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Automatic System of Monitoring Water Quality

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Abstract

The goal of this work is to devlop an automatic system of monitoring the quality of drinking water distributed to consumers. Turbidity is considered as a most feature measure of the water quality. Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Therefore, automatically assessment of the quality of a water body, whether surface water or groundwater, can help us answer questions about whether the water is acceptable for drinking, bathing, or irrigation without collect samples manually and send them to laboratory for checking and analyzing. For this purpose, we use IoT technology to deliver analysis of drinking water quality in real time. This technology can transfer wirelessly the data obtained by digitizing the data of the object or the domain of the adapter that it is adapting to the server.

Keywords: *Drinking Water, Automatic monitoring, Turbidity Water Sensor, Water Quality.*

1. Introduction

As we all know, water has many uses, such as for recreation, drinking, fisheries, agriculture and industry. Each of these designated uses has different defined chemical, physical and biological standards necessary to support that use. Water borne diseases are numerous and they resulted from consumption of contaminated water. Some of the causes of this problem are poverty, negligence and corruption that often robe these nations of the necessary resources to combat these maladies. It is quite a challenge to eradicate water borne diseases.

Water Quality can be defined as the chemical, physical and biological parameters of water. To determine water quality, it requires the measurement and analysis of specific characteristics; which include such parameters as temperature, dissolved mineral content, and bacteria. These characteristics are often compared with standards set by regulatory agencies to determine if the water is suitable for a particular use. Some water quality parameters can be determined "in-situ". These include temperature, pH, dissolved oxygen, conductivity, and turbidity (Shankar, 2011).

Water Quality Standards (WQS) are provisions of state, territorial, authorized tribal or federal law approved by EPA that describe the desired condition of a water body and the means by which that condition will be protected or achieved. According to all of the above, we can say that standards are the value that water quality standards take to be suitable for specific use. We provide that the turbidity in water adversely affects its flora and fauna and makes the water unsuitable for drinking and other uses. It is measured in nephelometric turbidity units (NTU) (Eroglu, 2001).

Water quality standards are put in place to ensure the efficient use of water for a designated purpose. Water quality analysis is to measure the required parameters of water, following standard methods, to check whether they are in accordance with the standard. Water quality analysis is required mainly for monitoring purpose. Some importance of such assessment includes:

- To check whether the water quality is in- compliance with the standards, and hence, suitable or not for the designated use.
- To monitor the efficiency of a system, working for water quality maintenance.
- To check whether upgradation / change of an existing system is required and to decide what changes should take place.
- To monitor whether water quality is in- compliance with rules and regulations.

The traditional method of water quality monitoring faces many problems such as wasting a lot of human energy and material resources, restricting sample collection and long time analysis. To avoid all that, we use in this work IoT technology to analysis of drinking water quality in real time.

IoT refers to an Internet of Things. Connecting any device (including everything from cell phones, vehicles, home appliances and other wearable embedded with sensors and actuators) with Internet so that these objects can exchange data with each other on a network (Mirocha, 2015).

Existing scientific developments have enabled new technological approaches to emerge such as, the IoT technology. Where a server or interconnected objects can be controlled remotely by the user via the Internet (Perumal, 2015).

2. Motivations and Contributions

Water pollution has been an increasing problem over the last few years. Water personal satisfaction may be a standout amongst those primary variables with control well being and the state for sicknesses. For insctane, after the cholera epidemic in Algeria (Exactly in Blida 2018), the victims inquiring how to build a cheap device to ensure the quality of drinking water.

The WHO (World Health Organization) has set up programs in some one third world nation aimed at providing clean and sanitary water. Clean water is essential for life. But, one in eight of the world’s population does not have access to it. The lack of clean water close to people’s homes also affects people’s time livelihood and quality of life.

