Real-Time Water Quality Monitoring System

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Abstract - *The need for effective and efficient monitoring, evaluation and control of water quality in residential area has become more demanding in this era of urbanization, pollution and population growth. Ensuring safe water supply of drinking water is big challenge for modern civilization. Traditional methods that rely on collecting water samples, testing and analyses in water laboratories are not only costly but also lack capability for real-time data capture, analyses and fast dissemination of information to relevant stakeholders for making timely and informed decisions. In this paper, a real time water quality monitoring system prototype developed for water quality monitoring in Residential home is presented. The development was preceded by evaluation of prevailing environment including availability of cellular network coverage at the site of operation. The system consists of a Raspberry Pi, Analog to Digital Converter, Water quality measurement sensors. It detects water temperature, dissolved oxygen, pH, and electrical conductivity in real-time and disseminates the information in graphical and tabular formats to relevant stakeholders through a web-based portal and mobile phone platforms. The experimental results show that the system has great prospect and can be used to operate in real world environment for optimum control and protection of water resources by providing key actors with relevant and timely information to facilitate quick action taking.*

Keywords: **Raspberry Pi, Real-Time, Water Quality, Cloud, Data Visualization, ADC, Cost Effective**

1. INTRODUCTION

In the 21st century, there are lots of inventions, but at the same time were pollutions, global warming and so on are being formed, because of this there is no safe drinking water for the world's pollution. Nowadays, maintaining pure supply of water to the people is getting more challenging day by day. In India mainly is big cities the municipality corporation use lots of chemical to purify the river water then supply that to the people. And we reserved that water without any test. And we also don't know the water is either safe for drinking or not. And now a day's water quality monitoring in real time faces challenges because of global warming limited water resources, growing population, etc. Hence there is need of developing better methodologies to monitor the water quality parameters in real time. The water parameters pH measures the concentration of hydrogen ions. It shows the water is acidic or alkaline. Pure water has 7 pH value, less than 7pH has acidic, more than 7pH has alkaline. The range of pH is 0-14pH. For drinking purpose it should be 6.5-8.5pH. Turbidity measures the large number of suspended particles in water that is invisible. Higher the turbidity higher the risk of diarrhea, cholera. Lower the turbidity then the water is clean. Temperature sensor measures how the water is, hot or cold. Here in this paper we tried to find the problem and then make a solution for it.

1.1 Problem Statement

Due to the fast growing urbanization supply of safe drinking water is a challenge for the every city authority. Water can be polluted any time. So the water we reserved in the water tank at our roof top or basement in our society or apartment may not be safe. Still in India most of the people use simple water purifier that is not enough to get surety of pure water. Sometimes the water has dangerous particles or chemical mixed and general purpose water purifier cannot purify that. And it's impossible to check the quality of water manually in every time. So an automatic real-time monitoring system is required to monitor the health of the water reserved in our water tank of the society or apartment. So it can warn us automatically if there is any problem with the reserved water. And we can check the quality of the water anytime and from anywhere. By keeping this mind we designed this system especially for residential areas.

2. RELATED WORK

Central Water Commission (CWC) monitors water quality, by collecting samples from representative locations within the processing & distribution system. These samples are analyzed at the well-equipped laboratories. At these laboratories samples from raw water, filter water and treated water are taken for analysis. The estimation of water parameters like turbidity, pH, dissolved oxygen, etc. is done with the help of meters. So the disadvantages of this existing system are that; there is no continuous and remote monitoring, human resource is required, less reliable, no monitoring at the source of waters i.e. no on field monitoring and the frequency of testing is very low. Due to these disadvantages of the existing system it is required to develop a system that will allow real time and continuous monitoring of water quality. Thus various advanced technologies for monitoring water quality have been proposed in the recent years. In the structure of the wireless sensor networking in which a number of sensor nodes are located in a lake is proposed. A much smaller number of UAVs also watch the lake and they are controlled by the central monitoring station (CMS). The sensor nodes and UAVs are both movable whereas the CMS is fixed. The CMS collects the information from the sensors and process them. In a framework for monitoring water quality by incorporating bacterial contamination of water for open water bodies using WSN (consisting of sensors for sensing parameters of interest), UV Light to probe the contamination of water and Fluorescence as a monitoring tool is proposed. Presents a web based wireless sensor network, for monitoring water pollution by means of Zigbee and WiMax technologies. This system would have a local Zigbee network that will be capable of measuring various water quality parameters, a WiMax network and web based monitoring with the help of a controlling computer. The system is intended to collect and process information, thus making decisions in real time via a remote web server. The data is directed through the Zigbee gateway from sensor nodes to the web server by means of a WiMax network, thus permitting users to distantly monitor the water quality from their place instead of gathering data from the scene. Experimental results reveals that the system is capable of monitoring water pollution in real time.

