IoT Based Real Time Water Quality System

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Abstract - **One of the finite resource as essential to agriculture and industry as well as basic human existence is freshwater. Water quality monitoring is an important tool in the management of freshwater resources. The traditional method of testing water quality is to assemble samples of water manually and send them to the lab for testing and analyzing. This method is time consuming, wastage of man power, and not economical. The water quality measuring system that we have implemented checks the quality of water in real time through various sensors to measure the quality of water. As a variation in the value of this parameter points towards the presence of pollutants. The Wi-Fi module in the system transfers data collected by the sensors to the microcontroller, and transfers the data to the smart phone/PC. This proposed system keeps a strict check on the pollution of the water resources and be able to ensure an environment for safe drinking water.**

keywords - **Water quality, PH, Conductivity, Temperature, Turbidity, IOT, Wi-fi (ESP8266).**

I. INTRODUCTION

Water is known to be the universal solvent, plays an important role in the survival of various forms of life on earth. Furthermore, quenching our thirst, this transparent chemical substance is used for several other purposes. It is used to fulfill several household tasks. Water is also used for agricultural purpose and industrial use. Only 3% of the world's water is suitable for drinking and 2% of which is found mainly in glaciers and ice so in reality, only 1%of the earth's water is accessible and potable!

Historically, the development of civilizations has led to a shift in the pattern of water use from rural/agricultural to urban/industrial, generally according to the following sequence: drinking and personal hygiene, fisheries, navigation and transport, livestock watering and agricultural irrigation, hydroelectric power, industrial production, industrial cooling water, recreational activities and wildlife conservation. Auspiciously, the water uses with the highest demands for quantity often have the lowest demands for quality. By contrast, drinking water requires the highest quality water but in relatively small quantities. With increase in the industrialization and the growth of large urban centers have been accompanied by increases in the pollution stress on the aquatic environment. From ancient times, water in rivers, lakes and oceans has also been considered as a convenient receiver of wastes. This abuse conflicts with almost all other uses of water and most seriously with the use of freshwater for drinking, personal hygiene and food processing.

The breakneck development of the society and legion human activities speeded up the contamination and deteriorated the water resources. Water quality monitoring is essential to identify any changes in water quality parameters from time-to-time to make sure its safety in real time. The Central Pollution Control Board (CPCB) has established a series of monitoring stations on water bodies across the country which monitor the water quality on either monthly or yearly basis[1],[2]. This is done to ensure that the water quality is being maintained or restored at desired level. It is important that it is monitored on regular basis. Water quality monitoring helps in estimating the nature and extent of pollution control required, and suasiveness of pollution control measures. Information we get by checking the quality of water helps us to manage the state's water resources now and into the future.

II. RELATED WORKS

Water quality monitoring has gained more interest among researchers in this twenty first century. Numerous works are either done or ongoing in this topic focusing various aspects of it. The main theme of all the projects was to develop an efficient, cost effective, real time water quality monitoring system which will integrate wireless sensor network and internet of things.

The accessible water resources are getting depleted and water quality is deteriorated due to the rapid increase in population and need to meet demands of human beings for agriculture, industrial, and personal use. The quality of ground water is also affected by pesticides and insecticides. In India, rivers are getting polluted due to industrial waste and discharge of untreated sewage. CPCB has planned to go hi-tech and plans to establish 'Real Time Water Quality Monitoring (WQM) Network' across Ganga Basin, to eliminate problems associated with manual water quality monitoring,. In 2007, Stephen Brosnan [3] investigated a wireless sensor network (WSN) to collect real time water quality parameters (WQP). In 2010, Quio Tie-Zhn [4] developed online water quality monitoring system based on GPRS/GSM. By means of GPRS network information was sent, which helped to check remotely the WQP. In 2011, Kamal Alameh[5] presented web based WSN for monitoring water pollution using ZigBee and WiMAX networks. The system measured various WQP and collected, processed measured data from sensors, and directed through ZigBee gateway to the web server by means of WiMAX network to monitor quality of water from large distances. This System was also capable of monitoring water pollution in real time. In 2012, Dong He[6] developed WQM system based on WSN [7]. The remote sensor was based on ZigBee network. WQP tested by WSN and sent data to Internet using GPRS. Information was gathered at remote server, with the help of Web. In 2013, Kulkarni Amruta [8] created solar powered WQM utilizing remote sensor network. Base station gathers the information from distant remote sensors. Also the BS associated with ZigBee module was powered by sunlight baseboard (Energy harvesting).