There are many different diseases that can be caught from dirty water (Eroglu, 2001). Like is showing in Figure 1, water quality parameters are divided into several types of parameters (physical, chemical, biological, ...):

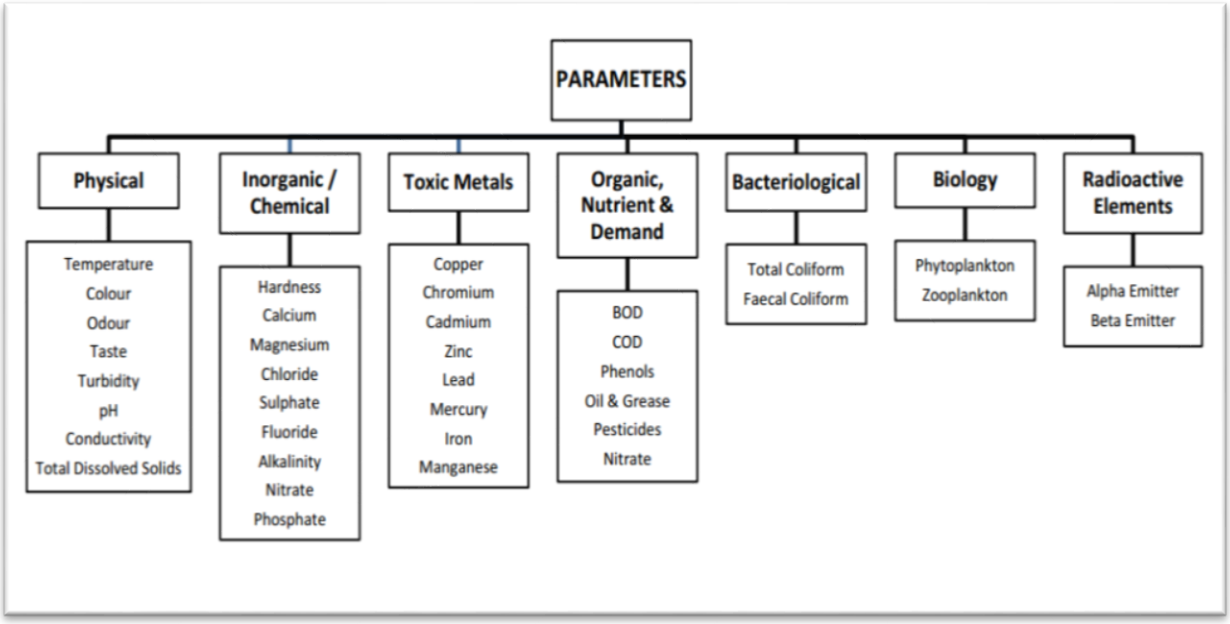

Figure 1: Water Quality Parameters (Eroglu, 2001)

For this purposes, we thought the design of a simple monitoring system capable of analyzing a water. The objective of this system is to find the quality of the water and sending alarm message to the corresponding authorities or to consumers. We implement this project at home drinking water reservoir. For that, we are using Raspberry board for finding turbidity value sensor. Then, we use a web application to have display the observations on water parameters. Finally, the user gets a notification about water.

3. Related Works

In the traditional water quality monitoring system, different instruments been used to monitor the quality of water which include “Secchi disks (measure water clarity), probes, nets, gauges, meters”, etc. The traditional method is just not enough to measure water quality and identify any drastic changes in it. This method not only impedes accurate water quality measurement but also at times fails to predict sudden changes in the water system. Hence, information is also derived from satellite and aerial photographs by observing the surrounding environment and the changes in specific parameters such as flow of water, color in large overview, direction of water flow etc. There are three major steps to execute traditional water quality monitoring. The major three steps are as follows:

Water Sampling, water samples collected in large mass using various tools. These water samples are then examined in the laboratories. Water sampling and analysis are only performed by ISO-certified laboratories. Unreliable results enhance issues concerning pollution when a corrective response cannot be performed within time. Sampling and monitoring tests can be conducted by expert technicians. Further to sampling, testing is carried out. Testing procedures and parameters have been classified into "Physical, Chemical, bacteriological and microscopic" categories:

- **Physical tests:** these indicate properties that are detectable by the senses. They include Color, turbidity, total solids, dissolved solids, suspended solids, odor and taste.
- **Chemical tests:** these tests determine the parameters in water like "pH, hardness, presence of a selected group of chemical parameters; biocides, highly toxic chemicals, and B.O.D".
- **Bacteriological tests:** it shows the presence of bacteria, a characteristic of faecal pollution. These tests examine to identify the presence of microbial pathogen in the water that might occur with contamination. The presence of such organisms indicates the presence of faecal material and thus of intestinal pathogens.

