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DESIGN OF A PROTOTYPE OF WATER QUALITY PHYSICS MEASURING EQUIPMENT BASED ON MICROCONTROLLER

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ABSTRACT

Water is an important element for all life forms on earth. Water is also very important for sustainable development, socio-economic, healthy ecosystems and for the survival of humans themselves. Without proper water management, competition for water utilization between sectors will have an impact on the escalation of the water crisis that has triggered emergencies in various sectors that depend on water. One real example of the problem above is in Mappi Regency. Although it is surrounded by many rivers and the Arafuru Sea, Mappi Regency is one of the regency in southern Papua with the problem of the clean water crisis. The existing river and sea water sources have not been managed because so far there have been no specific studies that measure water quality in these locations.

This paper describes the work that has been done on the design of a prototype water quality physical parameter measuring instrument that aims to collect data on water quality physical parameters in real-time. This system is able to measure key physical parameters of water quality such as temperature, pH, dissolved oxygen (DO) and electrical conductivity. These parameters are used to detect water quality in general. The designed sensor is then implemented and connected to a microcontroller. The microcontroller then processes and analyzes the data for later storage in a micro SD. In this design, the microcontroller used is Bluno. The data is stored in the form of spreadsheet tabulations files. The sensor is shown to work within the desired accuracy range. The results show that the system is able to read the physical parameters of water quality and successfully processes, transmits, and stores data.

Keywords: *water quality (temperature, pH, DO, EC), microcontroller, prototype*

1. INTRODUCTION

Water is an essential element for all forms of life on earth. According to Aquastat data, there are about 326 million gallons of water on Earth. Water is in a constant cycle. 98 percent of this water is in the oceans, 1.6 percent in the polar ice caps, 0.36 percent in groundwater, aquifers and wells. Up to 0.036 percent is in lakes and rivers, the rest is in the form of clouds and water vapor in the air or in the bodies of living things.

Water is the essence of life. Water is also very important for sustainable development, socio-economic, healthy ecosystems and for human survival itself. Without proper water management, competition for water use between sectors will have an impact on the escalation of the water crisis that triggers emergencies in various sectors that depend on water.

Water quality is a term that describes the suitability of water for certain uses, for example: drinking water, fisheries, irrigation/irrigation, industry, recreation and so on. Water quality can be known by measuring certain parameters of the water. Measurements that are usually carried out are measurements of physical, chemical, biological parameters as well as appearance tests (smell and color). Water quality generally indicates the quality or condition of water associated with a particular activity or use. Thus, the quality of water will differ from one activity to another, for example: the quality of water for irrigation purposes is different from the quality of water for drinking water purposes.

Water quality measurement is divided into insitu (onsite) and exitu (offsite). Measurement of physical parameters such as temperature, pH, DO and others as well as appearance tests (depth, brightness, odor and color) are usually carried out in situ or measured directly at water sources. Measurement of chemical parameters such as the content of nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), Phosphate (PO_4) and others, as well as biological parameters such as the number of coliform bacteria, plankton, benthos and others are carried out externally or measured in the laboratory.

The current water quality measurement is still relatively difficult to do. Each parameter, whether physical, chemical or biological, has a different sampling method, measuring instrument and test method. In addition, the cost to carry out measurements is also relatively expensive, so this sometimes becomes an obstacle for stakeholders to be able to obtain water quality data that is relatively easy, cheap and with reliable data. The water quality data will be very important in policy making and analysis of water use for various sectors.

One concrete example of the above problems is in Mappi Regency. Although surrounded by many rivers and the Arafuru Sea, Mappi Regency is one of the districts with a clean water crisis, especially in southern Papua. The existing water sources, both rivers and seas, have not been managed because so far there has been no specific study that measures water quality in these locations. If the water quality data is available, this will facilitate the formulation and policy making related to the management and use of the water.

