International Journal of Modern Electronics and Communication Engineering (IJMECE) ISSN: 2321-2152
Volume No.-7, Issue No.-1, January, 2019

IoT based Portable Water Quality Monitoring and Notification System

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Abstract: Creeks and estuaries play a vital role in providing shelters for aquatic organisms. Recent time has witnessed severe degradation of water quality of estuaries owing to heavy industrialization, rise in population, agriculture and anthropogenic activities. The dumping of the industrial effluents, domestic sewages into the estuaries have accelerated the deterioration of their quality. Monitoring and analysis of the various hydrological parameters of the estuaries give us a fair idea of their pollution, thereby enabling us to report their quality status. Moreover, the accidental and purposive hazardous dumping of chemicals and other toxic materials from the industries and other sources pose an immediate threat to public health. In order to deal with such emergency situation, it is peremptory to measure the various water quality parameters in real time to get a fair idea of any unusual signs of water quality deterioration, so that necessary corrective measures can be initiated in time. This paper proposes an Internet of Things (IoT) design for real time portable water quality monitoring and notification system, measuring the basic water parameters such as pH, temperature, electrical conductivity. Such system can also create an awareness and aid to alleviate the risk associated with the spreading of pollution from various sources.

Keywords: Real time water quality monitoring, Internet of Things (IoT), Thane creek

I. INTRODUCTION

Water is one of the most valuable natural resources essential for human survival and the ecosystem's health. Water comprises of coastal water bodies and fresh water bodies (lakes, river and groundwater). Water pollution occurs when a water body is adversely affected due to the addition of large amount of unwanted, harmful materials. The contamination and pollution of water is of great concern for us now and the problem of water pollution has acquired a critical stage. Water pollution can result from several natural sources or from various anthropogenic activities like waste material from industrial processes, water runoff from agricultural lands, domestic effluents and sewage, waste treatment plants to name a few.

With the advent of urbanization and increasing populations, there is a major demand for drinking water. In view of the increasing problem of deterioration of water quality and the resultant health hazards, it is necessary to implement efficient water quality monitoring and surveillance systems. Moreover, random variations in the water quality are possible due to certain unpredictable events. Sudden heavy rain or storm may lead to enhanced mud flows and polluted runoffs. Accidental releases of hazardous chemicals and toxic materials into the water bodies may occur without any early warning. Some industrial chemical disasters in worst case, can also be life threatening. Therefore, to address the above issues, real time analyses of the various water quality parameters are required. This may further support early warning and decision making under critical situations.

The traditional water monitoring methods rely on collecting water samples, testing and analysing water samples in laboratories which are not only costly but lack capability for real time data capture and analyses. Further research is required to improve the available technologies for water quality monitoring in terms of their simplification and increased cost effectiveness.

In this project, a case study was conducted in assessing the water quality of thane creek . Thane creek (Longitude 72°.55" to 73°.00" E & latitude 19°.00" to 19°.15" N) lies to the south of Bombay Harbor extending northwards joining Ulhas river estuary through a minor connection near Thane city. The creek is tide dominated and is fringed with mangrove mudflats along both the banks. The heavy domestic and industrial effluents received by the creek are due to the industrial complexes and densely populated residential complexes across the banks of the thane creek. The creek is has a width of 200-500 m and depth of 3-9 m approximately. The water samples were collected during high tide between the pillars of thane Creek Bridge. Several laboratory tests were conducted for the physical and chemical analysis of the water samples in order to indicate the suitability of the creek's water for domestic use.

In this project, it is proposed to develop a portable multi-parameter water quality monitoring system would be deployed in situ for the study of quality parameters in real time. This paper also proposes an Internet of things (IoT) set up to display the monitored data in real time on internet, fulfilling the notion of analyzing and there by devising measures to prevent the enormous amount of water pollution in view of the increasing demand of potable water supply.