Finally, the tested water samples are then thoroughly monitored and observed by an expert technician who can read through the lines of the resulted report. They then make an investigative analysis with a parallel consideration of the historical records of the previous water tests. Any similarity of the currently extracted results to the previous records will give way to an intense deliberation for prediction of any unknown changes or hazards to the water quality (Ramdani, 2012).

There are various studies of water quality monitoring system such discussed in (Vermesan, 2014), (Geetha, 2016) and (Geneva 2011). The studies in (Vermesan, 2014), the author proposed that an IoT based water monitoring system that measures water level in real-time. The model is based on idea that the water level can be very important parameter when it comes to the flood occurrences especially in disaster prone areas. However, the authors in (Geetha, 2016) aim to develop a wireless water quality monitoring system that aids in ontinuous measurements of water conditions based on pH and turbidity measurements. In (Geneva 2011), the author proposed an Internet of Things application in management smart homes (water analysis includes) but it lacks intelligence on decision making.

In addition, the authors in (Chowdury 2019) proposed system will immensely help Bangladeshi populations to become conscious against contaminated water and to stop polluting the water. (Chilamkurti, 2009) proposed a system for collected, processed and measured data from sensors, and directed through ZigBee gateway to the web server through WiMAX network to monitor quality of water from large distances in real time. Nevertheless, (Vijayakumar, 2015) designed a low cost system design for real time water quality monitoring in IoT utilizes sensors to check many important physical and chemical parameters of water. The Table 1 summarizing the strengths and weaknesses of our proposal solution according to existing solutions:

Table 1: Comparative between proposal solution and existing solutions.

Features	**Traditions Solutions**	**Proposed Solution**
Time	After collecting samples	Real time
Place	At the laboratory	Anywhere
Accuracy and effectiveness	Not enough	Sufficiently
Decision making	Sometimes fails	Intelligent
Energy	Wasting	Conserving
Needs	Human energy and material resources	Automatically
User	Expert technician	Amateur
Runnig time	Long time	Continuously

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4. Experimental materiel and techniques

For propose a system that performs water quality monitoring and regulated water supply operation. We use a sensor of turbidity to analyze after an anomaly the water purity in order to send the alert message to the consumer. Using the standard internet protocol, this technology can transfer wirelessly the data obtained by digitizing the data of the object or the domain of the adapter that it is adapting to the server.

4.1. Hardware Description

All the experiments performed on a ProBook Pro laptop with 2.10GHz Intel Core (i3) processor and 4 GO RAM. Howevet, The material used for the realization our system are following:

1. Raspberry Pi 3 Model B: is a wonderful platform that can be used to build automation systems. It is perfect to connecting to other open-source hardware parts like sensors.
2. Turbidity Meter: Turbidity is an internationally recognized criterion for assessing drinking water quality. It most commonly quantified by the Nephelometric Turbidity Unit (NTU). Our turbidity meter is an optoelectronic instrument that assesses turbidity by measuring the scattering of light passing through a water sample containing colloidal particles that harbor pathogens. Nephelometry refers to the process of aiming a beam of light at a sample of liquid and measuring the intensity of light scattered at 90° to the beam (Ritabrata, 2012).

For measuring turbidity, we will use two components; an LDR (Light Dependent Resistor) or photoresistor; which will change it resistance based on the light around it. This property helps the LDR to be used as a Light Sensor (Kumar 2017). We will use also Laser Transmitter Module as light resource (See Figure 2).