2. LITERATURE REVIEW

Sugapriyaa Tha, Rakshaya S., Ramyadevi K., Ramya M., Rashmi P. G. entitled "Smart Water Quality Monitoring System For Real Time Application." Published in 2018 International Journal of Pure And Applied Mathematics. This paper highlights a brief explain about the specialities and designing's of smart water quality system consisting of turbidity, pH, temperature and conductivity sensors [1].

In 2019, Vaishnavi V. Daigavane and Dr. M.A Gaikwad, Water Quality Monitoring System Based on IOT, explain pH, turbidity, flow sensor and IOT (Internet of Things) [2]. Also in 2019, Niel Andre Cloete Reza Malekian and Lakshmi Nair [3] briefed the online water quality monitoring system based on Zigbee receiver and transmitter modules for communication between the measuring and notification node. It is an artificial method hence collection of data and other process will be done slowly.

2.1. Definition Of Water Quality

Water is a covalent bond of hydrogen and oxygen compounds with the chemical formula H_2O. Physically, water is divided into three forms, namely water as a liquid (fluid), water as a solid (solid), and water as a gas (steam). Water can change from one form to another depending on time and place and the temperature. Based on its intended use, water use can be broadly classified into four groups, namely water for irrigation purposes, water for energy generation purposes, water for industrial purposes and water for public purposes. In general, water quality means the quality or condition of water associated with a particular designation. Water quality standard is a measure of the limit or level of organisms, substances, energy, or components that exist or must be present and/or pollutant elements in water. Water pollution is the entry of organisms, substances, energy and or other components into water by human activities, so that the quality of the water drops to a certain level which causes the water to be unable to function according to its designation [4].

2.2. Temperature

Temperature is a very important physical factor in water. The temperature and the substances/elements contained therein will determine the density, density and saturation of water. The water temperature will be different from one point to another or different based on a certain depth. The difference is caused by differences in the geographical latitude and position of a body of water with respect to the sun, causing the reception of solar radiation in each region to be different. In Indonesia, the average air temperature during the day in various places ranges from 28.2 ^{0}C to. 34.6 ^{0}C and at night the temperature ranges from 12.8 ^{0}C to d. 30 ^{0}C. The state of the temperature depends on the altitude above sea level. The water temperature is generally a few degrees lower than the surrounding air temperature [5].

2.3. Dissolved Oxygen

Oxygen can be a limiting factor in determining the presence of living things in the water. The decrease in dissolved oxygen will affect the life of organisms through the process of respiration and oxidation-reduction reactions to chemical compounds in water. Dissolved Oxygen (DO) is the amount of dissolved oxygen particles in water. The number of DO particles can be used as a measure to determine water quality. Life in water can survive if there is a minimum dissolved oxygen of 5 mg of oxygen in every liter of water (5 parts per million/ppm). DO depends on the resistance of organisms, the degree of activity, the presence of pollutants, water temperature and so on [6].

2.4. Potential of Hydrogen (pH)

Potential of Hydrogen (pH) or better known as the degree of acidity is the concentration of hydrogen ions (H+) in water, the amount is expressed in minus logarithm of the H ion concentration between 0 – 14. A pH value < 7 indicates an acidic environment, while a value > 7 indicates an acidic environment. an alkaline environment, for pH 7 is referred to as neutral. Waters with a pH of < 4 are very acidic waters and can cause death for organisms that live in them, while pH > 9.5 are very alkaline waters which can cause death due to reduced water productivity. Seawater has a relatively more stable pH than fresh water. The pH of seawater is in a narrow range, usually in the range of 7.7 – 8.4 while the pH of fresh water varies widely.

pH is influenced by the buffer capacity, namely the presence of carbonate and bicarbonate salts it contains [7].

2.5. Electrical Conductivity (EC)

Electrical Conductivity (EC) is directly related to the concentration of ionized dissolved solids in water. Ions from the concentration of dissolved solids in water create the ability of the water to generate an electric current which can be measured using a conductivity meter. EC functions to measure the electrical conductivity of materials contained in water. The more materials (metallic and non-metallic minerals) in the water, the greater the measurement results. On the other hand, if very few ingredients are contained in water, the result is close to zero or is called pure water [8].