II. EARLIER WORK

Many wireless sensor network (WSN) based systems have been designed for the real time monitoring of a variety of water quality parameters. Cesar Encinas et al. designed a aquaculture water quality monitoring system based on wireless sensor networks and Internet of Things (IoT).The system developed was claimed to be modular, portable, low cost, versatile option for remote monitoring of dissolved oxygen, pH and temperature of water and allowed sharing of necessary information through cloud for improvement of aquaculture activities[1].Cho Z. Myint et al. proposed a real time IoT based water quality monitoring system with reconfigurable smart sensor interface device, Field Programmable Gate Array (FPGA) design board, Zigbee based wireless communication module. The system measured parameters of surface water like pH, water level, turbidity, carbon dioxide (CO_2), temperature in real time basis, minimizing the time and cost involved in such water quality measurements [2]. Salim T.I. et al. proposed an WIFI integrated online water monitoring (OWM) system for measurements such as temperature, pH, Dissolved Oxygen, Turbidity, Conductivity, TDS, Salinity, etc. with high data sampling rate enabling real time measurements. Additionally, with the provision of historical view feature, all the old measurement data were analyzed [3]. K. H. Kamaludin et al. also developed similar IoT based water quality monitoring system with embedded Radio Frequency Identification (RFID) system, Wireless Sensor Network (WSN) platform and Internet Protocol (IP) based communication into a single platform with LOS data transmission range up to 6.5km[4] whereas WSN based water quality monitoring system developed by Dziri Jalal et al. had additional anomalies detection algorithm to detect the contamination and malicious acts in the drinking water distribution system[5].

Scientists at CSIR-CEERI, Pilani developed portable water quality measurement unit installed on a floating platform to measure water quality parameters such as dissolved oxygen, pH, temperature, environment pressure and conductivity. The unit possessed wireless communication interface to communicate with central unit for remote monitoring, control and data transfer for appropriate management of aquaculture [6]. B. Menaka Devi et al. projected an approach to determine the quality of water using low cost and in-pipe sensors. An array of sensor node based on PIC1640 processor core was developed to assess the quality of water. Algorithms were developed for fusing the data collected by the sensors like flow sensor, conductivity sensor, temperature sensor, pH sensor, ORP sensor and turbidity sensor. ZigBee transceiver and GSM transmitters were used to transmit the collected data to the server [7].

Each of the systems aforementioned had been designed to cater to individual applications and needs. Moreover, the commercially available multi-parameter water quality monitoring systems are very expensive and not easily accessible.

III. SYSTEM BLOCK DIGRAM

The proposed system comprises of the sensor unit containing multiple sensors for multiple water parameter monitoring with their respective signal conditioning units, processor, power supply unit, transmitter unit for wireless transmission as shown in figure 1.

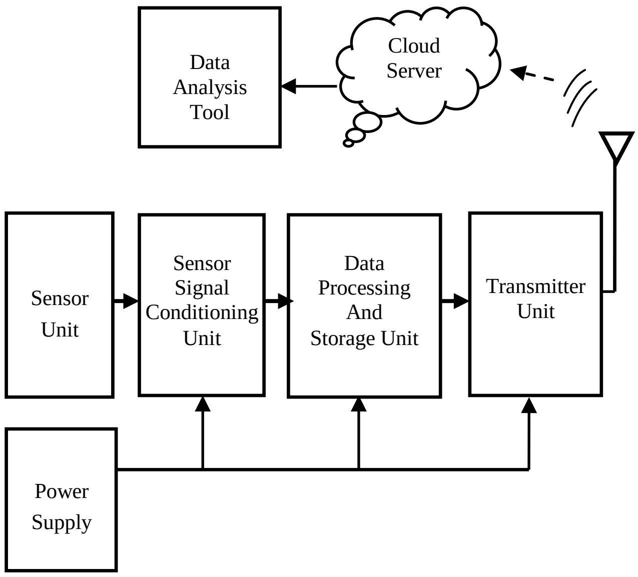


Figure1. System block diagram

Sensor Unit: In this section, sensors used are - an analog temperature sensor (pt100), Microset pH Probe sensor and Microset Electrical conductivity Probe sensor. Each of these sensors is submerged in the water samples and the measurements are recorded.

