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IOT Based Real-Time Water Quality Monitoring and Reporting

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Abstract - *Water is one of the essential resources for life on the earth. And the major concern is to find that whether the water is contaminated or pure. In Internet of Things (IOT) environment there is increase in development of various technological advanced systems. For real-time data acquisition, transmission and processing the water quality monitoring system monitors various parameters that defines the nature of water. This system is the implementation of integration of sensors with Single Board Computer for real time water quality monitoring in an IOT environment. Then based on collected data generate the water quality report and forward the same to the officials who are intended to resolve those issues. This immediate reporting cause to resolve the issues in less time so citizens will not face those issues for longer time. This water quality monitoring system consists of Raspberry pi, sensors, GPRS based wireless communication module and cloud storage. The Raspberry pi is the core component of the proposed system and it has programs in Python programming language to operate with different kinds of sensors used in system. Whenever unacceptable quality of water is detected the system will report about quality of water to respected authorities or officials. Also, the residents of the particular area can view the intended data, alerts and notifications on web portal. This system relies on the raspberry pi, sensors used and the availability of cloud service.*

Keywords: Internet of Things, Single Board Computer, real-time, water quality report, sensors, web portal, cloud service

1.INTRODUCTION

Water is a limited resource on the earth and is important for existence of human being and other creatures. Water is also necessary for agriculture and industrial uses. While using the water it is important to determine the quality of water as it has many bad effects on human beings if it is contaminated [4]. People face many health-related issues because of using contaminated water. An efficient water quality monitoring system is potential constraint for determining quality of water for domestic usage [1]. Internet of Things (IoT) is a network of intelligent things. In which these things or object communicate with each other. The IoT is used to sense the object and control them remotely over available functioning network resources, which give advantage of direct integration between the physical world and digital systems along with benefits in terms of efficiency, accuracy and economic. Monitoring of water level is used for determining how much amount of water is being used. So, it will help to determine average amount of water resource may require in future. Also, to track excess use of water that allows to save water as much as possible [2]. The existing water quality monitoring systems monitors quality of water in dams, large silos and reservoirs. But many times, there are incidents of supply of impure water to citizens still after the treatment process. Where water contains turbidity, inadmissible pH level and many dissolved substances that can be determined by checking conductivity of water. In such incidents people have to complaint regarding it to the authorities. So, this became the time taking process. Because of that people have to face the problem for longer time. But the proposed system will overcome this issue. This system will keep monitoring the quality of water continuously. Whenever system detect that, water quality has crossed the acceptance range of parameters defining the nature of water, immediately the report will be generated and sent to the authorities. This information will be likewise accessible to residents of the proposed territory through the website. This system consists of Raspberry Pi, pH sensor, turbidity sensor, conductivity sensor, temperature sensor, ultrasonic distance sensor and GPRS module etc. The raspberry pi is the core component of the system that has an interface to connect multiple sensors. Raspberry pi collects or read the data from multiple sensors in parallel and keep in local memory till the interval of sending collected data to the cloud storage. The turbidity sensor is used to measure the amount of particles of solid matter suspended in the water. Water appears to be cloudy if it is turbid and temperature of water raises as increase in level of turbidity, because suspended particles absorb the heat. Warm water holds less dissolved oxygen than cold, so increased water temperatures result in decreased levels of dissolved oxygen. The unit of measuring turbidity is NTU i.e.

Nephelometric Turbidity Units. Then the pH sensor is used to determine the pH level of water. Environmental Protection Agency concluded that, consuming highly acidic or alkaline water is harmful for human health. As per the EPA standards drinking water must have pH value in the range of 6.5 to 8.5. The conductivity sensor measures the capability of water to pass electric current. This is an indicator of the concentration of dissolved electrolyte ions in the water. It doesn't identify the specific ions in the water. However, significant increases in conductivity may be an indicator that polluting discharges have entered the water. The basic unit of measurement for conductivity is micromhos per centimetre (µmhos/cm) or micro siemens per centimetre (µS/cm). Also, the temperature sensor is used for monitoring temperature of water. Raspberry pi continuously collect data from all of these sensors and holds in memory. After specific time interval that data will be sent to cloud storage over the internet connection which is established using GPRS module. If any of the sensor value hits the threshold values set as per standards, then the report is generated and sent to the respective officials. All this data will be available through website which is easily accessible to citizens and respective authorities. This system implementation provides advantage of accuracy, immediate reporting and efficiency.