2.6. Analysis Of In-Situ Water Quality Measurement

In-situ water quality measurement is a water quality measurement that is carried out directly in the field. This is done because some water quality parameters have a short holding time analysis. Holding time analysis is the maximum time limit for a water quality parameter to be measured and produces a good measurement value. Holding time analysis only ranges from 30 minutes – 6 hours depending on what parameters will be measured. Some water quality parameters that can only be carried out in-situ are generally water physical parameters such as temperature, pH, EC, DO, salinity and other parameters. In-situ measurements require specific measuring devices for each parameter. In-situ measurement allows users to obtain data directly in the field at all locations even in remote places, but has limitations in terms of the cost of expensive measuring equipment and limited general parameters. For chemical parameters and special parameters such as heavy metals and biological parameters such as bacteria and plankton in water, measurements cannot be carried out in-situ.

Figure 1 Flowchart of In-Situ Water Quality Measurement (Source: Analysis, 2021)

Figure 2 Field Implementation of In-Situ Water Quality Measurement

Source: Personal Documentation, 2021

2.7. Prototyping

Prototyping is a design and build activity that consists of several stages such as collecting system requirements, designing and building prototypes, testing and evaluating prototypes. Basically, prototyping is a process to create a system that fits your needs. To create it you must first know how the system is running and then find out the problems that occur. Design and build prototypes to overcome these problems. If the problem still persists or improvement and refinement needed, the process returns to the system requirements gathering stage and so on. The stages will be completed when the user is satisfied with the prototype made so that the prototype will be used as a reference as the final product [9].

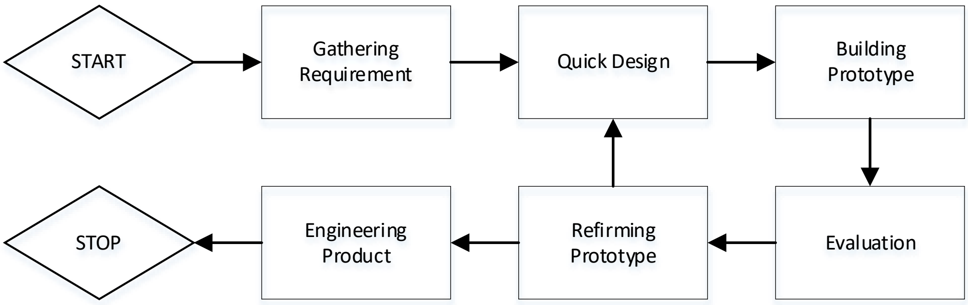

Figure 3 Flowchart of Prorotyping [9]

2.8. Device Design

Based on the analysis of the existing water quality measurement system, the author intends to offer a device design in the form of making a prototype of an in-situ-based water quality measuring device. The design of the proposed device is as follows.

- Based on the analysis of the two existing measurement systems, we need a solution for measuring in-situ water quality that is compact, has a relatively affordable price and has reliable data.
- The prototype of the water quality measuring device is in the form of a sensor measuring key parameters for measuring water quality, such as temperature, pH, Dissolved Oxygen (DO) and Electrical Conductivity (EC).

2.9. Analyze how the device works

Based on the analysis above, the following will explain how the device works. In this prototype, water quality sensors will provide input in the form of data. The data that has been received will be translated by the Arduino microcontroller system and then stored in a micro SD module. The following is a schematic of how the prototype system will work.