Water pollution is one of the biggest threats for the green globalization. Water pollution affects human health by causing waterborne diseases. To prevent the water pollution, necessary steps are to be taken. First step is to estimate the water parameters like pH, turbidity, conductivity etc., as the variations in the values of these parameters point towards the presence of pollutants. In the present scenario, water parameters are detected by chemical tester laboratory test, where the testing equipment's are stationary and samples are provided to testing equipment's. Thus, it is a manual system with weary process and is very time consuming. In order to minimize the time and to make the system automated, the testing equipment's can be placed in the river water and detection of pollution can be made remotely. To ensure the safe supply of drinking water, the quality should be monitored in real time for that purpose Arduino based water quality monitoring has been proposed.

III. INTERNET OF THINGS

The Internet of Things is a simple stereotype which means taking all the things in the world and connecting them to the internet. It is a giant network of interrelated computing devices, digital and mechanical machines, objects, animals or people which is provided with UIDs and the ability to send data over a network without the help of human-to-human or human-to-computer interaction[9]. Figure 1 shows the IoT architecture in a simple form. The IoT can be described as a huge web of embedded objects designed with built-in wireless technologies such that they can be monitored, controlled and linked within the existing Internet infrastructure. Each device has a unique identification and must be able to capture real-time data autonomously. The Fundamental building blocks of IoT consist of sensors, processors, gateways, and applications. By 2020,[10] it is estimated that 50 billion 'things' will be connected to the Internet. Wireless technologies such as the Wi-Fi, Bluetooth, ZigBee, RFID, 6LoWPAN (IPv6 Low power Wireless Personal Area Network) allow the device to be connected to the Internet and to each other. The cloud services collect, store and analyze the data collected by the sensors and allow people to take decision accordingly.

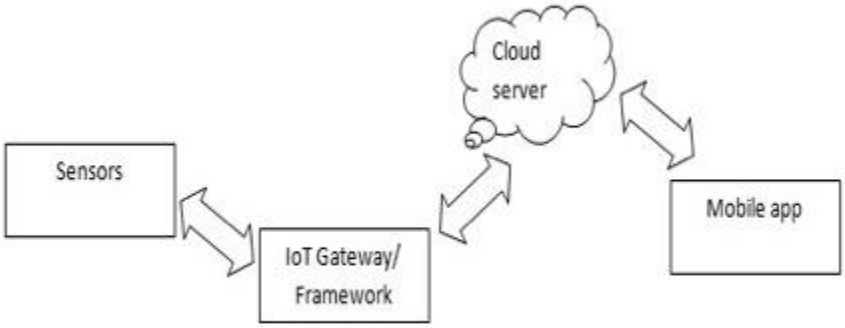

Fig 1:- IoT Architecture

Because of the rapid spread of mobile phones, mobile data management applications are being increased. Now Smart phones has become a platform both for computing and communication. Mobile phones are becoming cheaper, easier to use, and can be used for multiple types of information transmission. Along with sensor technology, the mobile data applications can improve the efficiency as well as accuracy of the data reporting for water quality monitoring system. Smart phones/tablets having sensors embedded with display and keypad can be connected to the Internet with an IP address (satisfies every requirement of an IoT device)[11]. They will work as the hub or remote control for IoT. Smart things are part of the Internet; authorized users have access to information; servers act as a sink to collect data from each object in Ubiquitous Network Architecture.

IV. IMPLEMENTATION

This system makes use of many sensors (pH, conductivity, turbidity, temperature, oxidation-reduction potential), processing module microcontroller, These sensors capture the data in the form of analog signals. The ADC converts these signals into the digital format. These digital signals are sent to the microcontroller via a Wi-Fi module. The microcontroller will furtherance the digital information, analyze it, and further communication is done by the Wi-fi module. The Wi-Fi module sends an Information with the water quality parameters onto the smart phone or PC of the concerned user, which also displayed on the LCD of the micro controller. In this water quality monitoring system, microcontroller accepts and processes the data collected from the sensors to the Web. page via Wi-Fi module. This is carried out with the help of coding. The code is written in Embedded-C and using the Arduino software to simulate the code.

Figure 2 shows the water quality monitoring system which employs sensors to collect the data. Then this data is given to the LPC2148 microcontroller module for processing and transferred via the ESP8266 Wi-Fi data communication module to the central server. This data can be accessed by the authorized users by logging into their accounts using a User ID and password to view data. The data is collected, processed, analyzed, and transmitted and displayed all in real time.