2. LITERATURE SURVEY

In this paper [1], they introduced a system for detecting impurities in the water and maintaining quality of water. This system uses pH sensor for detecting pH level of water. Then the IR circuit is used for determining change in colour of water. Laser sensor checks the presence of any solid impurities. Whenever system detects the impurities, it will successfully produce necessary alerts. This system was basically proposed for monitoring quality of water in public water distribution tanks. This system can be improved by adding more sensors and implementing using IOT.

In this paper [2], author proposed an IOT based system for detecting level and leakage of water. It also monitors quality of water. This system controls water pump using relay as per the level of water. Here the automation was done for filling tanks of water when they became empty by switching the relay of water pump. All data collected using pH and turbidity sensors will be available through website. On occurrence of particular event the SMS notifications informing water level, quality and pressure are sent to the registered devices.

Online water quality monitoring system [3] introduced by author consist of multiple monitoring nodes at different locations that collect data and stores at cloud storage. Here operating range and specifications of different sensors along with their working principle are explained. It consists of GUI platform developed with the help of Borland html and java programming. This project was proposed for monitoring quality of water in dams and rivers. Where the solution is provided for overcoming disadvantages of traditional process of collecting water samples and testing them in laboratories. This system is limited to monitoring quality of water at dams and rivers.

Reconfigurable water quality monitoring system [4] was based on Wireless Sensor Network technology. It consists of FPGA design board which is programmed using VHDL and C Programming language. This board was integrated with sensors and using ZigBee module communication was done with personal computer. It is local network in which personal computer act as central station where all data sent by monitoring nodes are stored and one can monitor it. This system has highly complex architecture which is difficult to implement. In this paper, author has focused on system implemented using WSN in an IOT environment.

In this system [5], impurities in water are detected by measuring capacitance. Here author proposed the design of the capacitive sensor. This sensor consists of two parallel copper plates. Second plate has slightly larger dimension for alignment purpose. The detection circuit used the auto range detection schemes for two different ranges of capacitors. By using this sensor, data was collected by Arduino Uno microcontroller board and further processing was performed. In this paper author also investigated impurities with various concentrations of Sodium Chloride, Sugar, Ferrous Sulphate and Copper Sulphate. Then the practical relationships are developed by which type of impurity and its concentration can be determined. This system is accurate enough to serve its purpose with maximum error less than 6 %.

A wireless sensor networks-based system [6] was developed for controlling water levels in tanks and to detect pipeline leakages. Any leak detection in water pipeline is performed by using flow sensitive resistor (FSR). Whenever pipeline leakage is detected sound alerts are generated. This will avoid the large amount of water being wasted. Also, when water tank became empty water pump is automatically powered ON and when tank gets full it will be switched OFF automatically. The main purpose of system is to save as much as possible amount of water from getting wasted. This system successfully performed its activities but it can be improved by integrating more sensors into system.

An autonomous surface vehicle design was proposed by authors [7], which can be navigated over water streams as per the directions provided by monitoring station. This vehicle collects water quality data from different locations of water streams. It is equipped with multiple sensors for determining quality of water. It has ability of laser-based obstacle avoidance and vision-based inspection capabilities. This solar powered vehicle is capable of collecting numerous water quality information throughout water column whilst in motion. It can also measure release of various greenhouse gas emissions. By using this vehicle authors successfully completed survey of hundreds of kilometres.

