Water Quality Monitoring System Using 3G Network

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***Abstract*—This paper presents a water quality monitoring system through the acquisition of data parameters such as temperature, pH level, turbidity, and amount of dissolved oxygen. The prototype consists of hardware such as sensors, Gizduino, Raspberry Pi, and 3G Pocket Wifi. Software element includes Raspbian as an operating system, Python as a programming language and MySQL for the database. The power source of the prototype comprises a battery and a solar panel. The testing of the prototype was done in three different bodies of water such as tap water, "Wawa" dam water and "Pasig" river. The raw data gathered from the testing were validated using calibration methods for the temperature sensor and pH sensor while the turbidity sensor follows the ISO 7027 and for the dissolved oxygen parameter, interpolation with the temperature values was computed. Also, the results revealed a minimal standard deviation for each of the parameters for all of the testing done from three bodies of water which validates the consistency of the data gathered. In terms of power supply, no power failure was encountered during the three testing sites. The data from the sensors were also transmitted to the database using MySQL through a 3G network.**

***Index Terms*—3G Communication; Database; Environmental Monitoring; Power System Computing.**

I. INTRODUCTION

People are more focused on monitoring watersheds for drinking water and we forget to take into consideration the importance of water bodies for a fishery that is now being polluted by so many factors in the environment causing a decrease in biodiversity [1].The most popular body of water that is known to have a rapid pollution rate in the Philippines is Pasig River. It connects two large water bodies in Manila, the Laguna de Bay and Manila Bay.

Additionally, the Pasig River has an economic activity it provides the major means of transport, water sources and a place for shelter to a large variety of fish. One of the many reasons that water bodies like Pasig River have been fallen prey to pollution is because of the water waste disposal of factories and households and even the solid waste being disposed of in it. It is known that the water quality in Pasig River is becoming worse, but there is no attention being put into it. In part of this, solutions to these kinds of problems need preliminary steps. Monitoring and assessment can be done first before having a definitive plan on how to eradicate water pollution problems [2]. Water monitoring systems can also be advantageous in many different aspects.

It can provide us information or data that we need such as pH levels, temperature, turbidity or amount of dissolved oxygen. These basic parameters that can be measured through electronic means can also determine further parameters such as a bacterial growth that can be relative to how polluted the water is. These data can also be used to determine which species are capable of surviving on the monitored water environment. Measuring water quality through this system can also ensure the growth of healthy fish and plants and can, later on, improve biodiversity. Some studies [3-9] have been conducted that have promising results.

The water quality monitoring system was developed that consists of sensors, a microcomputer and 3G wireless technology with the integration of solar panels as means of renewable energy that powers the system. It is callable of data transmission from the monitoring device to the remote server that stores information such as pH level, temperature, turbidity and amount of dissolved oxygen to determine the quality of water in bodies of water.

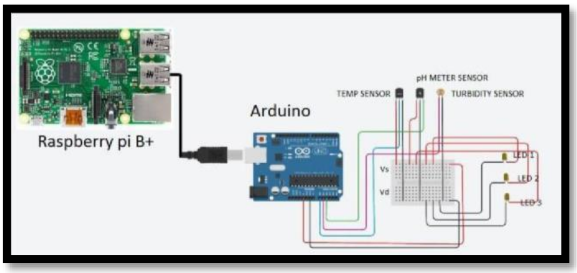
II. MATERIALS AND METHODS

A. System Design

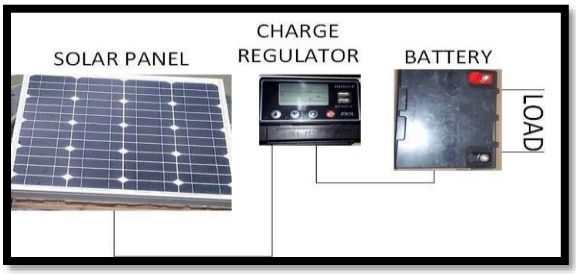
In the development of the water quality monitoring system, it included the physical design, hardware components and the software requirements. The physical design of the system is similar to a buoy since the proposed system was deployed in a body of water. On the other hand, the hardware part of the system is composed of sensors, microcontrollers and shields, 3G pocket Wi-Fi and power supply. Figure 1 shows the physical design of the proposed system wherein the solar panels are on top of the ring buoy and the sensors are placed in the middle. The proposed system considers the sensors that measure temperature, pH level, and amount of dissolved oxygen. Signal processing of the data acquired by the sensors was processed by the microcontroller and the transmission of the data gathered to the database through a 3G network was controlled by the microcomputer (Raspberry Pi).

