Water Quality Monitoring System using IoT

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Abstract: Water is an essential part because no life is possible on earth without water. So, water quality management is a very important thing but the techniques which are used currently are very costly and mostly performed by scientists in labs monthly or yearly. But nowadays it is important manage the water quality in real time because of increase in the number of waterborne diseases. In this paper, we are going to propose a low-cost solution which will analyze the water quality in real time using IoT. The water quality sensors like pH sensor, turbidity sensor, conductivity sensor will analyze water quality in real time and will be sent to the cloud using NodeMCU. So, with the help of technology, the process can be automated to get the results appropriately rather than depending on manual process

Keywords: IoT (Internet of Things), NodeMCU, turbidity sensor, cloud.

1. Introduction

Water pollution is one of the biggest problems in the world today. There are several reasons for this, like increasing population, industrialization, globalization, urbanization and lack of awareness about water usage. Lack of poor water quality not only affects the health of an individual but also harms the environment. The hazardous chemicals in the industries contaminate water. But nowadays people are becoming aware about the health issues. Maintaining water quality becomes very important as it directly affects health of individuals as well as all living organisms and also affects environment. But the methods which are present currently are expensive, time consuming, difficult and need experts. The traditional method includes three steps-

1. Water sampling
2. Testing Samples
3. Investigative Analysis

So, using technology, the process of water quality monitoring is automated and it gives better results than the traditional method[2]. There is no safe water for drinking. According to WHO, 77 million people suffer due to unsafe water and 21% of diseases are related to unsafe water. CPCB (Central Pollution Control Board) checks the water bodies monthly or yearly across the country[3]. Different water quality parameters can be easily used to monitor water quality in real time. The water quality monitoring is an efficient way to maintain quality of water in tanks situated in hostels, colleges, residential at good level. The quality can be monitored from remote locations using smart phones due to data being uploaded to cloud in real time. So that each and every individual who is concerned with the water quality and health issues can monitor the same from any location. The proposed system in this paper uses the following sensors,

pH Sensor is used for measuring pH of water. Turbidity Sensor is used for detecting suspended particles in water. If the turbidity of water is lower then the water is clean and if it is higher then it may cause the diseases like diarrhea, cholera.

Conductivity Sensor implemented in this system is a very low cost sensor developed from scratch using components like copper wires, plastic gauge, resistor, etc. Electric conductivity of water is its ability to conduct electric current. It depends on concentration of ions present and other chemicals in water. It's a indication of purity of water.

Temperature sensor is used to measure hotness or coldness of water. It's important measure because it heavily affects biological and chemical activities. Also the measurement of other sensors like pH, EC depends on temperature.

2. Literature Survey

Population growth may constitute to one of the reasons that results in the degradation of the quality of water over years. This may be due to the great use of pesticides, fertilizers, weed-killer, etc that contaminate the water and that affect the human live directly.

Ways to assess the Water Quality includes,

2.1 Traditional way of Water Quality Monitoring

The process involved in this traditional system includes water sampling, Testing these samples and Investigation Analysis. Here, various instruments and tools such as

probes, meters, gauge, secchi disks, etc. were used. But it was not an efficient way to measure the water quality parameters and fails to provide us with accurate water quality measurements. The testing carried out contains physical, chemical tests[2].

2.2 Technology based water Quality Monitoring System

1. Solar powered Water quality monitoring system using Wireless Sensor network[4]

The authors Kulkarni Amruta M. ,Turkane Satish M. says," The idea about this system is generally originated through solar panel. It involves monitoring the quality of water over different locations using distributed sensor node and base station connected using technologies such as Zigbee, etc. Data is gathered from different sensors at node side and send to base station via WSN. The main objective of this system is to measure different water parameters such as pH, turbidity, conductivity, etc. of drinking as well as water for domestic use. The system is designed such that the multiple distributed nodes are connected to a single base station using WSN and each of these base stations are connected to each other to form a network using Ethernet. Data generated is accessed remotely using WSN. Advantages of this system, low carbon emission, more flexible ,etc. This system fails because it covers limited area due to use of Ethernet instead of internet. Due to use of WSN power consumption is more and hence is unreliable."

2. Smart water quality monitoring system[1]

The authors A. N. Prasad, K. A. Mamun and F. R. Islam proposed a system to continuously and vigorously monitor the water quality in Fiji using IOT. The system is developed due to chemical waste, oil pills and fair degree of pollution in Fiji 's waterways. This system will measure the water quality parameters such as pH, oxidation & reduction potential, conductivity and temperature using remote sensing technology. There is continuous monitoring of water bodies and alert is send to the user if there is any threat with the quality of water .The collected data is send to cloud or FTP server using GSM module. The system is tested with different water types like sea water, surface water, etc.