3. SYSTEM ARCHITECTURE

Water storage is equipped with the sensors such as turbidity sensor, pH sensor, conductivity sensor for measuring quality of water, temperature sensor monitors the temperature of water and ultrasonic distance sensor determine the level of water in storage tanks. Raspberry pi works with digital inputs and outputs. But turbidity sensor and pH sensor provide the output in the analogue format. So, this analogue signal is converted into digital by using MCP3008 ADC chip and output of this chip is provided to raspberry pi. Raspberry pi collects the data in each predefined time interval. This data remains in memory until it is sent to the cloud storage or if network is not available then store it in local file system. This system requires internet connection which is establish using Sim800-GPRS module for communicating with cloud storage. It is a real time system. Hence, there is no need of any human or other machine interaction to measure the quality of water. Following figure [Fig.1] shows the arrangement of various components of system.

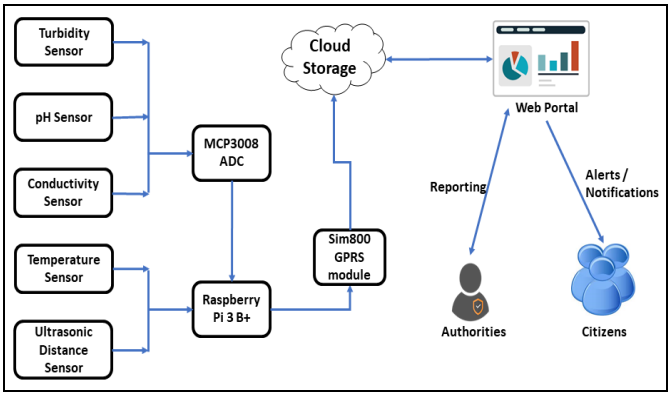

Fig -1: Architecture of working model

As shown in Fig 1, water storage is equipped with multiple sensors and these sensors are connected with raspberry pi. The turbidity sensor, pH sensor and conductivity sensor are connected to raspberry pi through MCP3008 ADC chip for converting analog signals from sensors to digital signal. These three sensors and also temperature sensor is immersed in water. Temperature sensor and ultrasonic distance sensor are directly connected to raspberry pi. Distance sensor is mounted at the top of the for determining level of water. Then raspberry pi sends collected data to cloud storage by using Sim800 GPRS module. Cloud storage is the place where all data from raspberry pi is stored into database as well as the web portal is hosted. All data stored at cloud can be accessed through web portal. Authorities can login to web portal to see all data from past to the current instance of time. They can get access to reports generated for quality of water and also can post some information if required. Citizens can view data intended to their residential area and alert / notifications, information post by the authorities. System will send the reports to authorities by e-mail and SMS. Also, the citizens who are registered their mobile numbers on system can get the SMS.

4. EXPERIMENTAL SETUP

The Fig 2 shows the connections of Turbidity sensor SKU: SEN0189 and custom designed conductivity probe with raspberry pi. Both the sensors give analog output. So, these sensors are connected through MCP3008 analog to digital converter. Turbidity sensor connected to channel 0 and conductivity sensor connected to channel 1 of the MCP3008. ADC chip generate digital output and gives it as an input to the raspberry pi. Operating voltage of both the sensor is 5V. Turbidity sensor gives analog output in the range of 0 – 4.5V with response time < 500ms. Then this voltage is mapped into turbidity value. It also has the digital output mode where you can set threshold value on sensor rather than in programs on which it operates. It gives logic 1 at output when turbidity value exceeds threshold value.