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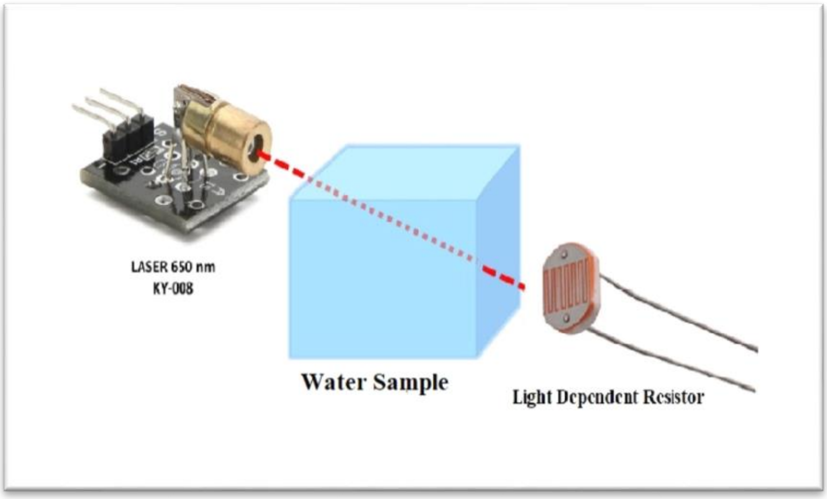

Figure 2: Principle of Turbidity Meter

Really, a Turbidity Meter holds one light source that directed through a water sample, a chamber to hold the water sample, and one or more photodetectors placed around the chamber. This meter only monitors light scattered by particles suspended in water to generate an output voltage proportional to turbidity or suspended solids. It operates on the principle that when light passed through a sample of water, the amount of light transmitted through the sample is dependent on the amount of suspended particles in the water. As the amount of total suspended solids increases, the amount of transmitted light decreases. The rest of the electronics in the system circuitry then measures the amount of transmitted light to determine the turbidity.

3. Analog to Digital Converter ADS1115[2]: the ADS1115 are great analog to digital converters that are easy to use with the Raspberry Pi using its I2C communication bus (See Figure 3).

[2] https://pdf1.alldatasheet.fr/datasheet-pdf/view/881974/TI1/ADS1115.html

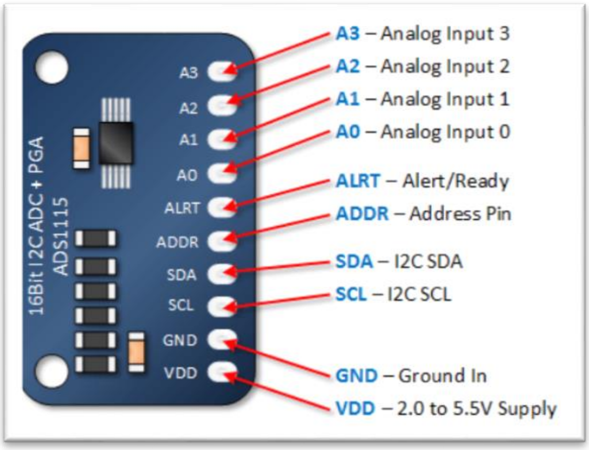

Figure 3: Analog To Digital Converter (ADS1115)

4.2. Software Description

During the implementation of our project, we needed different kind of Programing Languages:

1. Raspberry Pi3 Model B and the Web server code are written in Python languge.
2. Use SQLite database as containers to transfer rich content between systems and as a long-term archival format for data.
3. The web server is implemented using HTML and SQLite.
4. The mobile application requires both Java and XML laguages.
5. We used Pycharm for the implementation of our web server .
6. We used Android Studio to develop our mobile application.
7. We need to add FCM service to our mobile application after login to Firebase using an email and create a new project. In Client Side case, takes as parameters both of message title and message body. Then, we will generate our notifications as a result of a received FCM message. However, in Server Side case, we use Raspberry as server because it handles a short time than web server machine.

4.3. System Architecture and Operations

Our automated drinking water analysis system is a process that detects water pollution, it is done without human intervention and is repetitive. This system performs a number of actions called tasks or operations. The overall block conceptuelle of the proposed system is as shown in Figure 4. This proposed architect

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consiste a real-time networks and it includes with field sensor of measurement and control devices, as well as software and services. The data collected from all devices are gathered and sent to the Raspberry pi 3 model B.