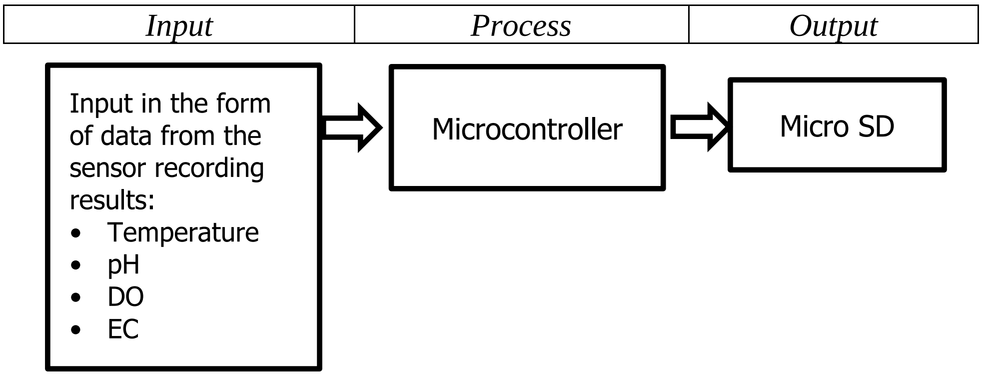

Figure 4. Schematic of how the prototype device works

Source: Analysis, 2021

3. RESULT AND DISCUSSIONS

In this section the author will implement the hardware based on the results of the analysis and system design that has been done previously.

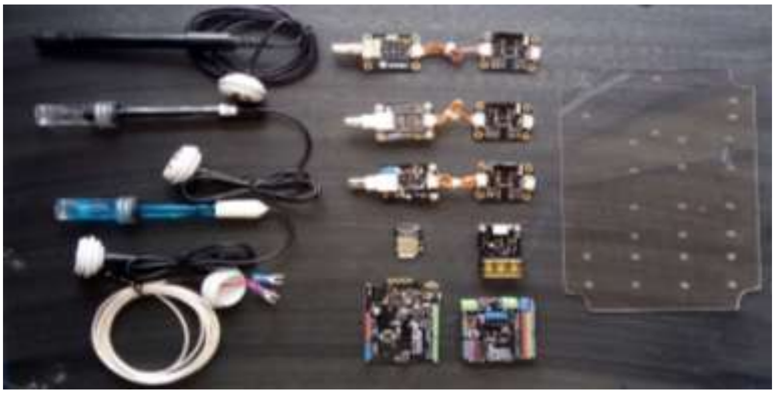

Figure 5 . Hardware to be Implemented

Source : Personal Documentation, 2021

3.1. Implementation of Bluno and Expansion Shield

The first step in implementing the system is to pair Bluno with an expansion shield. This is done to make it easier to assemble Arduino with other sensors that will be assembled later. The expansion shield used is an Arduino expansion shield that can also be used for Bluno. The pinout on Bluno can be directly attached to the expansion shield because it is an extension without requiring additional cables. The use of an expansion shield will simplify assembly because it does not require a bread board, complicated jumper cables or soldering and wire cutting processes.

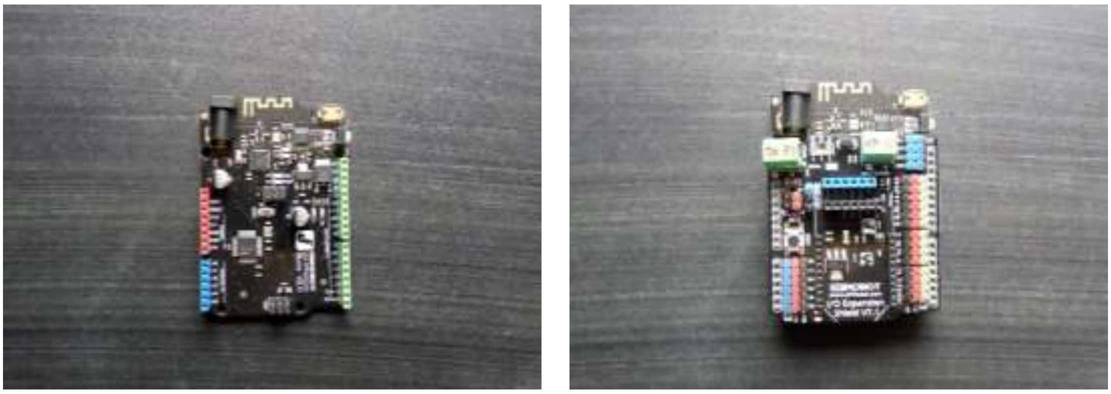

Figure 6. Implementation of Bluno with Expansion Shield
Source : Personal Documentation, 2021

3.2. Implementation of Micro-SD Module and Expansion Shield

The next step is to pair the micro-SD module with the expansion shield. This is done to increase the storage capacity of Bluno as well as a data logger. The device is then mounted on a base made of pre-perforated acrylic. Installation of this device on the base is done using 3mm nuts and bolts.