3. PROPOSED SYSTEM

Our goal is to develop a system for real time quality assessment for water health at residential places using Raspberry Pi. pH, Turbidity and Temperature sensors are used to gather the parameters necessary to monitor water health in real time. Following are the objectives of the proposed system.

- To measure various chemical and physical properties of water like pH, temperature and particle density of water using sensors.
- Send the data collected to a Raspberry Pi, show the data in display and send it to a cloud based Database using Wired/Wireless Channel.
- Trigger alarm when any discrepancies are found in the water quality.
- Data visualization and analysis using cloud based visualization tools.

The detailed block diagram of the proposed design is given in Diagram 1.

3.1 Block Diagram:

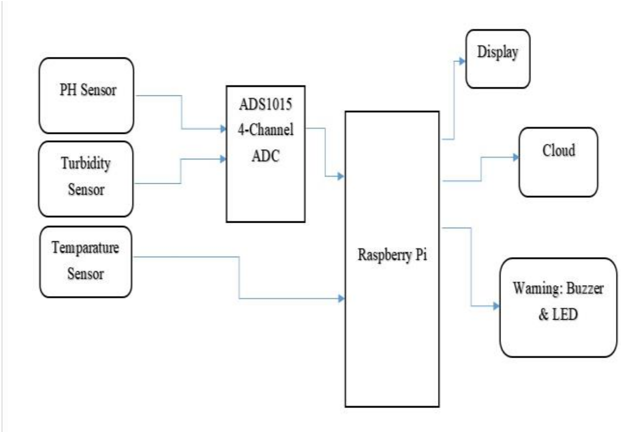

Fig - 1 : Block diagram of the proposed system

4. TECHNICAL DESCRIPTIONS

A. RASPBERRY PI

The Raspberry Pi3 Model B is a wonderful platform that can be used to build automation systems. Clearly, the Raspberry Pi3 model B board is perfect when being used as a "hub" for automation systems, connecting to other open-source hardware parts like sensors. Raspberry Pi3 Model B is a small sized single board computer which is capable of doing the entire job that an average desktop computer does like spreadsheets, word processing, Internet, Programming, Games etc. Raspberry Pi3 Model B Built on the latest Broadcom 2837 ARMv8 64bit processor, the new generation Raspberry Pi3 Model B is faster and more powerful than its predecessors. With built-in wireless and Bluetooth connectivity, it becomes the ideal IoT ready solution. It consists of 1.2GHz QUAD Core Broadcom BCM2837 64bit ARMv8 processor, BCM43438 Wi-Fi on board, Bluetooth Low Energy (BLE) on board,1GB RAM,4x USB 2 ports,40pin extended GPIO,HDMI and RCA video output. The Raspberry Pi3B model is shown in Fig - 1.

Fig - 2: Raspberry Pi 3 Model B

B. ADS1015 Analog to Digital Converter

For microcontrollers without an analog-to-digital converter or when you want a higher-precision ADC, the ADS1015 provides 12-bit precision at 3300 samples/second over I2C. The chip can be configured as 4 single-ended input channels, or two differential channels. As a nice bonus, it even includes a programmable gain amplifier, up to x16, to help boost up smaller single/differential signals to the full range. We like this ADC because it can run from 2V to 5V power/logic, can measure a large range of signals and its super easy to use. It is a great general purpose 12 bit converter.

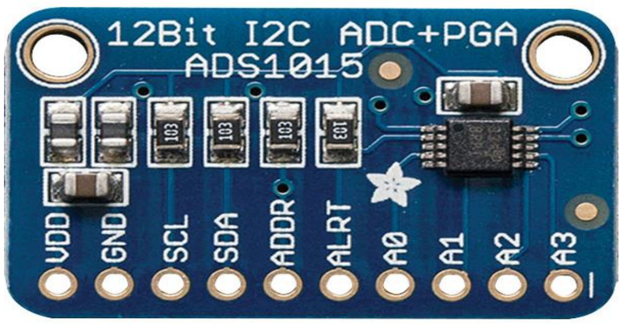

Fig - 3 : Adafruit ADS1015 ADC

C. PH Sensor:

pH measurements are predominantly conducted with pH-sensitive glass electrodes, which have, in general, proven satisfactory in measurements of pH. However, the behavior of pH-sensitive glass electrodes often falls short of what precision is required. Even with the most careful treatment, the potential of cells containing glass electrodes often drifts slowly with time after such cells were placed in a new solution. Drift of cell potentials is an especially severe problem in investigations dependent on precise observation of small pH differences. Measurements involving cells with liquid junctions are subject to further uncertainties due to the dependence of liquid junction potentials upon medium concentration and composition and due to pressure changes in the system.