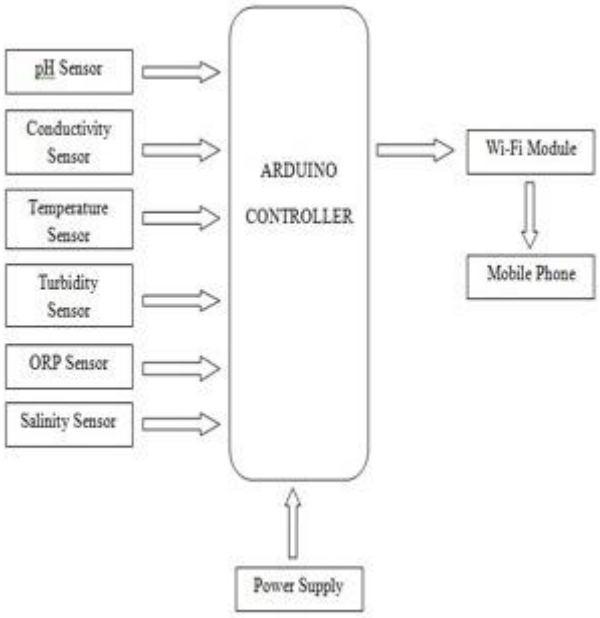

Fig 2:-Water Quality Monitoring System

A. ARDUINO UNO

The Arduino Uno microcontroller is based on real time emulation and embedded trace support. It supports embedded high speed flash memory. It is good to use where size is a key requirement for access control and point-of-sale applications, due to its low power consumption and small size. It is suitable for gateways and protocol converters in communication, soft modem, voice recognition, low resolution imaging, and provides high processing power and large buffer size[12].

B. WI-FI MODULE

The ESP8266 is a low cost Wi-Fi module consists of Wi-Fi chip with full TCP/IP stack and micro controller chip manufactured by M/S Espruino. It is a WLAN network, which hosts the applications or offload Wi-Fi network functions from other application processor. It boots up directly from external flash, during hosting the applications. Because of its integrated cache, performance of the system is improved and memory requirement is also minimized. Using CPU AHB bridge interface or UART interface, wireless Internet access can be introduced to any microcontroller based design when Wi-Fi module works as Wi-Fi adapter.

It uses serial transceiver (Tx/Rx) to send and receive data in Ethernet buffers, and serial commands to query and change configurations of the Wi-Fi module[13]. It only requires two wires (Tx/Rx) to communicate between a microcontroller and Wi-Fi module. It offloads Wi-Fi-related tasks to the module, allowing the microcontroller code to be very light-weighted. Wi-Fi Module is addressable over SPI and UART, making it easy to build an Internet of Things application. We use AT commands to connect to Wi-Fi networks and open TCP connections without need to have TCP/IP stack running in our own microcontroller. By just directing connecting the microcontroller to this module, we can start pushing data up to the Internet (Central server).

C. SENSORS

A transducer device used to detect events or changes in its environment, and then provide a corresponding electrical output is called a sensor. Precision, resolution, linearity, and speed are the most important characteristics of a sensor. Sensor calibration improves the sensor performance. By removing structural errors in the sensor outputs, its performance can be enhanced. Such errors can be find out by taking difference between sensor's measured output and its expected output[14]. Above repeatable errors obtained during calibration are compensated in real time during measurements carried out by sensors.

1. pH Sensor

pH is defined as a measure of how acidic or basic alkaline the water is! It is circumscribed as the negative log of the hydrogen ion concentration. The pH scale is logarithmic and its value goes from 0 to 14, and pH term translates the values of the hydrogen ion concentration. It is low for acidic and high for alkaline solutions. The pH of pure water is around 7. The hydrogen ion concentration decreases ten-fold and water becomes less acidic, for each increase in number of pH. A pH sensor has two electrodes namely; measuring electrode and a reference electrode. The positive terminal of a battery is connected to the measuring electrode and negative terminal to the reference electrode. The reference electrode gives fixed potential and when pH sensor immersed in the solution, the reference electrode does not change with changing hydrogen ion concentration.