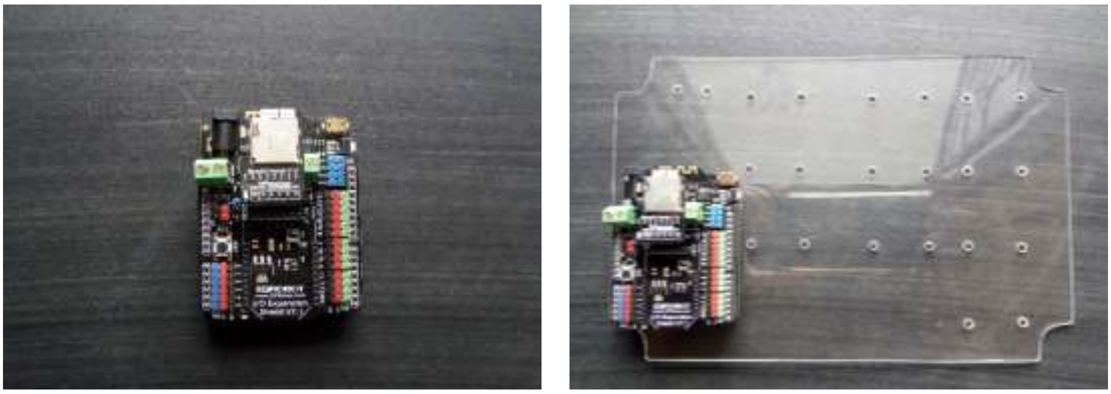

Figure 7. Implementation of the Micro SD Module with Expansion Shield

Source : Personal Documentation, 2021

3.3. Implementation Module and Probe sensors

Last step is to pair Bluno and the module and probe sensors. Modules and probe sensors function as tools that receive input from water whose quality will be measured. modules and probes installed consist of temperature, pH, DO and EC

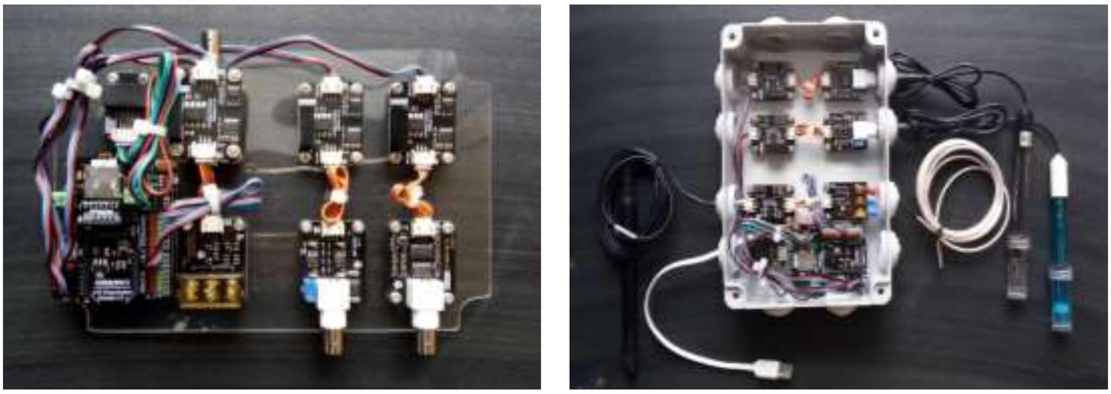

Figure 8. Implementation of the Micro SD Module with Expansion Shield
Source : Personal Documentation, 2021

3.4. Software Implementation

The software is made using Arduino IDE 1.8.2 with a heading system to make it easier to add sensors in the future. The use of the heading system is also carried out to facilitate correction and tracing of errors in the coding that has been done. The list of software code that has been made is available in the attachment of this final report.