Ideally, the change in liquid junction potential (residual liquid junction potential) between test solution and standardizing buffer should be small or at least highly reproducible. In practice, systematic errors between many measurements suggest that the reproducibility of the residual liquid junction potential is often poor and that residual liquid junction potentials are dependent on the construction and/or history of the liquid junctions used in various investigations. Since pH fluctuations in marine waters are very small, an absolute accuracy of less than 0.1 pH units and a resolution of at least 0.01 pH units is required. For an assessment of the CO_2/CO_3 systems even a higher accuracy is necessary.

Fig - 4: pH sensor

D. Turbidity Sensor:

Turbidity is defined as the reduction of transparency of a liquid caused by the presence of undissolved suspended matter. The origin of the particles found in seawater can be mineral (such as clay and silts) or organic (such as particulate organic matter or living organisms like plankton). Turbidity is not, however, a direct measure of suspended particles in water, but a measure of the scattering effect such particles have on light. Turbidity sensors measure the amount of light that is scattered by the suspended solids in water. As the amount of total suspended solids (TSS) in water increases, the water's turbidity level (and cloudiness or haziness) increases. Turbidity sensors are used in river and stream gaging, wastewater and effluent measurements, control instrumentation for settling ponds, sediment transport research, and laboratory measurements.

Fig - 5: Turbidity Sensor

E. Temperature Sensor (DS18B20) :

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply. Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Thus, it is simple to use one microprocessor to control many DS18B20s distributed over a large area. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems.

Key Features:

- Measures Temperatures from -55°C to +125°C (-67°F to +257°F)
- ±0.5°C Accuracy from -10°C to +85°C
- Programmable Resolution from 9 Bits to 12 Bits
- No External Components Required

Fig - 6: DS18B20 Temperature Sensor

F. ThingSpeak :

ThingSpeak is a platform providing various services exclusively targeted for building IoT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts, ability to create plugins and apps for collaborating with web services, social network and other APIs. We will consider each of these features in detail below.

The core element of ThingSpeak is a 'ThingSpeak Channel'. A channel stores the data that we send to ThingSpeak and comprises of the below elements:

- 8 fields for storing data of any type - These can be used to store the data from a sensor or from an embedded device.
- 3 location fields - Can be used to store the latitude, longitude and the elevation. These are very useful for tracking a moving device.
- 1 status field - A short message to describe the data stored in the channel.

To use ThingSpeak, we need to sign up and create a channel. Once we have a channel, we can send the data, allow ThingSpeak to process it and also retrieve the same. Let us start exploring ThingSpeak by signing up and setting up a channel.

4.1 Water Quality Metrics

The table below displays the metrics used by our system to measure water quality.

Table -1: Threshold values for pH and turbidity

	Safe water	unsafe water
pH	6.5 - 8.5	<6.49 and >8.5
Turbidity	< 5	> 5
Action	**Turn On Green Led**	**Turn On Red Led and Buzzer**

Table - 2: Threshold values for temperature sensor

	Normal	Hot	Cold
Temperature(T)	10<=T>=29	T>29	T<10
Action	**Green Led**	**Red Led**	**Blue Led**

5. PROOF OF CONCEPT

We present a system design of model depicted in the figures below. It show a pictorial description of the implemented design. The design has been tested with different solvents to check the integrity of the system.

Fig - 8: ADS1015 connected with sensors

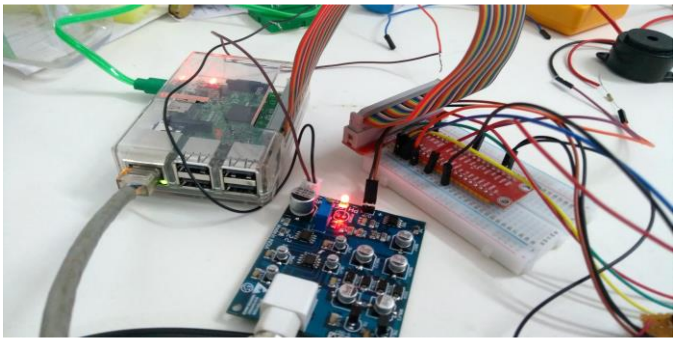

Fig - 9: Raspberry pi connected to sensors through GPIO Extension board

Fig - 10: Testing water quality in real time in normal water

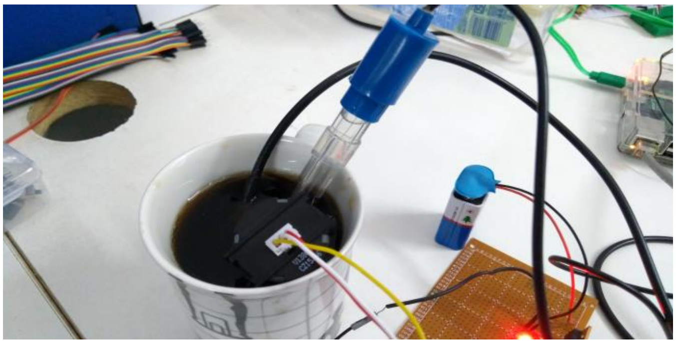

Fig-11: Testing water quality in real time by mixing solvents in water.