Signal conditioning unit: The data acquisition system is calibrated for the input voltage range 0-5V. Signals from the sensors are suitably processed like amplified, filtered (for any noise elimination) to achieve accurate measurements. The pH probe with glass electrodes have very high output impedance and low output voltage, thereby requires interfacing to high input impedance voltage measuring circuit. The signal conditioning circuits for various sensors are designed, developed and tested in the laboratory.

Data processing and storage: The processing unit is responsible to control the entire operation of the proposed system. The Arduino Uno processor board is used in the design. The analog signals from the signal conditioning unit are fed to the ADC pins of Arduino board, getting converted into an equivalent digital quantity and are further processed. The processor board also acts as a coordinator for wireless communication.

Transmitter unit: It establishes connection between the processor unit and the remote cloud server. All the processed sensor data are collected and information is uploaded to a cloud server using the GPRS network connection.

The IoT set up used in the proposed system enables the real time visualization and remote analysis of the variations in the parameters affecting the quality of water samples kept under observation. In our work, the internet of things application on thingspeak cloud server uploads the data from the remote device and stores them. Several real time plots are visualized on the cloud service indicating the variations in conductivity, temperature and pH of water.

The data output from the cloud server was further uploaded into the Matlab GUI for real time analysis and visualization.

IV. EXPERIMENTAL RESULT AND DISCUSSION

The experimental setup for the continuous measurement of water temperature, pH and conductivity was established as shown in figure 2-3 in the lab. Surface water samples (S1-S12) collected from various locations on the Thane creek bridge were considered for their quality analysis using the developed system. Same samples were also tested for verification and validation using standard measuring instruments at CWPRS (Central Water and Power Research Station), Pune.

In this project, temperature measurement of the water samples was done by platinum type RTD temperature sensor- pt100 which has a linear variation in resistance with temperature. In the current system, the designed signal conditioning unit produces output variation of 10mV with 1°C change in temperature. It was observed that within the temperature range of 0°C to 100°C, output voltage varies from 0V to 0.88V. The sensitivity observed was approximately 10mV/°C.

At 25°C, pH sensor output was noticed to be 0 mV at pH 7 and 59.2mV response per unit pH change. The pH signal conditioning unit displayed output voltage variation of 0.177 V per pH change.

For conductivity measurement, voltage (a low amplitude AC sine wave signal of low kHz frequency) was applied to the sensor probes and the resulting current was measured. The conductivity range was measured between 0-3300µS/cm with a resolution of 10µS/cm. The output voltage variation of the signal conditioning unit was observed to be 66mV per 10µS/cm. The calibration of these sensors with respect to standard instruments and buffer solutions was established which was reported by the author in the earlier research publication [8]. The sensors' outputs were sampled every 10 seconds. Each water sample was tested five times in a row; the average water parameter values were calculated. The data output was further uploaded to the Thingspeak cloud server. The comparison of the observed outputs of the signal conditioning units of various sensors with the standards indicated a close proximity between the two values.

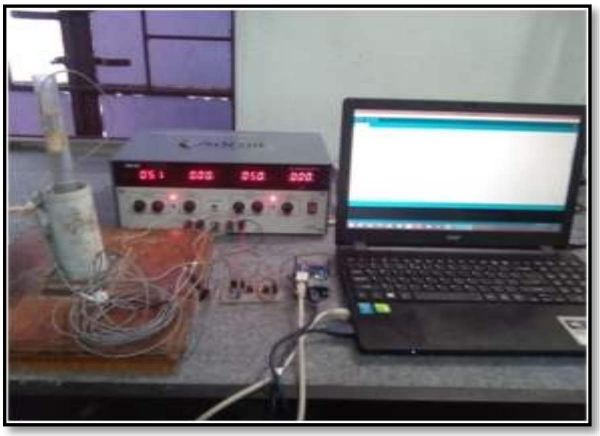


Figure 2. Experimental Setup for temperature

Figure 3. Experimental Setup for pH and conductivity measurement

Table1. displays the values of the several water quality parameters measured by the designed system.

