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Water Quality Monitoring System Using Raspberry Pi

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ABSTRACT

Water monitoring system is a system than monitor the condition of water. This system monitors the water on several condition. The condition monitored by this system is turbidity value, total dissolved solid value and pH value. For turbidity, the higher the reading from the sensor, the higher the turbidity of the water. For pH value, if the value of the reading is more than 7, the water is in alkaline condition. If the value of reading is less than 7, the water is in acidic condition. In this project, this system is using Raspberry Pi 3 model B+ as its main controller. Several sensors are used such as turbidity sensor, total dissolved solid sensor and pH sensor. The reading from the sensor is then send to Raspberry Pi and the sensor value is send to the other devices through built-in Wi-Fi of Raspberry Pi.

Keywords: Raspberry Pi, pH sensor, Turbidity sensor, TDS sensor, Temperature sensor, Water quality monitoring.

1. INTRODUCTION

Soil, water, atmosphere, natural vegetation, and landforms are among the five main elements that make up the ecosystem. Water is the most important factor for human survival among these. Other living habitats depend on it as well. Clean and readily available water is important for public health, whether it is used for bathing, household use, food processing, or leisure activities. As a result, maintaining water quality equilibrium is extremely important to us. Otherwise, it will be harmful to human wellbeing while still disrupting the natural equilibrium of other species. According to records, more than 14,000 people die every day as a result of water contamination around the world [1].

The traditional method of water quality control entails manually collecting water from various locations and testing it in a laboratory. This method takes a long time and heavy cost. Although the latest methodologies have several disadvantages, including laborious, lack of real-time water quality information, inadequate spatial coverage and lack of a controlling device to regulate the flow of water in the pipeline for secure drinking water supply. For source water surveillance and water plant service, online water management systems have made considerable progress[2].

Water is the essential requirement for living which should be checked progressively. Water impacts life on earth directly, it turned out to be essential to verify if the water is in good condition to be used[3].The system, which consists of numerous sensors, is used to measure water's physical and chemical properties. Temperature, PH, turbidity, conductivity, and dissolved oxygen in the water may all be monitored. The core controller can process the sensor data. As a core controller, the raspberry PI B+ model can be utilized. Finally, utilizing cloud computing, the sensor data may be accessed via the internet[4].

The development was preceded by an assessment of the current environment, which included

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the availability of cellular network coverage at the operating site. A Raspberry Pi, an Analog to Digital Converter, and water quality measuring sensors make up the system. It monitors water temperature, dissolved oxygen, pH, and electrical conductivity in real time and distributes the data to key stakeholders in graphical and tabular representations via a web-based portal and mobile phone platforms[5]. Commonly, chemical parameters have two main factors, that is pH and biochemical oxygen demand (BOD). The last is bacterial parameters that has four common parameters like total Bacteria, E.coli, Salmonella sp, and Coliform[6].

The paper would be organized first defines the structural design of the water quality monitoring system, then it will describe the hardware and software of the data monitoring nodes, and finally it will explain the design of the hardware and software of the system's data base. The project's conclusion is drawn in the final section.

2. METHODOLOGY

2.1 Flowchart

The flowchart in Figure 1 is a flowchart representation of the whole Water Quality Monitoring System Using Raspberry Pi processes. From start to finish, a flowchart uses symbols and phrases to clearly explain a process. The software will begin with the Raspberry Pi 3 B+ being initialized, followed by an analysis of the water's temperature, pH, turbidity, and total dissolved solids. The measurements of temperature, pH, turbidity, and total dissolved solids were taken. Moreover, the collected data between Raspberry Pi 3 B+ and sensors was sent to LCD.

The four parameters listed above can be monitored at any moment by the user. If the turbidity value exceeds a certain threshold, an alert notification will be sent to the Blynk application. If the turbidity value still remains below 25 and total dissolved solid value more than 300 ppm another alert notification will be sent from the Blynk application allowing the user to give an alert. Finally, the process ends. Figure 3.3 shown the full picture of the project.