Figure 1: Physical design of the proposed system

Figure 2 shows the hardware component of the proposed system wherein Figure 2(a) shows the schematic diagram of the sensor module which is composed of microcontroller that is responsible in the signal processing of the sensor signal and the microcomputer which is responsible in the formatting of the sensor reading for transmission to the remote server. Figure 2(b) shows the power supply using solar panels with a charge regulator and a charging battery that gives power to the sensor module. The sensor module includes a temperature sensor (LM35), pH sensor, dissolved oxygen sensor (LM35) and Turbidity sensor (LDR).



(a)



(b)

Figure 2: (a) Schematic diagram of the sensor module (b) Power supply consideration for the system

One of the most vital parts of this system is the set of sensors to be used which includes the temperature sensors that will show the apparent temperature of the water. pH sensors were also utilized to measure the hydrogen ion exponent and converted it to a specific range that would determine the pH level of the water. Another component to be used in this system is the sensor that determined the turbidity of the water.

The main device of the system is the Raspberry Pi which is a single board computer that is capable of processing the data acquired by the sensors. This computer is needed in the system since it has a USB 2.0 port that can accommodate a USB 3G modem and can be programmed to transmit the processed data into the database.

Since the Raspberry Pi does not include an internal ADC, an external device must be added. In this project, the researchers, specifically used the Gizduino v4.1 which has enough I/O ports for the sensors in this design.

In order for the data processed be transmitted to the remote database, a 3G pocket WiFi with a network service provider was needed. Specifically, the team used a Globe Pocket WiFi.

The power supply is also one of the significant pieces of hardware to be used in this research. The group included a solar panel to gather energy from the sun and store it to a battery. A 50W solar panel will be specifically utilized with a 12V battery. There is a need for a charge controller with an inverter which is a microprocessor controlled device, to regulate the charging on the battery.

The main software that is involved in this project is the operating system that will be installed on the Raspberry Pi computer. The group utilized Raspbian Operating System specifically the Debian 7.0 which is a stable version,and has a codename *"Wheezy."* It includes updated software packages such as the Python. Another program that will be used to configure the gizduino's function as an analog-to-digital converter is the Arduino application. For the database part, phpMyAdmin MySQL Database was used.

This research was conducted to provide useful data such as pH level, temperature and amount of dissolved oxygen to determine the quality of water in bodies of water. These quantitative measurements are significant in determining the quality of water.

The system is devised to record and store the data that was needed to monitor the water quality. This was done with the use of software such as the MySQL. This was used for the database part of the system to organize all the raw data. The computer used in this project which is the Raspberry Pi already includes an internal memory, and an additional SD card slot that can be used to extend the memory capacity of the computer and to have more space for more data.

After acquiring the data, it is transmitted through a 3G network to the phpMyAdmin MySQL Database in which it can be accessed by another host computer through the internet. Figure 3 shows the process flowchart for the testing of the hardware and software components of the proposed system. Calibration of the hardware component particularly the sensor readings and transmission of data to the server have been tested and verified. After ensuring the operation of each component, the software must also be simulated to make sure that the data gathered are processed and analyzed correctly.

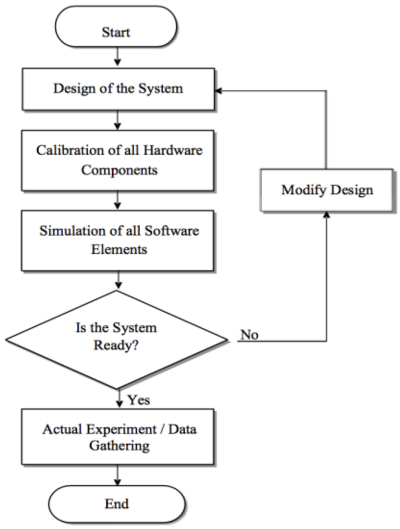
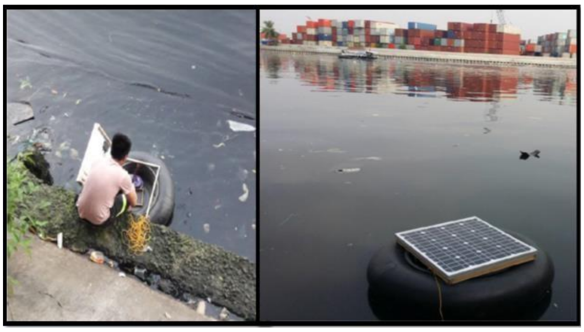


Figure 3: Process flowchart for the testing of the proposed system

B. *System Implementation*

The proposed system has been deployed in the Wawa Dam in Rizal, Province and the Pasig River in Metro Manila area. Figure 4 shows the actual implementation of the proposed system and the monitoring of the water parameters (temperature, pH level, turbidity and the dissolved oxygen) in the deployment sites. Figure 4(a) shows the Wawa Dam deployment and Figure 4(b) shows the Pasig River deployment. The data was analyzed at the mentioned location for two weeks with a multiple numbers of sample attained for each analysis.