Table1.Water Parameters Measured At 28°C

Sr No.	Samples	pH	EC (µS/cm)	TDS (mg/l)
1	BIS Standard For drinking water	6.5-8.5	400	500
2	S1	7.13	357	232.0
3	S2	6.90	333	216.4
4	S3	6.65	302	196.3
5	S4	6.68	216	140.4
6	S5	6.57	259	168.3
7	S6	6.57	261	169.6
8	S7	6.70	248	161.2
9	S8	6.61	228	148.2
10	S9	6.81	266	172.9
11	S10	6.51	241	156.6
12	S11	6.65	254	165.1
13	S12	6.84	297	193.0

Real time plots obtained for the basic water quality parameters as shown in figure 4-5 were visualized at thing speak webserver https://thingspeak.com.

The change in the pH and conductivity of the water sample under test is suitably and accurately indicated through the plot (figure 4). The change in temperature with time is properly observed from the plot (figure 5).

Figure 4. pH and conductance vs.Time plot at https://thingspeak.com

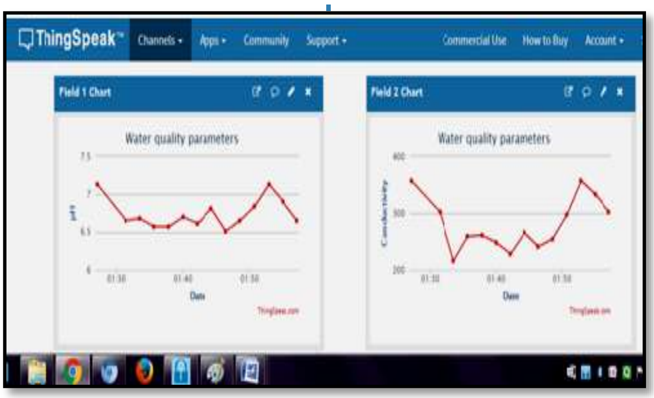
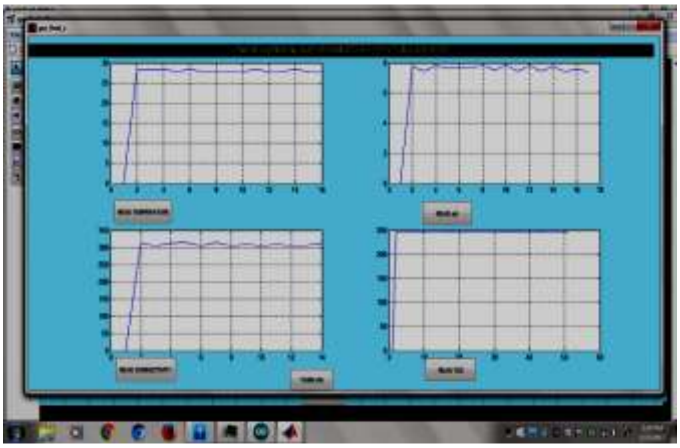


Figure 5. Temp vs. Time plot at https://thingspeak.com

Real time plots obtained for the basic water quality parameters as shown in figure 6 were visualized using Matlab GUI plot functions.

Figure 6. Plots of water quality parameters on Matlab GUI



V. CONCLUSION AND FUTURE SCOPE

The project provides cost effective solution the basic water quality measurements in real time. Such measurements may serve as early warning system so that it would be able to identify the location in the water bodies where there necessity of water quality analysis, ensuring safe and secure water for various applications. The initial laboratory experiments were conducted for the various sensor calibrations. The results obtained from the designed electronic circuits indicated fair closeness to the standard instruments and is in accordance to the BIS standards. The water samples under test were found to be potable agreeing to the potable water quality standard. Future work is focused to the miniaturization of the designed electronic circuits and implementing the entire multi-parameter real time water quality monitoring set up on a floating platform. Such an arrangement is proposed to be deployed for long time to continuously monitor the estuarine or surface water.

Further, on the success of one such system, multiple prototypes of the aforementioned system are proposed to be generated to monitor the water quality at different locations of the water body.

ACKNOWLEDGEMENT

This work has been supported by the Department of Electronic Science, Fergusson College, Pune. We are also grateful to Shri. Kishore Kumar Swain, Scientist 'B', Central Water & Power Research Station, Khadakwasla, Pune for his valuable guidance and support.

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