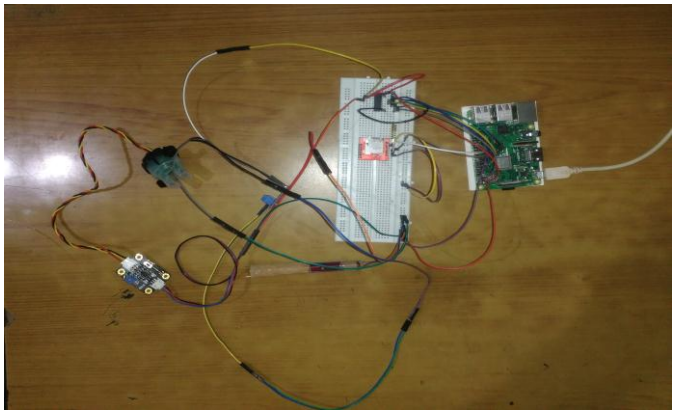

Fig -2: Connections of turbidity and conductivity sensor to Raspberry Pi

In Fig 3 the connections of pH sensor, ultrasonic distance sensor and temperature sensor with raspberry pi are shown. The pH electrode is connected to pH sensor module using BNC connector. The pH sensor also works in analog mode. Hence, it is also connected through MCP3008 ADC to convert analog output signal from sensor to digital. It is connected to channel 2 of ADC chip. This sensor operates at 5V power. If power is less than 5V sensor gives incorrect output. pH measuring range of sensor is between 0-14 pH. The temperature sensor wired in such way that it will allow to enable 1-wire protocol. This protocol uses only 1 wire to communicate complete information about the state of the sensor. It is device communication bus system which gives ability of low-speed data, signalling and power over a single conductor. It is possible to connect upto 75 devices to one bus. Sensor works with 3V - 5V power. An ultrasonic distance sensor (HC-SR04) is a digital sensor that can be directly connected with raspberry pi. It consists of Vcc, Trig, Echo and Gnd pins. Here Echo pin gives output of 5V and Trig pin take
input of 3.3V so there will be variation in voltage levels. This problem can be eliminated by using voltage divider network.

This network will drop the voltage divider network. This network will drop the voltage to GPIO pin from 5V to 3.3V.

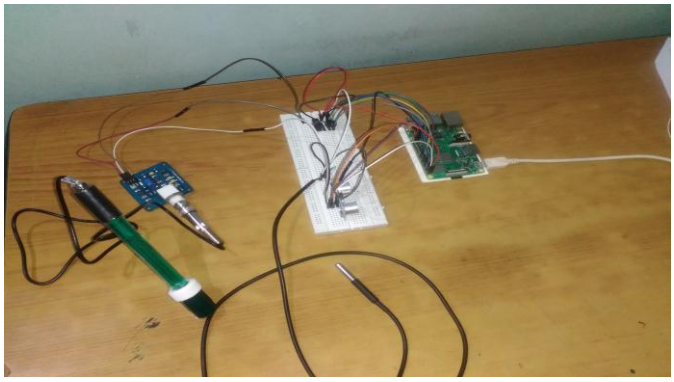

Fig -3: Connection of pH sensor, distance sensor and temperature sensor to Raspberry Pi

Fig 4 shows connections of all the sensors that are pH sensor, turbidity sensor, conductivity sensor, temperature sensor and ultrasonic sensor with raspberry pi. In this system sensors are measuring quality and level of water. Raspberry pi collects all data from sensors and whenever threshold value will be hit it will generate the report for that event. Breadboard is used for making connections. MCP3008 ADC is used to convert analog output values of pH sensor, turbidity sensor and conductivity sensor into digital values for connecting with raspberry pi.

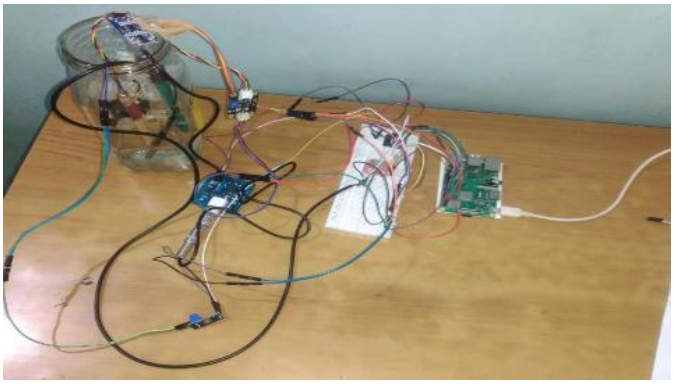

Fig -4: Final System

5. RESULTS

The Fig 5 shows readings from the sensors which are measuring quality and level of the water. The turbidity, pH, conductivity, level of water and temperature values are displayed with its measurement units on the terminal window. Also, it shows the alert for crossing threshold values. System holds data in memory and sent it to cloud storage after intervals of time or if there is threshold value hit the data will be immediately sent to the cloud storage.

