

Developing a Real Time Sensor to Monitor Water Quality in IoT Environment

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ABSTRACT: In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time. In this paper we present a design and development of a low cost system for real time monitoring of the water quality in IOT(internet of things).The system consist of several sensors is used to measuring physical and chemical parameters of the water. The parameters such as temperature, PH, turbidity, conductivity, dissolved oxygen of the water can be measured. The measured values from the sensors can be processed by the core controller. The raspberry PI B+ model can be used as a core controller. The results indicate that this inexpensive system is capable of detecting these high impact contaminants at fairly low concentrations. The results demonstrate that this system satisfies the online, in-pipe, low deployment-operation cost, and good detection accuracy criteria of an ideal early warning system.

KEYWORDS: Water quality monitoring, Internet of Things, Raspberry PI, Cloud computing.

I. INTRODUCTION

Clean drinking water is a critical resource, important for the health and well-being of all humans. Drinking water utilities are facing new challenges in their real-time operation because of limited water resources, intensive budget requirements, growing population, ageing infrastructure, increasingly stringent regulations and increased attention towards safeguarding water supplies from accidental or deliberate contamination. There is a need for better on-line water monitoring systems given that existing laboratory-based methods are too slow to develop operational response and do not provide a level of public health protection in real time.

Traditional methods of water quality control involve the manual collection of water samples at various locations and at different times, followed by laboratory analytical techniques in order to characterize the water quality. Although, the current methodology allows a thorough analysis including chemical and biological agents, it has several drawbacks: a) the lack of real-time water quality information to enable critical decisions for public health protection (long time gaps between sampling and detection of contamination) b) poor spatiotemporal coverage (small number locations are sampled) c) it is labor intensive and has relatively high costs (labor, operation and equipment). Therefore, there is a clear need for continuous on-line water quality monitoring with efficient spatio-temporal resolution. The main conclusion was that many of the chemical and biological contaminants used have an effect on many water parameters monitored including Turbidity (TU), Oxidation Reduction Potential (ORP), Electrical Conductivity (EC) and pH.

By focusing on the above issues our paper design and develop a low cost system for real time monitoring of the water quality in IOT environment. In our design raspberry PI B+ is used as a core controller. The design system applies a specialized IOT module for accessing sensor data from core controller to the cloud. The sensor data can be viewed on the cloud using a special IP address. Additionally the IOT module also provides a Wi-Fi for viewing the data on mobile. There is a clear need for a shift in the current monitoring paradigm and this paper proposes the idea of monitoring the quality of water delivered to consumers, using low cost, low power and tiny in-pipe sensors. In particular, the contributions regarding the low cost system is the design and development of low cost networked embedded systems as well as optical sensors (turbidity) for water quality monitoring.

The remaining of this paper is organized as follows. Section II reviews related work with IOT. Section III presents the methodology and justification for the selection of water quality parameters to be monitored. Section IV presents the

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system design and the experimental implementation of the hardware and software modules. Section V validates the performance of the developed system and finally the paper concludes.

II. RELATED WORKS

The internet has changed all the human lives in past deader. The IOT becomes a foundation for connecting things, sensors and other smart technologies [6]. IOT is an extension of the internet [7].IOT gives an immediate access to information about physical objects and leads to innovative service with high efficiency and productivity. There are several important technologies related to the IOT are ubiquitous computing, RFIP, wireless sensor network, cloud computing.

Cloud computing is a large-scale, low cost processing unit, which is based on the IP a connection for calculation and storage .The characteristics of the cloud computing has been discussed in [8],[9],[10],[11]. The IoT application areas include home automation, water environment monitoring, and water quality monitoring etc. the water quality monitoring application involves large distributed array of monitoring sensor and a large distribution network [12], [13]. It also requires separate monitoring algorithms as reviewed in [14]. In our proposed method, we introduced a cloud computing technique for viewing sensor values on the internet. The rest of this paper is organized as follows.

In addition, several water monitoring microsystems (sensor nodes) have been developed for large scale water monitoring based on wireless sensor networks (WSNs) technology. In a sensor node is developed for monitoring salinity in ground waters as well as the water temperature in surface waters.

III. METHODS

Drinking water quality standards are determined according to World Health Organization (WHO) [12] guidelines for drinking-water quality as well as These organizations set the standards for drinking water quality parameters and indicate which microbiological, chemical and indicator parameters must be monitored and tested regularly in order to protect the health of the consumers and to make sure the water is wholesome and clean. Table I enumerates the suggested parameters to be monitored.

TABLE I
SUGGESTED PARAMETERS TO BE MONITORED

	Parameter	Units	Quality Range	Meas. Cost
1	Turbidity	NTU	0 - 5	Medium
2	Free Residual Chlorine	mg/L	0.2 - 2	High
3	ORP	mV	650 - 800	Low
4	Nitrates	mg/L	<10	High
5	Temperature	°C	-	Low
6	pH	pH	6.5 - 8.5	Low
7	Electrical Conductivity	μS/cm	500 - 1000	Low
8	Dissolved Oxygen	mg/L	-	Medium

Table I also presents the measurement cost (for purchase and maintenance) associated with these parameters based on recent review of measurement and instrumentation methods, compensation and calibration procedures and probe lifetime concerning these parameters. Therefore, the parameters selected to be monitored are the following: 1) Turbidity, 2) Oxidation Reduction Potential (instead of Free Chlorine), 3) Temperature 4) pH, and 5) Electrical Conductivity. It is noted that Free Chlorine concentration (HOCl) can be approximated based on the ORP, pH and temperature measurements.