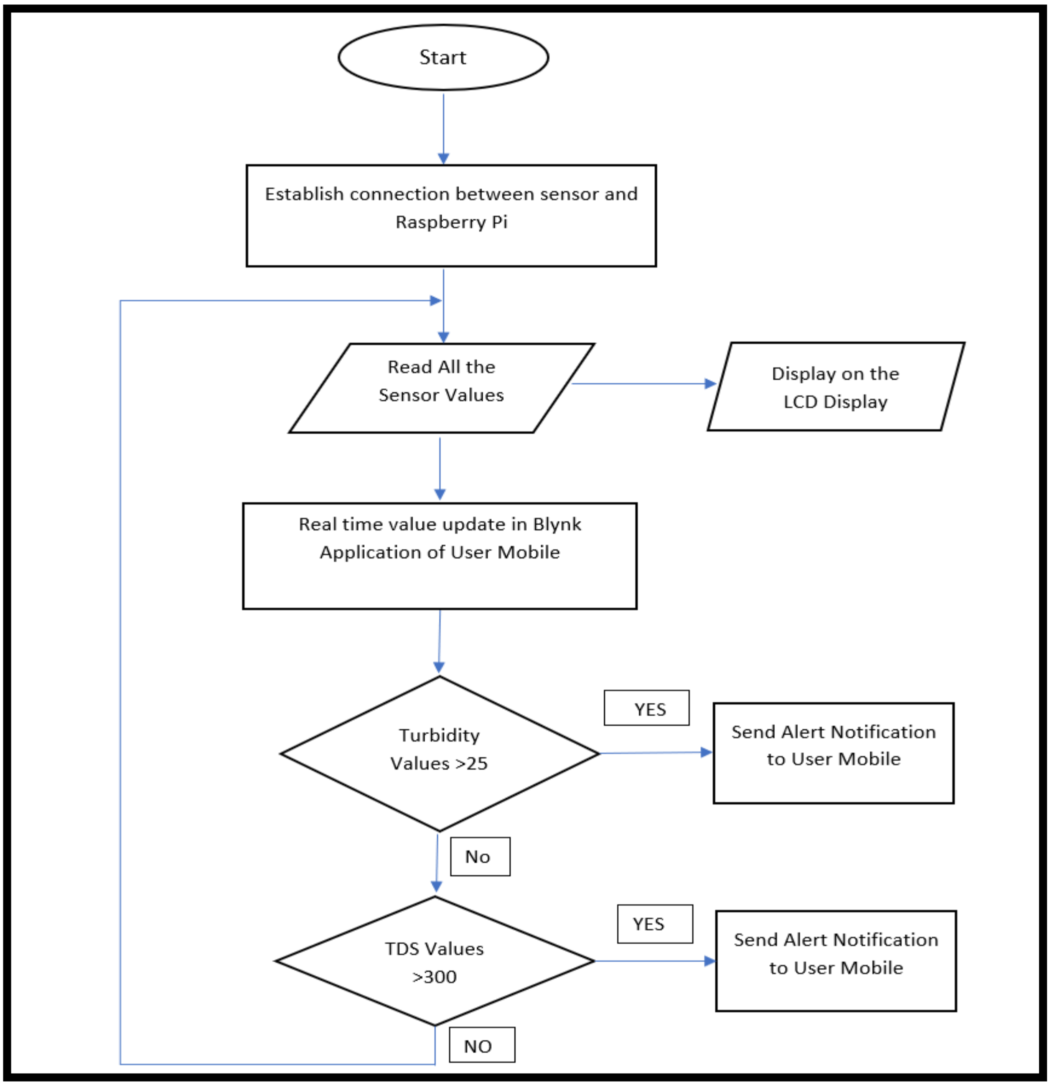

Figure 1. Flow chart of water quality monitoring system.

2.2 Hardware

In this section discussed about the microprocessor, sensor and components used to achieve the water quality monitoring system. The further explanation of this hardware can be found below.

2.2.1 Raspberry Pi 3 Model B+

It is considered as heart of this architecture. Raspberry pi is a low cost, small computer board with Linux as operating system. It has several advantages when compared to other micro-controllers such as inbuilt Wi-Fi module. The Program for collecting the sensor data is written in python language and sends that data to the cloud database.

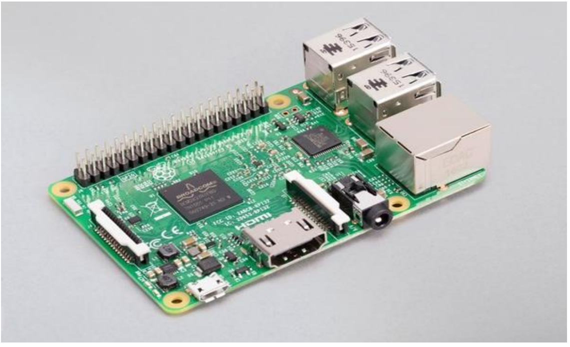

Figure 2. Raspberry Pi 3 Model B+.

2.2.2 Analog to Digital Converter (ADS1115)

Analog-to-digital converters (ADCs) are precision, low-power, 16-bit, I2C-compatible ADCs available in an ultra-small, leadless X2QFN-10 packaging and a VSSOP-10 package. A low-drift voltage reference and an oscillator are included in the ADS111x devices. A programmable gain amplifier (PGA) and a digital comparator are also included in the ADS1114 and ADS1115. These qualities, together with a wide working supply range, make the ADS111x ideal for sensor measurement applications that are power and space constrained.

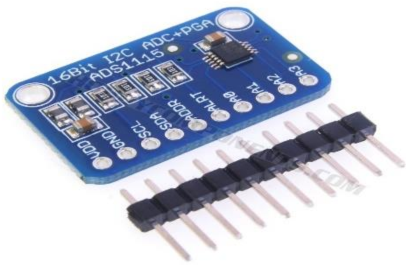

Figure 3. ADS1115.