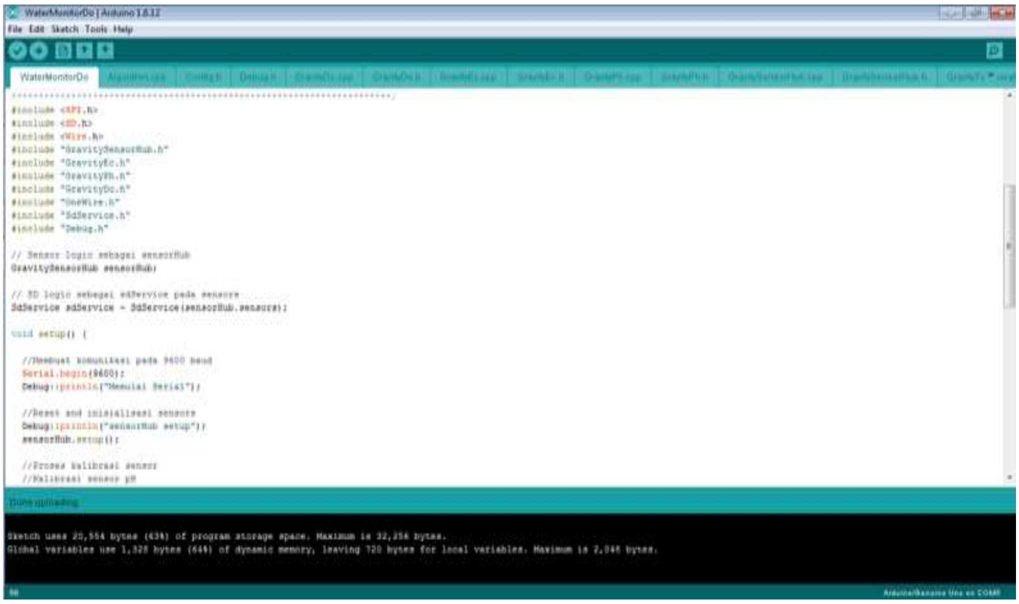

Figure 9. Software Implementation
Source : Personal Documentation, 2021

3.5. Field Implementation

The prototype of a microcontroller-based water quality measuring device was implemented directly in the Yuliana River, Kofar Village, Minyamur District; Digul River, Isyaman Village, Edera District and Kok II River, Wagin Village, Nambioman Bapai District. Implementation is carried out in the riverside area to far into the middle of the river by using a speedboat. This is done to obtain a wider distribution of data so that it is hoped that a more comprehensive picture of the water quality in these locations can be obtained. In addition, field implementation also carried out on water treatment facilities and public wells in Kepi Village, Obaa District.

Both Measurements carried out in the morning and evening to obtain an overview of the dynamics of water quality conditions.

Figure 10. Field Implementation In River and Public Well

Source: Personal Documentation, 2021

4. CONCLUSION

Design and build of a prototype of water quality physics measuring equipment based on microcontroller has been successfully carried out. The sensors used in this prototype are limited to measuring key parameters such as temperature, pH, Dissolved Oxygen (DO) and Electrical Conductivity (EC). The data produced by the prototype is already in the form of digital data stored in the SD card and in the form of spreadsheet files. This of course will facilitate the process of documenting and processing data carried out by researchers so that in the end conclusions regarding the measured water quality can be done in real time.

Other sensors can be added, such as a real time clock (RTC) module to record water quality measurement times, global positioning system (GPS) module to record and determine the location of water quality measurements and the addition of various other available water quality measurement sensors so that the resulting data can be more comprehensive. In addition, to perfect the prototype, energy sources can be added in the form of solar panels and charge controllers.

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