3. Prediction of water quality and smart water quality monitoring system[3]

The authors karthick T. , Gayatri and Tarunjyot proposed a system to monitor and predict quality of water using sensors like pH and Dissolved oxygen sensor. The system is proposed to overcome the conventional approach which includes manual collections and assessment of raw data. This is a smart water quality management system which uses machine learning to predict the quality using sensors like pH, CO_2, temperature and turbidity. This is a reconfigurable shrewed sensor if gadget that coordinates collecting information, operating and transmitting to remote location.

4. Intelligent IoT Based Water Quality Monitoring System[2].

The authors Soundarya Pappu, Prathyusha Vudatha's say, "Due to population growth, fresh water management becomes very much essential and creates demands an increase in agriculture, industry and other requirements. Water quality can be measured in terms of chemical, physical and biological content traditional water quality system. Also with the advent of wireless sensor technologies, some amount of research carried out in monitoring the water quality using wireless sensors deployed in water and sending short message to farmer's about water. Also research been carried out in analyzing the quality of water using machine learning algorithms too.

M2M communication has evolved which leads to device communication between themselves and analyse data intelligently in the residential areas. This system is developed which employees pH sensor and TDS meter to measure hydrogen ions and total dissolved solvents. In addition to this a machine learning algorithm K-Means Clustering is employed to determine quality of water.

5. Arm Based Online Water Monitoring System[5]

The authors Neethu S Suku1, Lijesh , Department of ECE, Musaliar College of Engineering and Technology, Kerala, India says that," The existing system only monitors the water level and electric conductivity manually and report to the authorities. The proposed system is developed by using number of sensors such as pH, Turbidity, etc. and monitored using ARM 7 controller. Sensor values are provided manually to the controller using keypad. The data is uploaded onto the server using Bluetooth module an hence it is limited to a short range. The system contains two different android applications, one for monitoring and the other for providing alerts."

3. RELATED THEORY

The system contains several sensors (pH Sensor, TDS Sensor, Turbidity Sensor, Temperature sensor) connected to core controller. The controller processes the data collected by different sensors. The data is uploaded to cloud so that it will available anywhere in the world. The data collected from the sensors can be viewed using wi-fi system. The users can assess the quality of water on their mobile device.

There are two parts in this system, hardware and software. The hardware part consists of different type of sensors, NodeMCU board. The software part consists of Arduino IDE, Firebase.

3.1 Hardware and Software Requirements:

Hardware Requirements:

1. pH Sensor

Fig 1: pH Sensor

pH Sensor is mainly used to indicate acidity of the water.

pH Value is expressed with numeric scale ranging from 0 to 14, in which 7 represents neutrality of water. The value on the scale increases with increasing alkalinity and decreases with increasing acidity.

PH Sensor Specifications:

- Measuring Range : 0-14 pH
- Module Power: DC 9.00V 1A
- Accuracy (+/-) 0.1 pH(24 C)
- Response Time < 1 min
- Industry pH Electrode with BNC connector
- pH interface 2 foot Patch
- Power Indicator LED
- Output Analog values in the range (0.5 V to 3 V)

2. Turbidity Sensor

Fig 2: Turbidity Sensor

Turbidity sensor generally measures the amount of light scattered in the water. As the total amount of suspended solids increases, turbidity level increases which is detected by cloudiness or haziness of water**.** It is good measure of water quality. It is generally measured with the help of voltage. A light beam is reflected back from water and detected by a light detector, then more voltage means less turbidity.

Turbidity Sensor Specifications:

- Working Voltage : DC 5V
- Working Current: 30 mA (max)
- Isolation Resistance: 100 M ohm (min)
- Response Time < 500 min0
- Operating Temperature: -30 C -80 C

3. Conductivity Sensor / TDS sensor

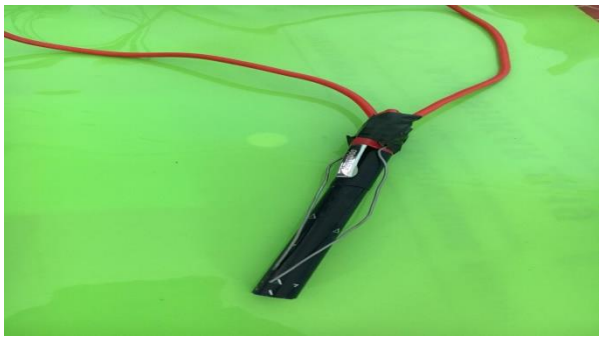

Fig 3: Conductivity Sensor

Electric Conductivity is a measure of the ability of water to pass an electric current; it is affected by the

presence of dissolved solids such as chloride, nitrate and phosphate. Conductivity can be a very useful indicator that a discharge of some sort has entered a stream, or some other change has occurred. Distilled water has conductivity in the range of 0.5 to 3 µmhos/cm.