2.2.3 Temperature Sensor

The temperature of water signifies how hot or cold it is. The DS18B20 temperature sensor has a temperature range of -55 to +125 °C. This temperature sensor is a digital model that provides precise readings [7].

Figure 4. Temperature Sensor.

2.2.4 pH Sensor

The acidity or alkalinity of a solution is measured by the pH of that solution. The pH scale is a measurement unit with a range of 0 to 14, with 7 as the neutral point. A basic or alkaline solution has a value greater than 7, while an acidic solution has a value less than 7. It is powered by a 5V battery. pH levels should be between 6 and 8.5 [2].

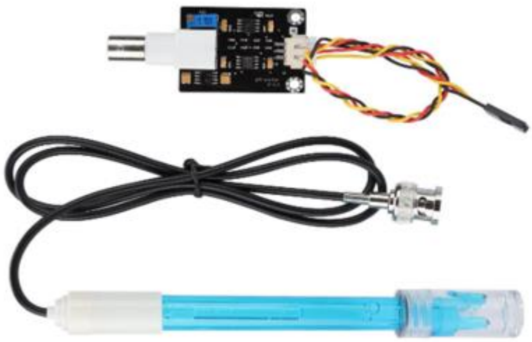

Figure 5. pH Sensor.

2.2.5 Turbidity Sensor

The cloudiness of water is measured by turbidity. The degree to which water loses its transparency is reflected by turbidity. It's thought to be a reliable indicator of water quality. Turbidity prevents buried aquatic vegetation from getting enough light. Since suspended particles at the surface aid in the absorption of heat from sunlight, it can also raise surface water temperatures above usual[3].

Figure 6. Turbidity Sensor.

2.2.6 Total Dissolved Solid

The number of milli grammes of soluble particles dissolved in one litre of water is referred to as TDS (Total Dissolved Solids). The more soluble materials dissolved in water, the lower the TDS value, and the less pure the water is in general. As a result, the TDS value can be utilized as a single point of reference for evaluating the purity of the water. This can be used to test and monitor water quality in a variety of settings, including residential water, hydroponics, and other industries[3].

Figure 7. Turbidity Sensor.

2.2.7 Liquid Crystal Display

This LCD display module is a high-quality two line of 16 characters Display with on-board contrast control, backlight, and an I2C communication interface with an I2C interface. For Arduino beginners, a sophisticated LCD driver circuit connection is unnecessary. The true advantages of this I2C Serial LCD module are that it reduces circuit connections, saves some I/O pins on the Arduino board, and reduces firmware programming with the widely accessible Arduino library [8].

Figure 8. Liquid Crystal Display 16x2.

2.3 Software

Raspberry Pi OS with desktop, Balena etcher, VNC viewer, and Blynk Application are among the software used in this project. The further explanation of this software can be found below.

2.3.1 Raspberry Pi OS with Desktop

This is the software's "basic GUI" version. It includes the Pixel desktop graphical user interface, as well as some standard Linux software, utilities, and program like a web browser (Chromium), VLC media player, text editor, terminal emulator, and so on, but none of the Raspberry Pi-specific instructional or programming tools. Even if you've installed it, you may use the "Recommended Software" program (or the apt package manager) to install only the utilities and apps you need. So, the download image is about 1.2GB and the installed image is about 4GB, you'll need at least an 8GB SD card [9].

Figure 9. Raspberry Pi OS with Desktop*.*

2.3.2 Balena Etcher

BalenaEtcher is a free and open-source tool for writing image files such as.iso and.img files, as well as zipped folders, to storage media to create live SD cards and USB flash drives. Balena produced it, and it's licensed under the Apache License 2.0.

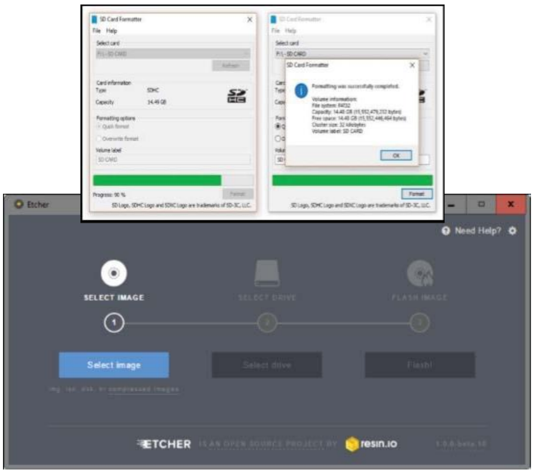

Figure 10. Balena Etcher

2.3.3 VNC Viewer

VNC Viewer is used to control local computers as well as mobile devices. A device with VNC Viewer software installed, such as a computer, tablet, or smart phone, can connect to and control a computer in another location. It is a graphical desktop sharing system that allows you to remotely control the desktop of a remote computer (running VNC Server) from your device, and it sends keyboard and mouse or touch events to VNC Server so that once connected, you have control over the computer you've accessed. If you use your mobile phone, for example, you can use the computer you've remotely accessed as if you were sitting right in front of it[10].

