(II)

APPENDIX A

PIN CONFIGURATION



TOP VIEW