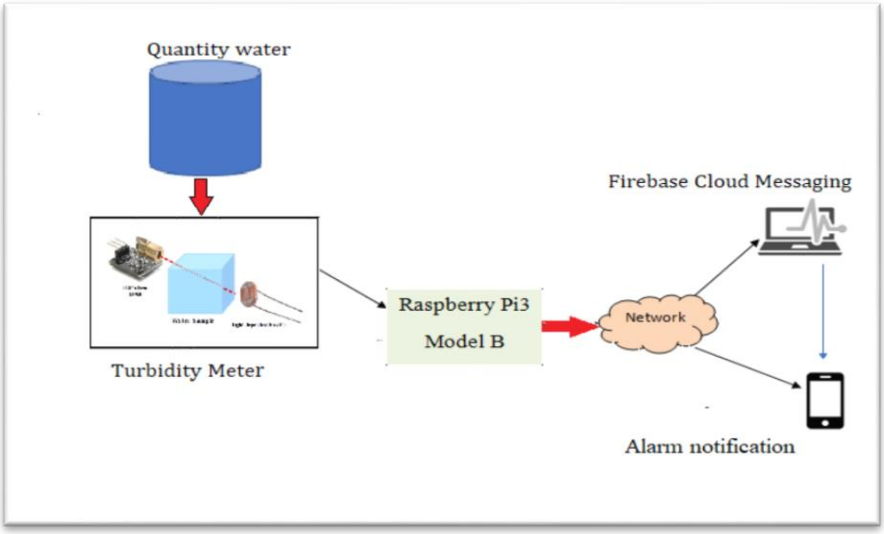

Figure 4: General System Architecture

The operations of the water analysis at the level of the reservoir. To achieve the tasks of management the technical means are presented in Figure 5:

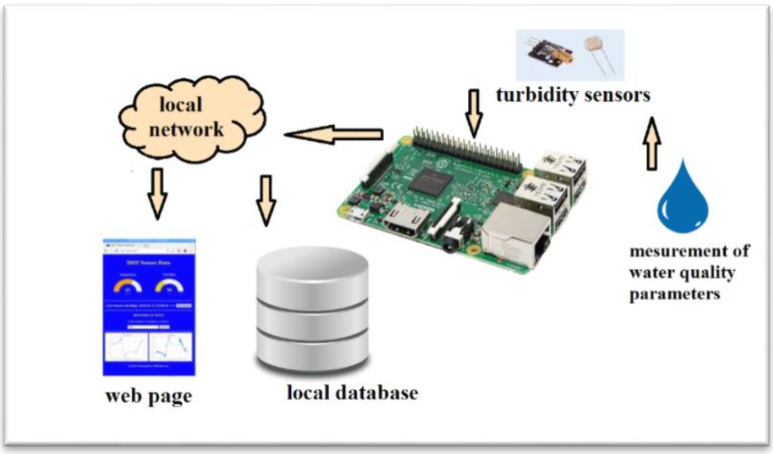

Figure 5: System Operations

The treatment of notifications are managed automatically by our system so as to improve the quality of drinking water:

1. Reading turbidity value sensor data: we will use specific sensor to measure turbidity . This sensor is connected to Raspberry which can read only digital signals that refers to different values according to sensor.
2. Sending sensor data to web server: in this part, we will host a server on computer, where Raspberry represents the client side; which sends sensors data to server via WIFI. We used the Convert ADS1115 to convert the analog format, of sensor to digital format.
3. Sending alarm message: an alarm will send to user if there is a water contamination or change in water quality. Indeed, to send notification from Raspberry to mobile application we will use Firebase Cloud Messaging which is a free, cross-platform messaging solution that lets us send push notifications to audiences without having to worry about the sever code (See Figure 6).