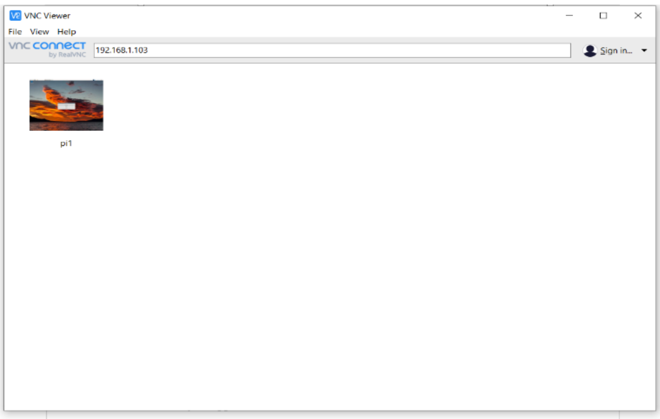

Figure 11. VNC viewer.

2.4 Water Quality Parameter

The parameters employed by our system to measure water quality are listed in Table 1. It shows the range of each sensor and its unit to display them when it being tested. It is important to know the threshold of each sensor to determine the water quality. It determines the potability of water by measuring four qualitative factors. pH, temperature, turbidity, and total dissolved solid are the characteristics that this system considers. As stated in Table 3.1, these parameter values are compared to standard permissible limits for drinking water [11].

Table1 Parameter of Monopole Antenna Design (Copper and Aluminum).

Sensor	Standard Value Range
Temperature	21-30℃
pH	6.5-8.5
Turbidity	6-10 NTU
Total Dissolved Solid	50-150 PPM

3. RESULTS AND DISCUSSION

The prototype is put to the test in two scenarios. One is the clean water test setting, in which a known tap water sample is examined for its properties in order to ensure that the prototype is functioning properly. Dirty water testing, in which the water sample examined is a natural water body known as pond water.

3.1 Clean Water Testing

The water sample used in the experiment was tap water. The sensor placed in the water sample collected in the tank, while the interface, processor and transmission module were kept on the ground. The water proof sensors temperature, pH and total dissolved solid sensor directly placed in the tank filled with tap water. While the turbidity sensor placed on plastic cover to avoid damage of the sensor. Putty was used to create a data transmission SSH server client link between the transmitter and receiver, which were both connected to the same Wi-Fi network. In real-time monitoring, the Blynk application was created to monitor water quality without the need for a common Wi-Fi network and the ability to observe it from afar. Figure 12 shows the clean water testing prototype.

Figure 12. Clean Water Testing Prototype.

Table 2 Output Data from Clean Water Testing**.**

Duration(min)	Temperature (℃)	pH	Turbidity	TDS
2	29.38	7.02	8.5	133.59
4	28.92	7.04	10.2	135.68
6	28.72	7.05	10.7	136.11
8	28.50	7.07	11.5	136.72
10	28.30	7.1	11.9	137.23

Table 4.1 contains the results of the indoor test. With such a pH of 7.1, the water is fit for drinking, agriculture, and aquatic requirements. Furthermore, the turbidity ranges between 8.5 and 11.9 NTU, indicating that it is suitable for agricultural and aquatic use. The total dissolved solid sensor reads 137.23ppm, indicating that the amount of total dissolved solid is low and safe to drink, farm, and swim in. Finally, the temperature is 28°C, which means that drinking, farming, and aquatic activities are all safe.

3.2 Dirty Water Testing

The experiment employed pond water as a water sample. The sample was taken at a nearby pond, which was chosen as the location for dirty water testing. The sensor placed in the water sample collected in the tank, while the interface, processor and transmission module were kept on the ground. The water proof sensors temperature, pH and total dissolved solid sensor directly placed in the tank filled with pond water. While the turbidity sensor placed on plastic cover to avoid damage of the sensor. Putty was used to create a data transmission SSH server client link between the transmitter to the receiver, which were both linked to same Wi-Fi network. In real-time monitoring, the Blynk application was created to monitor water quality without the need for a common Wi-Fi network and the ability to observe it from afar**.** Then will receive an alert notification for the dirty water in the smartphone**.** Figure 13 shows the dirty water testing prototype and figure 14 shows the alert notification in blynk application.