4. Temperature Sensor

Fig 4: Temperature Sensor

Safe range for drinking water is eight degrees centigrade of the body's temperature. So the water temperature should be between 28 and 44 degrees centigrade. the ideal range and be conscious of it, then wherever possible, staying within that temperature range is a good idea

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5. NodeMCU

Fig 5: NodeMCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC and hardware which is based on the ESP-12 module.

Specifications:

- CPU :ESP8266
- Operating Voltage :3V, 5V
- GPIO :10
- Operating System :XTOS
- Storage :4MBytes
- IDE used :Arduino IDE

Software Requirements:

1. Arduino IDE
2. Android Studio
3. Firebase Database

3.2 System Architecture

Water Quality Monitoring System includes both hardware and Software technologies. This system uses sensors (Turbidity, pH, Conductivity(TDS),Temperature) and the NodeMCU Board which works as a controller which can be connected to the internet using in-built Wi-Fi module. To measure different water quality parameters data is acquired from these sensors in the analog form. The ADC convertor is attached to these sensors, to convert the analogy signal into digital format. The microcontroller examines itself on the basis of the information acquired by these different sensors. The examined information is continuously uploaded to the cloud and can be accessed by the user using application that is being installed in their phone. Due to this, the user can be able to monitor the information about the quality of water from anywhere and at anytime.

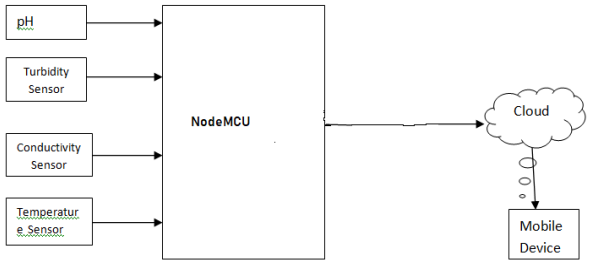

Fig 6: System Architecture of water quality Monitoring system

4. IMPLEMENTATION

4.1 FlowChart

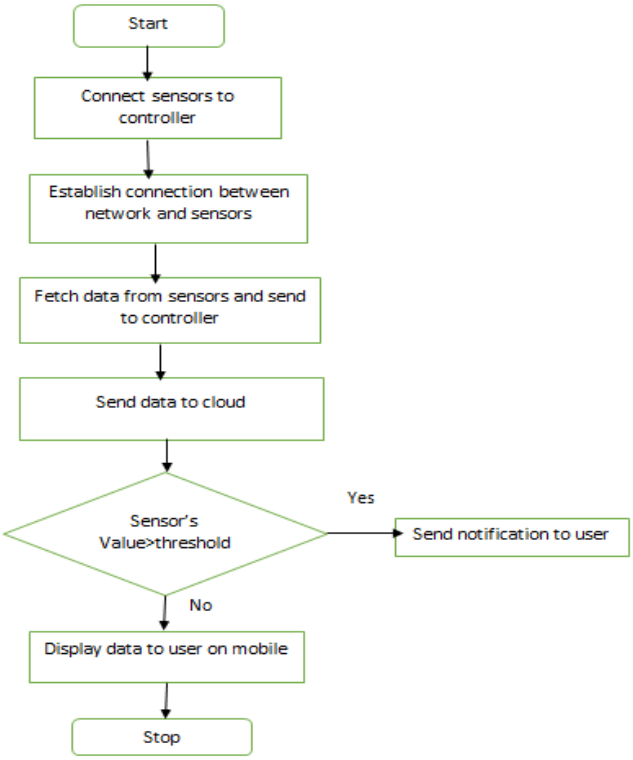

Fig 7: Flowchart of water quality monitoring system

4.2 Pseudocode

Input :Data from pH sensor and Turbidity Sensor
Output :Display voltage ,Turbidity and pH values of water
Begin
Establish connection between NodeMCU & cloud
Include required libraries
Read Values from Turbidity Sensor
For 1 to n do
sensor+=Values from Turbidity Sensor