(a)



(b)

Figure 4: Actual Implementation of the proposed system in (a) Wawa Dam and (b) Pasig River

III. Result and Discussion

The testing of the prototype was done in three different bodies of water such as tap water, “Wawa” dam water and “Pasig” river. Thus, the result will be presented according to the tested parameters of Parameters include temperature, amount of dissolved oxygen, pH level and turbidity level. Figure 5 shows the graph of the temperature testing versus a number of samples done in the three different bodies of water. Based on Figure 5, the average temperature for tap water sample is 22.28°C. It shows that the discrepancy on the temperature of ± 0.6 % which signifies the consistency of the data that the temperature sensor yielded. As for the Wawa dam water sample, the average temperature is 24.98 °C with discrepancy on the temperature of ± 2.6 %. The average temperature of the Pasig River water sample is 26.03°C with a discrepancy of the temperature of ± 1.6 %.

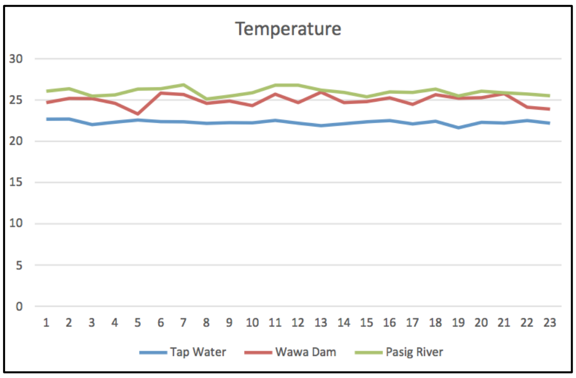


Figure 5: Temperature testing versus the number of samples

Figure 6 shows the graph for the amount of dissolved oxygen versus a number of samples done in the three different bodies of water. Based on Figure 6, the dissolved oxygen on the tap water has an average value of 7.62 mg/L. It shows that the discrepancy of ± 0.3 %. The dissolved oxygen of Wawa Dam has an average value of 6.83 mg/L with a discrepancy of ± 1 %. The dissolved oxygen of the Pasig River water has an average value of 6.49 mg/L with a discrepancy of the dissolved oxygen of ± 0.3 %.

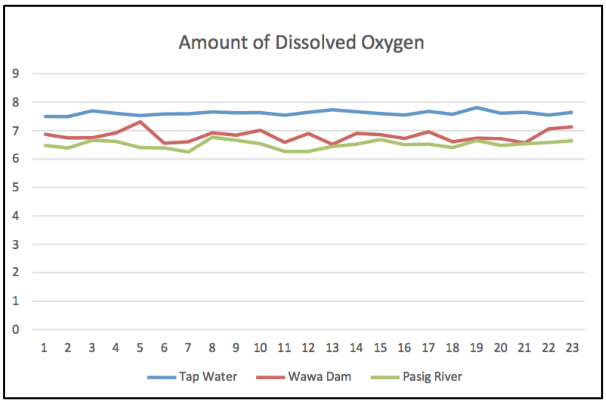


Figure 6: Amount of dissolved oxygen versus the number of samples

Figure 7 shows the graph for pH level versus a number of samples done in the three different bodies of water. Based on Figure 7, the pH meter on the tap water has an average value of 7.39 pH. It shows that the discrepancy of the pH meter of ± 0.003 %. The pH meter of the Wawa Dam has an average value of 7.53 pH with discrepancyof the pH meter of ± 0.003 %. The pH meter of the Pasig River water has an average value of 7.05 pH with a discrepancy of the pH meter of ± 0.003 %.