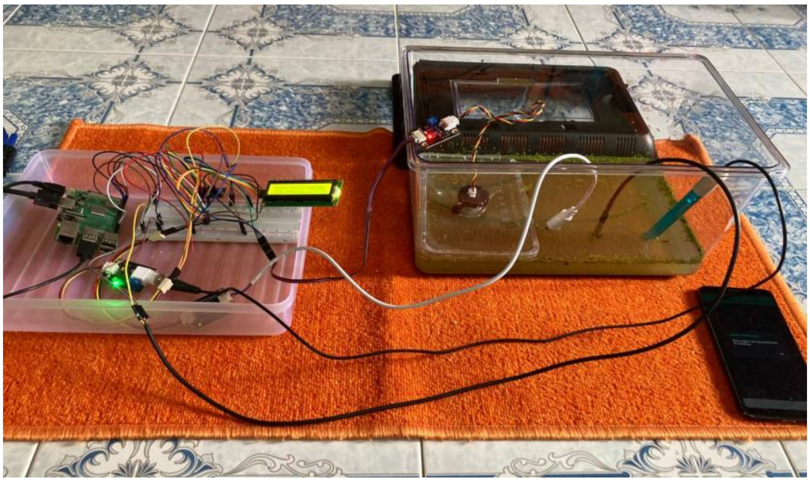

Figure 13. Dirty Water Testing Prototype.

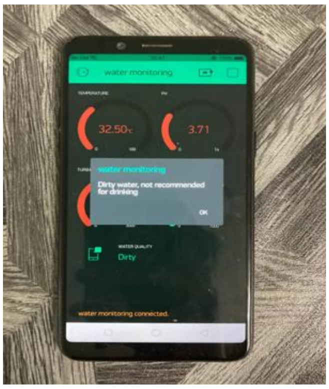

Figure 14. Alert Notification in Blynk Application.

Table 3 Output Data from Dirty Water Testing.

Duration(min)	Temperature (℃)	pH	Turbidity	TDS
2	30.88	6.41	1025.25	652.31
4	30.73	6.33	1028.86	649.69
6	30.52	6.38	1032.81	648.84
8	30.42	6.48	1034.80	648.25
10	30.18	6.49	1035.05	647.78

Table 4.2 shows the results of the dirty water test. With a pH of 6.49, the water was found to be mildly acidic, making it unsafe for drinking or agricultural usage. The majority of fish and planktons prefer neutral or slightly basic conditions, whereas few aquatic creatures can survive in this acidic environment. The water has a turbidity level of 1025.25 to 1035.05 NTU, suggesting that it is murky and unsafe for drinking. The water has become green due to an abundance of algae and planktons. Because to the excessive turbidity, underneath plants have a difficult time obtaining sunlight and carrying out photosynthesis. The amount of total dissolved solids measured is 647.78 ppm, suggesting that the amount of total dissolved solids is too high to consume. It is, however, suitable for agricultural use as well as aquatic life. Finally, the water temperature is around 30°C, but it varies depending on the activities in the pool and the surrounding temperature.

3.3 Comparison between Clean and Dirty Water

In this section, discussed more about each sensor analysis on clean and dirty water. The water quality parameters show some differences in both of selected solution. Clean water was tested using tap water, and dirty water was tested using water from a nearby pond. It depicts some significant and slight changes in each of the experiment's sensors. The comparison between clean and dirty water clearly explained below.

3.3.1 pH Sensor Analysis

Tap water and pond water were used to demonstrate the differences in pH levels. Pond water has a rating of less than 7, but tap water has a grade of around 7. The experiment lasted 10 minutes, with readings delayed by 2 minutes. The graph below shows the pH measurements of tap water and pond water. With a pH of around 7, tap water is nearly neutral. It also maintains a constant value for a period of 10 minutes. Pond water has a pH value of less than 7. The presence of live creatures in pond water affects the pH of the pond water.