Fig - 12: Collecting turbidity value from dirty water

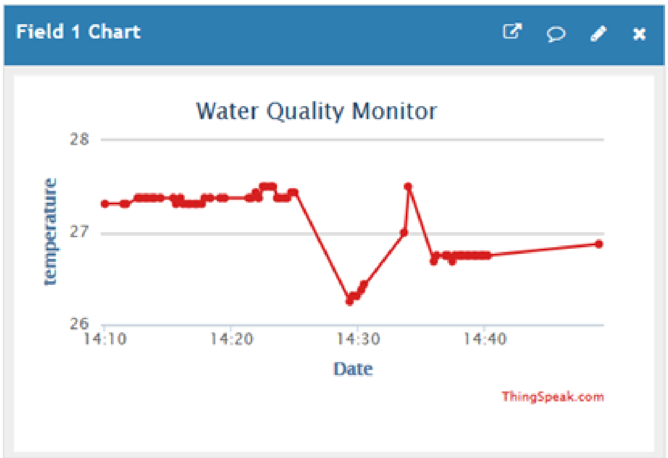

Chart - 1: Real time visualization of temperature variation in water sample

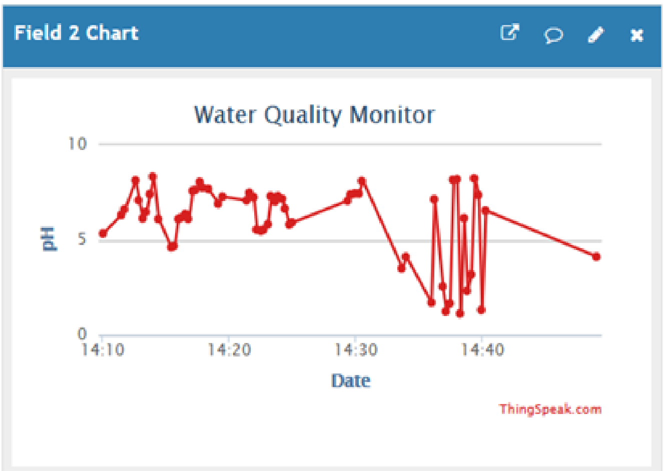

Chart - 2: Real time visualization of pH variation in water sample

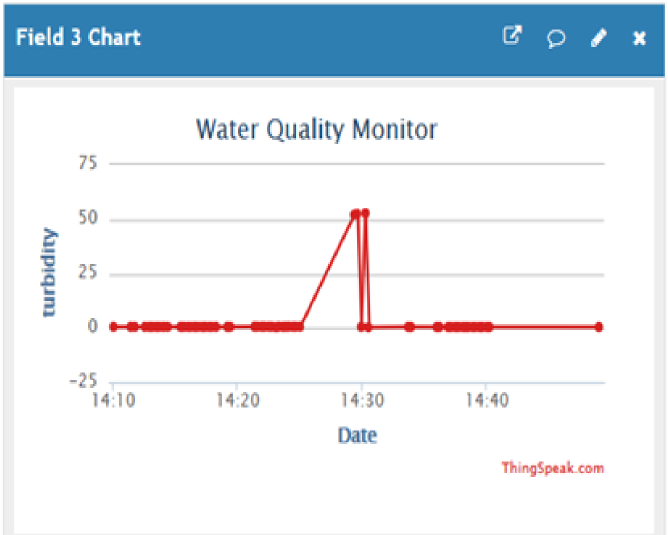

Chart - 3: Real time visualization of turbidity variation in water sample

6. CONCLUSIONS

Monitoring of real time quality of Water from reserve tank of house and colony makes use of PH, turbidity and temperature sensor with Raspberry Pi and existing Cloud system for data analytics. The system can monitor water quality automatically, triggers alarms immediately to prevent any health hazards and it is low in cost and does not require people on duty. So, the system is likely to be more economical, convenient and fast. The system has good flexibility. Only by replacing the corresponding sensors and changing the relevant software programs, this system can be used to monitor other water quality parameters. The operation is simple. The system can be expanded to monitor hydrologic, air pollution, industrial and agricultural production and so on. It has widespread application and extension value.

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