End
sensorValue=sensor/n;
Voltage=sensorValue(5.00/1023.00)*
*Turbidity=100.00-(Voltage/VClear)*100.00*
Read Values from pH Sensor
Assign to pHArray[N]
*Voltage=avg(pHArray,N)*5.0/1024;*
*pHValue=3.5*Voltage+offset*
Read values from conductivity sensor
Voltage=condValue(5.0/1024)
Read temperature sensor value
Celcius=sensors.getTempCByIndex(0);
Send Sensors Data to Cloud
If(sensorValue>threshold)
Alert User
Else
Display Values
End

The above Pseudocode explains about measuring the Water quality using different parameters of water. The System is designed using pH sensor, Turbidity sensor, Conductivity sensor, Temperature sensor connected to a controller. Data gathered using Sensors is send to cloud for monitoring and displayed to user using an application. Input to the system is the data acquired from the sensors and output are the voltage, Turbidity, pH values of water.For doing so, establish connection between NodeMCU and Firebase cloud.

Read continuously N values of turbidity sensor, find its average and assign to sensorValue. Calculate voltage as sensorValue*(5.00/1023.00) which is used to Convert analog (0-1023) to voltage (0 - 5V). Calculate turbidity as 100.00-(voltage/VClear)*100.00 as relative percentage(0% = clear water).VClear is initialised to 2.85 ,the Output voltage to calibrate (with clear water) and display the Turbidity value.Read values from pH Sensor and assign to array pHArray[N].Calculate voltage as avg(pHArray,N)*5.0/1024. Function avg() is used to calculate average of N pH values. Calculate pH value and display.

Read value from conductivity sensor and calculate voltage as condValue*(5.0/1024)Read data from temperature sensor and convert the readings to degree celcius.Send data from all the sensors to cloud. Display the gathered data on mobile application. Whenever the sensor values get beyond threshold then send notification to the user.

5. RESULTS

The Water Quality Monitoring system is developed on the NodeMCU and the output is displayed on an android application using Firebase. When the sensors to measure quality parameters of water (pH, Turbidity, Conductivity, Temperature) are connected to the controller then their respective values are uploaded is shown. Also the overview of android application shows the values. The output shown of desktop system and android application are in resemblance .

Hardware Setup:

Fig:8 Setup of Conductivity Sensor

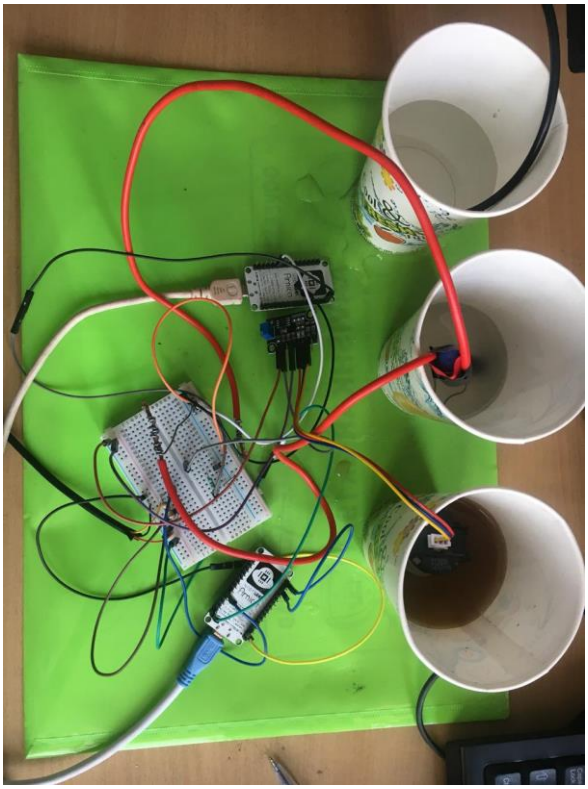

Fig 9: Setup of water quality monitoring system

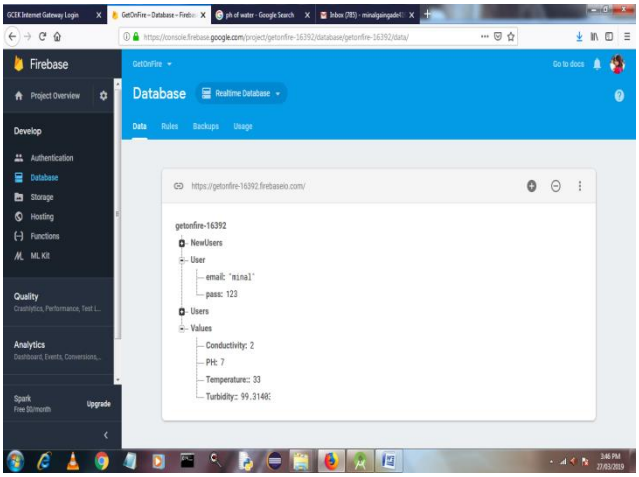

Fig 10: Data uploaded to firebase cloud

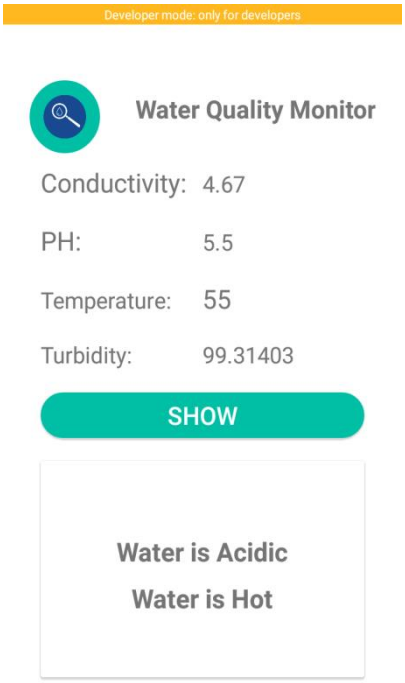

Fig 11: Data accessed on android application

According to the author Neethu S Sukul and Lijesh of ARM based online Water Monitoring System for monitoring water quality based on ARM7 processor, the data captured is displayed on the LPC2148 and if the values are greater than threshold then commands are given to the vendor. But the proposed Water quality monitoring system based on IoT not only captures the data but also takes the controlling actions over threshold conditions. And if the residentials are out of station then regular notifications will make him updated with the system continuously. The android application gives the snapshot of current situations regularly.

The methods are compared according to following parameters:

Parameter	Method 1	Method 2
	ARM Based Online Water Monitoring System.	Water Quality Monitoring System Using IOT.
1.Hardware	ARM7 processor, Temperature sensor, Turbidity sensor, pH sensor,HC-05 Bluetooth Module.	Arduino UNO, Turbidity sensor, pH sensor, Temperature sensor, Conductivity sensor, WiFi Module.
2.Software	Eclipse, Java	Arduino IDE, Firebase, Android Studio.
3.Area Covered	Upto 10 metres	Upto 500 metres
4.Setting threshold for sensor value	Manual	Automatic
5.Display mechanism	LCD Display, Android application. Local System	Android application, Remote system
6. Advantages	Immediate result , Fast processing.	Sensor values are gained automatically, Low cost sensors,
7.Disadvantage	High Cost.	Slower processing as compared to ARM 7.

Table 1:Comparison of existing and proposed system

The following are the graph of water quality based on different sensor tested on the water samples of different location. Here we have analyzed water of three locations they are as follows:

1. River Water
2. Filtered Water
3. Tank Water

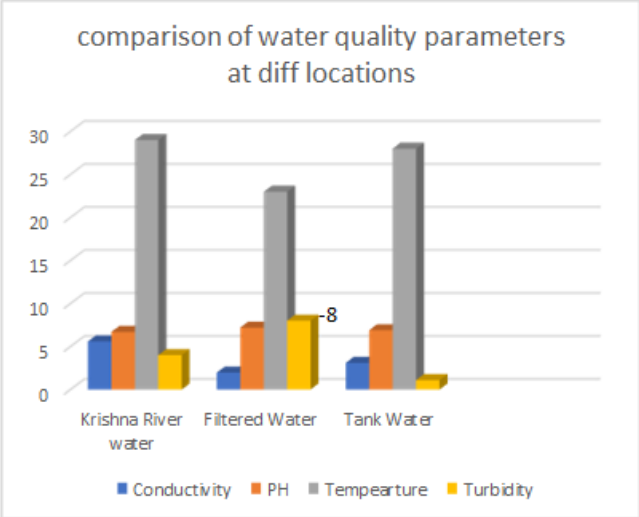

Fig 11: Graph of water quality values at different location

6. Conclusion

Water quality monitoring is very much essential as it is directly related to health. The traditional system for water quality monitoring is not very much effective to monitor the quality of water. In 2015, only 70% of the total population started using safe water management service but still 30% population were unaware. So, using this system consisting IOT and android application most of people would get aware because using smart phone is a common thing nowadays. And the rate of people using safe water service would rise to 80%-90%. Proposed system will identify threshold input as per recommendation and will monitor the quality which will be assessed using different parameters. Due to this, we will be known with what quality of water we consume and accordingly precautions and purification can be held on water to avoid waterborne diseases. As per

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