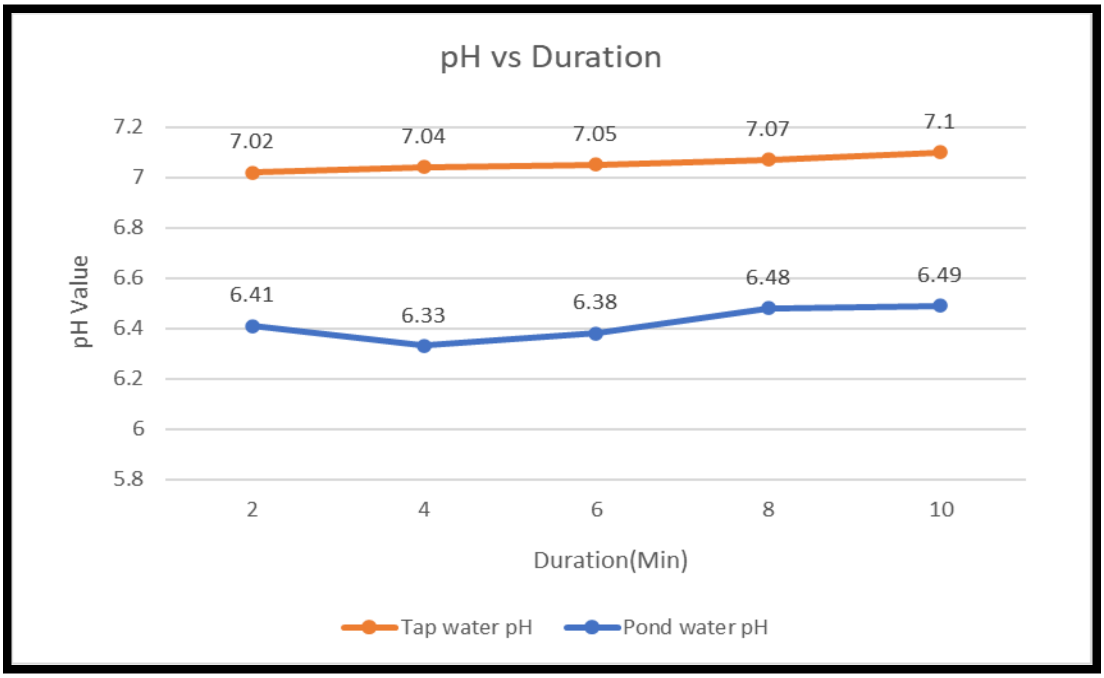

Figure 15. Water PH Graph.

3.3.2 Turbidity Sensor Analysis

The differences in turbidity levels between tap water and pond water were demonstrated. The turbidity of pond water ranges from 1025 to 1035 NTU, whereas tap water is roughly 8 to 12 NTU. The experiment lasted 10 minutes, and the readings were 2 minutes past time frame. The graph below shows the turbidity readings of tap water and pond water. Because tap water has a turbidity of around 12 NTU, it is safe to drink. It also keeps the NTU below 25, indicating clear water indication for 10 minutes. The turbidity of pond water is 1035 NTU. The presence of a high concentration of silt and clay particles, which turn the water a light brown colour and increase turbidity of the pond water.

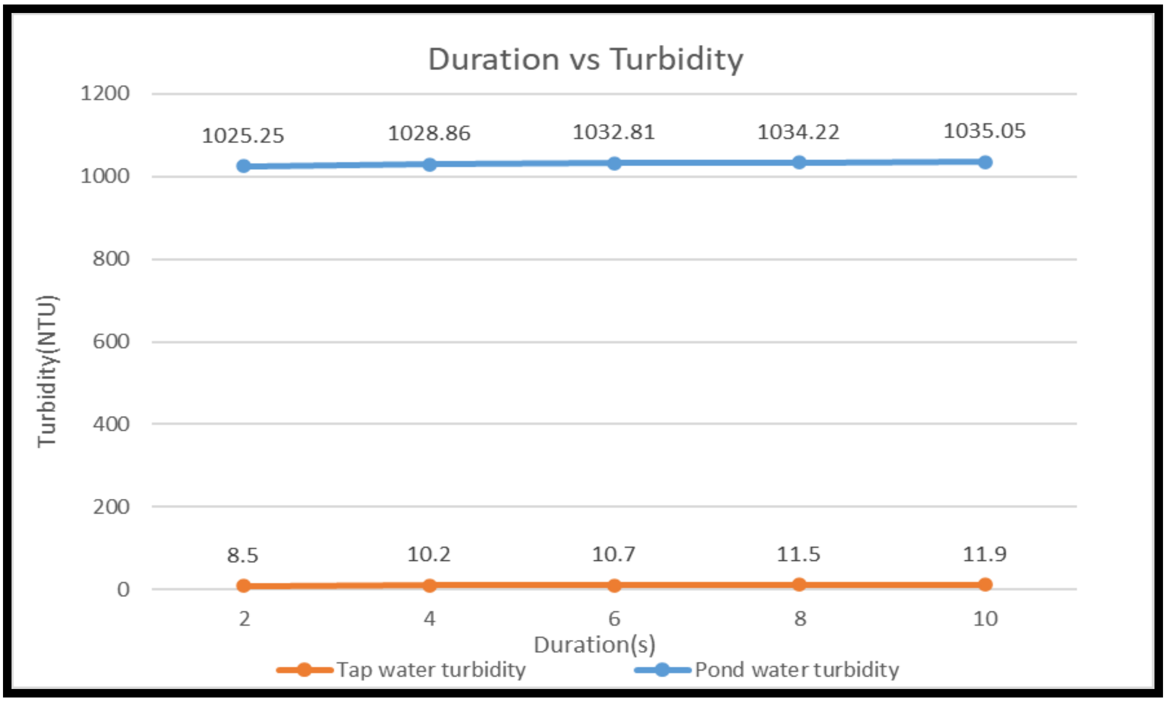

Figure 16. Water Turbidity Graph.