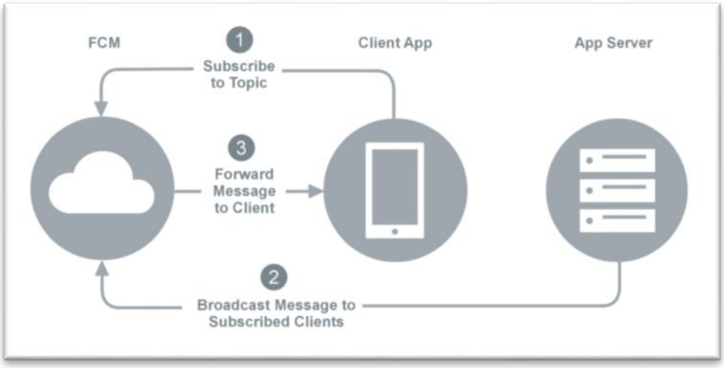

Figure 6: System of Notification with Firebase Cloud Messaging[3]

4.4. Work Environment

As shown in Figure 7, our project environment contains both of: Raspberry, Sensor, computer and other accessories:

- First, We make connection between Raspberry and computer using Remote Control Connection which is Pre-installed on windows to access Raspberry Desktop.

[3] https://firebase.google.com/docs/cloud-messaging/

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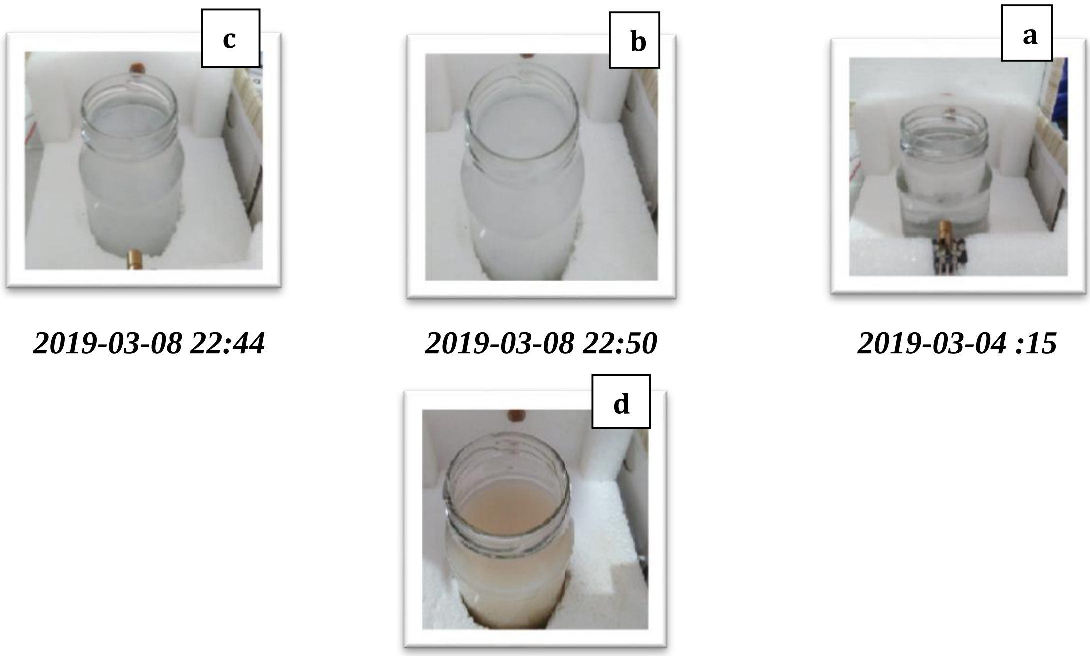
- Then, we tested our system on two conditions; on clean water and on turbid water. The results about clean water gives us a range of analog signal that allows us to define the Threshold for water contamination.
- Note that, for increment the level of turbidity we add different quantities of milk to the clean water.

Figure 7: Work Environment

5. Results (Checking Turbidity)

In this section, we focus is on experimentations studiens and evaluation of system. The implementation of our system makes it possible to evaluate the results obtained. This evaluation performed by using a set of tests. The tests make it possible to estimate the quality of drinking water and to compare with the standards norm.

Turbidity can range from less than 1 NTU to more than 1,000 NTU. Between 30 and 50 NTU, the water is visibly and drinkable (Figure 8.a); between 50 and 100 NTU, it is cloudy (Figure 8.b), between 100 and 200 NTU, the water nearly blackish (Figure 8.c), and more 200 NTU is blackish (Figure 8.d).



2019-03-08 22:44 *2019-03-08 22:50* *2019-03-04 :15*

2019-03-08 22:40

Figure 8: Turbid Water Check.