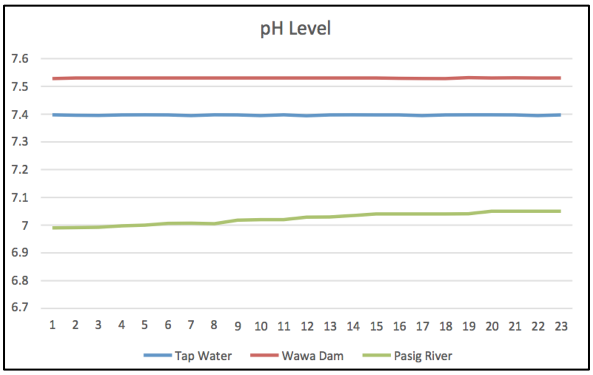


Figure 7: pH level of water versus the number of samples

Figure 8 shows the graph for Turbidity versus a number of samples done in the three different bodies of water. Based on Figure 8, The turbidity on the tap water has an average value of 4.00 NTU. It shows that the discrepancy of the turbidity of ± 0.01 %. . The turbidity of the Wawa Dam has an average value of 8.76 NTU with a discrepancy of the turbidity of ± 0.01 %. The turbidity in the Pasig River water has an average value of 24.48 NTU with a discrepancy of the turbidity of ± 0.01 %.

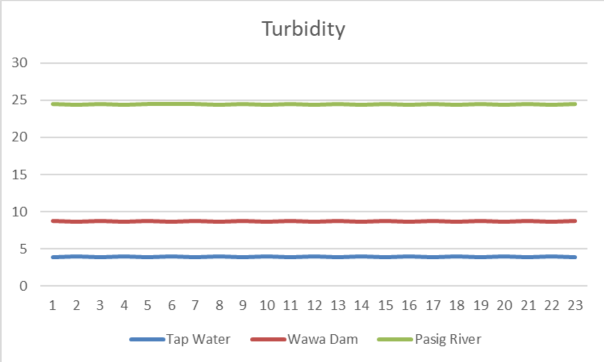


Figure 8: Turbidity versus the number of samples

Thus overall , for the temperature analysis, Figure 5 reveals that the temperature which was recorded for the tap water sample as considerably consistent as compared to the two other water samples. This could be due to the fact that the tap water sample which was placed in an inflatable pool was indoor, and it could be considered that there were no other factors that could have influence significant changes in the temperature. On the other hand, for the temperature recorded at the Wawa Dam and Pasig River, the graph showed a rippled output and the values were slightly greater than that of the recorded temperature for tap water. This could be caused by the fact that the testing was done outdoors with an uncontrolled environment and the surface temperature of the water in Pasig River and Wawa Dam was mostly dependent on the ambient temperature.

As for the amount of dissolved oxygen analysis, results in Figure 6 showed that for the three different samples just simply shows an inverted graph from that of the graph for the temperature. Because the values derived for the amount of dissolved oxygen were just interpolated from the values of the temperature. The results imply that there is an inverse relationship between the temperature and amount of dissolved oxygen.

As for the pH analysis, the graph in Figure 7 showed that shows that Pasig River water is the most acidic while Wawa Dam water is the most basic. It also reveals that the tap water (Maynilad) is farther from the neutral point which is 7 but is less acidic, and it can be due to the presence of alkaline in the water from the reservoir of Maynilad.

As for the turbidity level, results in Figure 8 showed three different trends between these three types of water. It clearly confirms that among the three samples of water, the PasigRiver water is the most turbid and as expected, the tap water is the least turbid. In terms of NTU standards, water is considered clear if its turbidity value does not exceed 5 NTU. Pasig River water recorded higher value compared to the other two water samples the water exceeds the normal turbidity value and may be unsafe for aquatic life as the criteria set by Department of Ecology - State of Washington [10] requires the turbidity to be lower than 10 NTU.

IV. CONCLUSION

The main objective of this study was met and the authors were able to acquire the data needed in the monitoring of water using 3G network. The results of the testing which was done using three different water samples in acquiring the four parameters for water quality which are temperature, amount of dissolved oxygen, pH level and turbidity level reveal a substantial difference. Also, the raw data recorded suggested a consistent trend which signified that the data acquired by the sensors were acceptable. There were some insignificant inconsistencies when it comes to temperature and turbidity level. This could be due to the fact that the instrument used for these sensors were DIY because of economic reasons. However, based on the data gathered which gave the researchers minimal percent difference in certain water quality parameters, the sensor used can still acquire precise water quality parameters. On the other hand, the use of 3G network as a medium of transmission of data from the local host database to the remote database was achieved. The authors were also able to validate the data gathered with the use of Arduino IDE's serial monitor and Raspberry Pi LX Terminal's grab serial function. Upon running these programs, the data acquired for the four water quality parameters correspond with each other. Lastly, in terms of power supply, there was no failure that occurred. The solar panel served as the safeguard to ensure that there was enough power and the battery's specification was able to satisfy the power requirements of all the components in the system.

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