3.3.3 Turbidity Sensor Analysis

The differences between tap water and pond water in terms of total dissolved solids were demonstrated. Pond water has total dissolved solid content of 653 to 647 parts per million, whereas tap water has a total dissolved solid content of 133 to 137 parts per million. The experiment lasted 10 minutes, with readings delayed by 2 minutes. Total dissolved solids measurements from tap water and pond water are shown in the graph below. In tap water, the total dissolved solid level is roughly 137 ppm, showing that the dissolved solid level is low. In pond water, there are 647 parts per million of total dissolved solids (ppm). The pond water contains salts, minerals, and contaminants. TDS levels rise over time as these chemicals get more concentrated in the pond water.

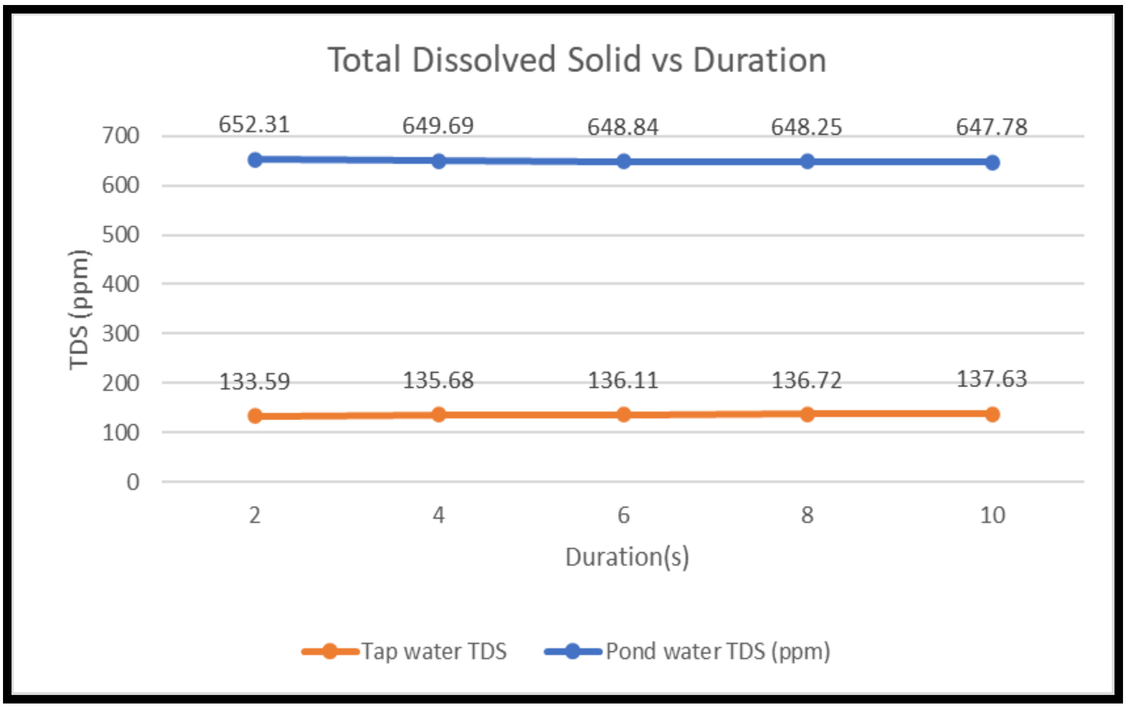

Figure 17. Water Total Dissolved Solid Graph.

3.3.4 Temperature Sensor Analysis

The temperature analysis was done with tap water and pond water, which are two different sorts of solutions. Water from a tap originates from an inside source that is protected from direct sunlight, whereas water from a pond was exposed to direct sunlight before being sampled. The readings are obtained every 2 minutes for a total of 10 minutes. The graph below demonstrates that tap water is substantially colder than pond water. In comparison of tap water with pond water, pond water temperature is higher. It is because the direct sunlight before the water sample was taken affects the temperature readings, pond water fluctuates more. Figure 4.9 shows that pond water has the higher temperature when comparing with tap water.