In order to log turbidity sensor measured data on the database, we created a table named "turbidities" and it have two columns, where we will log our collected data: time (date and hour) and turbidity value (See Figure 9).

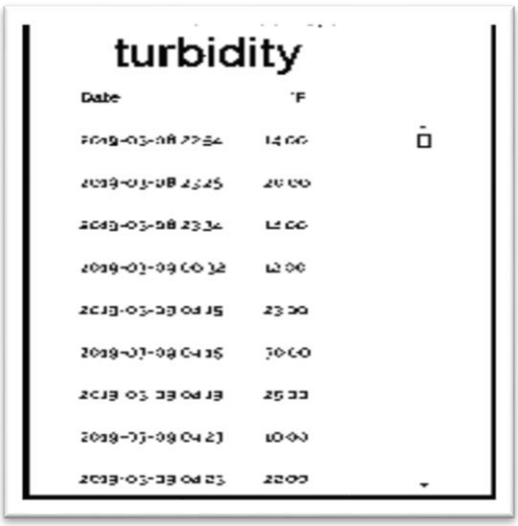


Figure 9: Table of Historical Sensor Values Web Page.

The choice of a photoresistor implies that of the laser to be able to cross the most opaque fluids. One can check if there is anomaly features of water, the informations about this anomaly are sending as a notification reported in the mobile application:

- A first measurement with pure water gives low values for zero turbidity.
- Then, we use the milk to make evident the path of the ray between the laser and the photoresistance. So, the value increases as the fluid gets darker.
- When we amount the quantity of milk increases, the radius is diffuse and the value of the turbidity increases.
- Until the beam can no longer cross and the value measured by the photoresistor is equivalent to the ambient brightness.

Typically, we introduce some gauges to present actual turbidity values on a better way by using JustGage[4] on your html/css files that allows us to generate and animate nice and clean gauges (Figure 10).

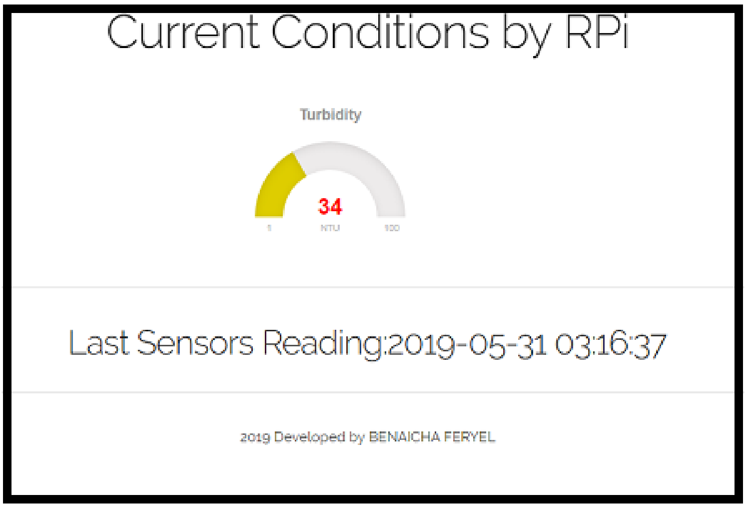


Figure 10: Current Sensor Values Web Page.

6. Conclusion

This project aims to develop an automatic system to monitor the water quality level based on water quality index as a standard. The developed system successfully detected the turbidity levels. For this aim, we used our turbidity meter as a sensor for

[4] https://toorshia.github.io/justgage/

measuring the turbidity feature of drinking water. This tool simply measures the amount of light coming from the light sender to the light receiver in order to calculate the water turbidity. Then, we are using an Raspberry board for finding turbidity value. Then, we use a web application to have display the observations on water parameters. As well, we use a web application to have display the observations on water parameters. Generally, the system developed offers fast, efficacy and easy monitoring of water and ensuring the quality water is continuously notified.

As prospects for our work, we propose to improve it by future work in order to obtain more efficient analysis. These future works are as follows:

- Use more sensors for measuring physical and chemical parameters of water.
- Extend this project by sending the sensor data to cloud for global monitoring of water quality.
- Build a sofestic tool and simple use with the aid of this project.

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