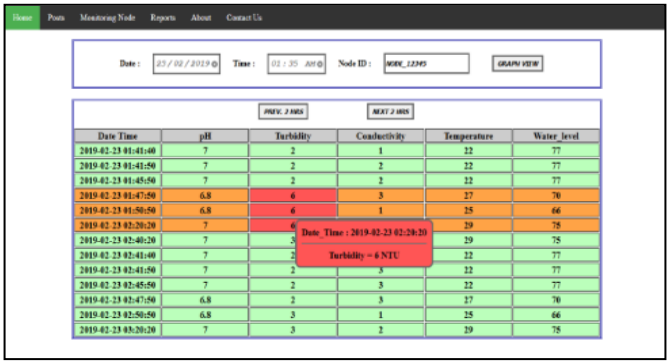

Fig -5: Data acquired from all sensors

Fig 6 shows the sample e-mail and SMS notification sent to authorities. It contains details of pH, turbidity, conductivity and temperature values. Also, the note of which parameter is out of its threshold value.

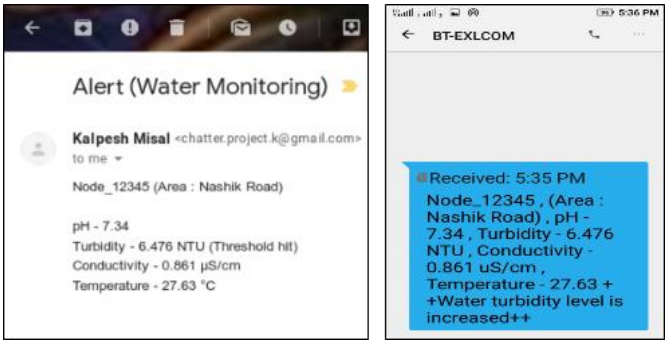

Fig -6: E-mail and SMS notification

The web portal allows authorities to login and monitor all history of water quality monitoring node. Also to check reports generated for quality of water. Users can view the readings of the sensors in the form of table as well as graph. Data retrieved for selected monitoring node is shown in Fig 7. It also has page to provide information about the hardware components used in the system.

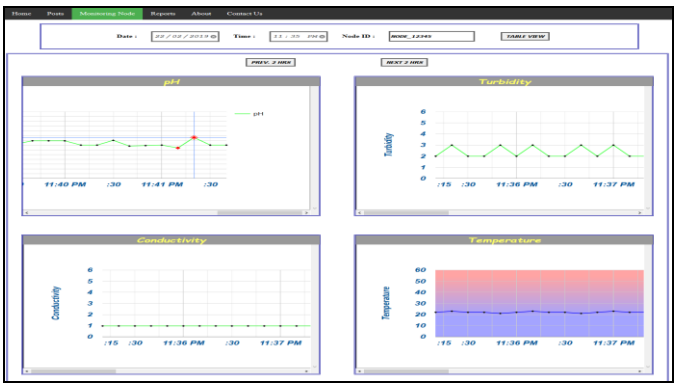

Fig -7: Data retrieved from database

6. CONCLUSION

Water is basic need of all the living beings. If that water is contaminated it will cause harmful effect on human as well as other living beings. So, to get notified about the level of contamination in water, this system is proposed. This system is monitoring quality of water continuously. It reads values from sensors and check for threshold set for parameter. When sensor values hit the threshold value, the notification of that event is successfully sent to authorities and citizens. Users can also access the data of water quality from database using web portal. So, the system is finally completed and deployed to perform it's best.

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