2 Conductivity Sensor

Salts dissolve in water breaks into positive and negative ions. Conductivity is the ability of water to conduct an electrical current and dissolved ions are the conductors. The major positively charged ions are sodium, calcium, potassium, and magnesium and the major negatively charged ions are chloride, sulfate, carbonate, and bicarbonate. Minor charged ions to the conductivity are nitrates and phosphates. Electric conductivity is measured with the help of a probe and a meter. The probe consists of two metal electrodes spaced 1 cm apart (unit: mili- or micro-Siemens per cm). A constant voltage is applied across electrodes. The

current flow through the water is proportional to the concentration of dissolved ions in the water, which measures the electrical conductivity.

3 Turbidity Sensor

Turbidity is defined as the quantitative measure of suspended particles in a fluid. It can be soil in water or chocolate flakes in your favorite milk shake. While chocolate is something we so want in our drinks, soil particles are totally undesired. Keeping aside the potable purposes, there are several industrial and household solutions that make use of water in some or other manner - for example, a power plant needs them to cool the reactors, washing machines and dish washers depend on water.

4 Temperature Sensor

A chip that tells you what the ambient temperature is called an Analog temperature sensor. To determine the temperature, these sensors use a solid-state technique .That's to mention, they don't use mercury, bimetallic strips, nor do they use thermistors. Instead, they use the actual fact as temperature will increase; the voltage across a diode will increase at an acknowledged rate. In Technical aspect, this is actually the voltage drop between the base and emitter-the Vbe- of transistor. By amplifying the voltage change, it is simple to generate an analog signal that is directly proportional to temperature. In this, we are using LM35 sensor.

5 ORP Sensor

An Oxidation Reduction Potential Sensor measures the activity of oxidizers and reducers in an aqueous solution. ORP sensor is a potentiometric measurement from a two-electrode system similar to a pH sensor. Sometimes it is also referred to as a redox measurement. An ORP sensor measures the ratio of oxidized to reduced forms of all chemical species in solution, unlike a pH sensor.

6 Salinity Sensor

A Sensor precisely measures the total dissolved salt content in an aqueous solution is the salinity sensor. They measure water with a wide variety of salinities, from brackish water to ocean water, and even hyper-saline environments. The Salinity sensor is capable of measuring the entire range of 24-52,000 ppm (parts per million). One of the most basic tests conducted in solutions is salinity. It determines the total concentration of salts in a sample. In a solution, current flows by ion transport. Increase in the concentration of ions in the solution will result in higher conductivity values. The Salinity sensor contains two carbon electrodes. A potential difference is applied to these electrodes which results in a current proportional to the concentration of the solution.

D. THINGSPEAK

HTTP over Internet. Anyone can create applications like sensor logging, location tracking, and social network of things with status updates with the help of ThingSpeak[15]. It is an public domain IoT application and API to store and retrieve data from things with the help of HTTP and MQTT protocol over the Internet or via a Local Area Network. it enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates API of ThingSpeak permits processing of numeric data like averaging, median, summing, rounding and time scaling. it supports 8 data fields, elevation, latitude, longitude, and status. they can send sensors data to cloud to store data in a channel using sensors and websites. Cloud provides easy access to the stored data. ThingSpeak channel data can be analyzed, visualized , calculate new data, or interact with web sites and social media. With this one can calculate new data, and visualize data in the form of plots, charts, and gauges using analytical tools online. ThingSpeak can access MATLAB to provide sensor data. It uses instruments for devices to communicate for actions. One can react both to raw data and new data in a channel and also can help devices to execute by queuing the commands.

V. RESULT

Authorized users can access data by logging on ThingSpeak website. On entering the registered user ID and password, it will be directed to the web page where the parameters are displayed in real-time in the form of plots. The credentials of water quality monitoring system can be enhanced to obtain more efficient reliable results. The number of parameters to be sensed can be increased by the addition of multiple sensors to measure dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonia nitrogen, nitrate, nitrite, phosphate. The system can be further upgraded using wireless sensor networks. The system can be expanded to pay continued attention to hydrologic, air pollution, industrial and agricultural production and so on. It has widespread application and extension value.

VI. CONCLUSION

The Water Quality Monitoring System is a real time system for water quality measurement based on GSM. The system is incredibly versatile and economical. This system that measures numerous parameters pertaining to the water and send them to the monitoring center. It can monitor water quality automatically, and it is low in cost and doesn't need individuals on duty. The system has good flexibility. It is a versatile system, because of which simply by replacing the sensors and by making some changes within the computer code, the system can be used to measure some other parameters of water. The proposed system is reliable , easy to maintain and it can be extended to measure water pollution as well. By effectively using the proposed system, one can save time and cost can also be reduced.

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