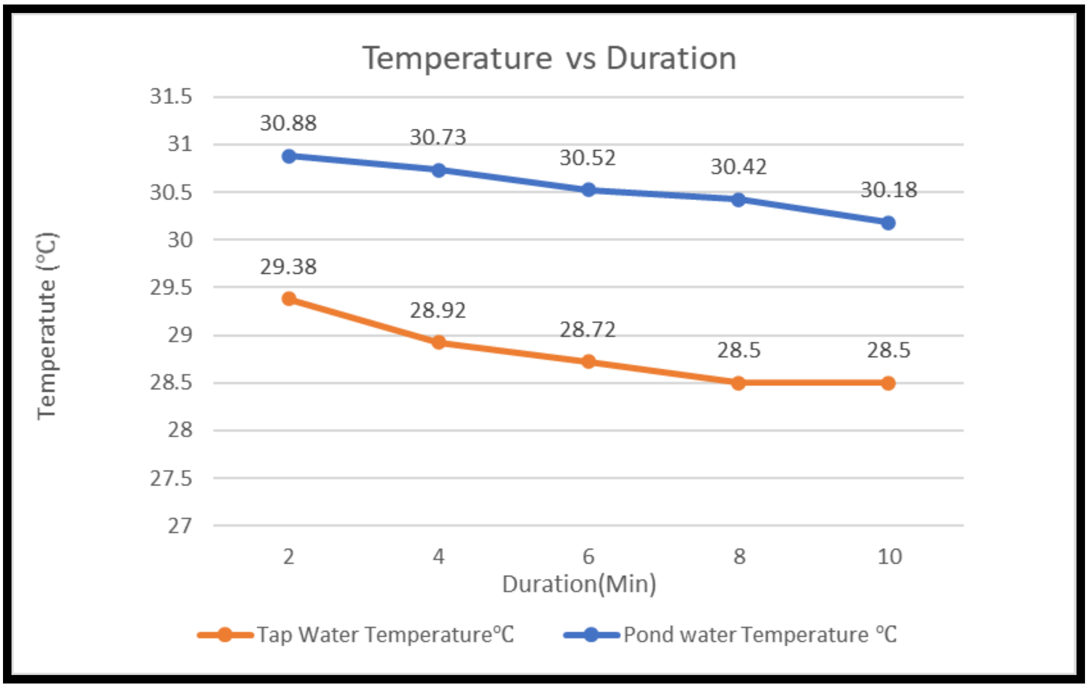

Figure 18. Water Temperature Graph.

3.3.4 Temperature Sensor Analysis Day and Night Time

Clean water and dirty water were used to create the temperature analysis. Both types of water filled in the container and placed in direct sunlight from morning to night. For a total of 14 hours, the readings are taken every two hours. At 10 a.m., the analysis began. Clean water is substantially colder than dirty water, as shown in the graph below. When compared to dirty water, clean water loses a greater amount of heat. Temperature readings are affected by the sun as well, and dirty water changes significantly. High temperatures were observed at the 4th and 6th hour when the sun was at its peak, as shown in Figure 4.10. As the sun sets later in the evening, the sensor, on the other hand, senses a dip in temperature. In general, dirty water able to detect more temperature than clean water.

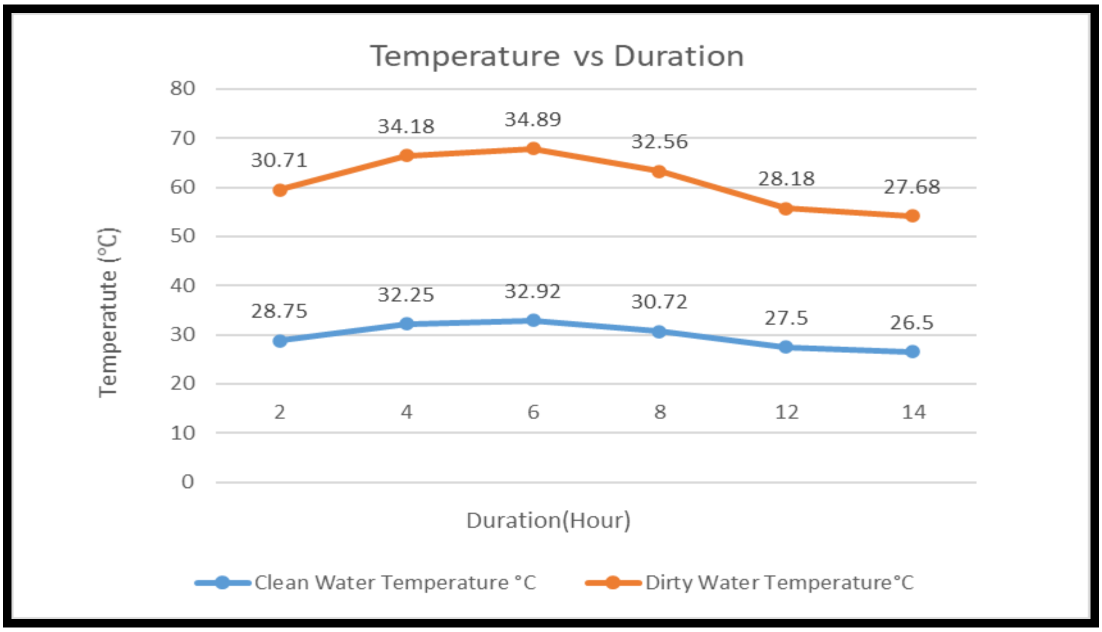

Figure 19. Water Temperature Graph during Day and Night Time.

4. CONCLUSION

The water quality monitoring system using raspberry pi has been designed effectively. The monitoring system can be set up and used to keep track on water quality. Despite the fact that the water quality monitoring system technique is simple, it can make the process easier than manual techniques. As a result, the system would aid authorities in assessing the state of the water in their immediate surroundings, such as the river and lake. The current implementation of water resource management and proper use is both cost-effective and beneficial to society. The technology can be expanded in the future to a cloud-based server in smart cities for sustainable water use, as well as to expand water samples and practical deployment in university residential areas.

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