In this section, we present the theory on real time monitoring of water quality in IoT environment. In section III A, the overall block diagram of the proposed method is explained. In section III B, each and every block of the system is explained in detail.

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A. OVERALL BLOCK DIAGRAM

The overall block diagram of the system is shown in fig 1.

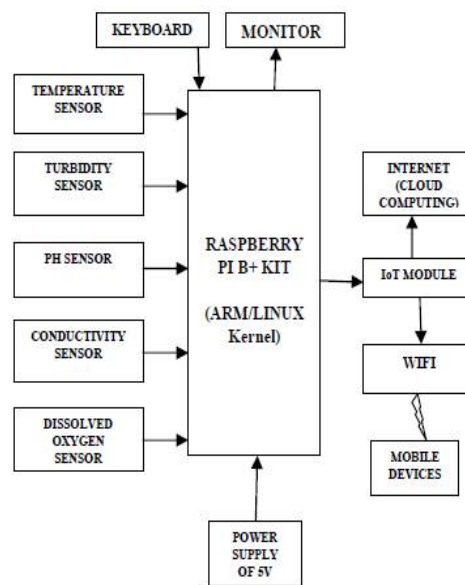


Fig 1: Overall Block diagram

In this proposed block diagram consist of several sensors (temperature, Ph, turbidity, conductivity, dissolved oxygen) is connected to core controller. The core controller are accessing the sensor values and processing them to transfer the data through internet. Raspberry PI is used as a core controller. The sensor data can be viewed on the internet using cloud computing.

B. PROPOSED SYSTEM

In our proposed method, Raspberry PI B+ is used as a core controller. The raspberry pi is run on LINUX kernel by the use of keyboard and monitors the LINUX OS is boot on to the Raspberry PI. The temperature sensor, conductivity sensor, turbidity sensor, dissolved oxygen sensor, Ph sensor can be read directly from the command line. However, this requires us to input a command every time we want to know the sensors reading. Then Raspberry Pi sends the data to the IoT module. The IoT module send the data to internet using cloud computing and also to WIFI for accessing mobile devices. The hardware circuit diagram for connecting IoT module with Raspberry Pi is shown in fig 2.

Then the monitoring parameters of the water from the sensors are transmitted through IoT module to the gateway. The gateway is responsible for data analysis and forward sensing data to the remote server. The server collects sample data by receiving the UDP packets containing sample data from the IoT module and gateway and store in database.

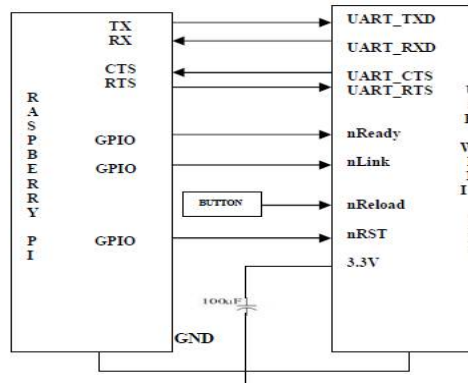


Fig.2 Circuit diagram for connecting core controller to IoT module.

IV. EXPERIMENTAL VALIDATION

In this section we present the results of the experimental trials performed to validate the behaviour and evaluate the performance of the developed hardware and algorithms on intentional contamination events. The experimental setup consists of the sensor node that takes samples every 5s from potable water flowing through a flow cell. Escherichia coli bacteria and arsenic contamination in drinking water is very severe problem.

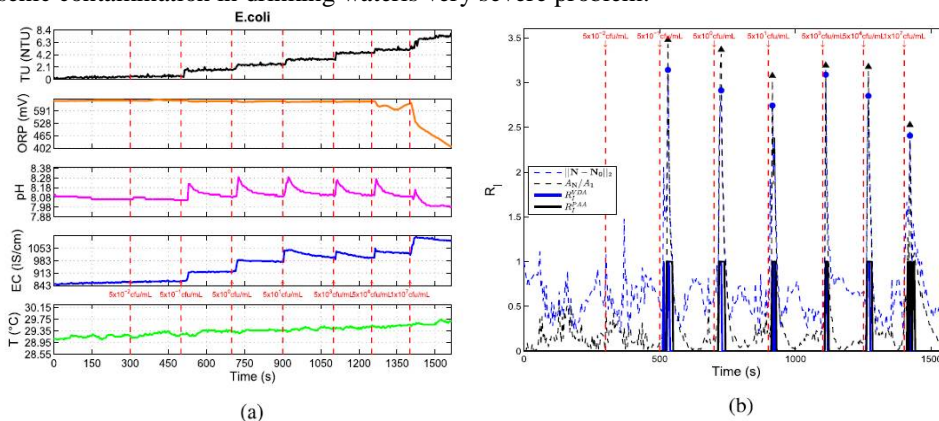


Fig. 7. Experiments with E.coli bacteria contaminated water. (a) Sensors responses to E.coli bacteria. (b) E.Coli bacteria contamination detection.

Fig. 7(a) presents the measurements received using the developed sensor node when the following concentrations of E.coli were injected: 5×10^{-2} , 5×10^{-1} , 5×10^0 , 5×10^1 , 5×10^3 , 5×10^4 , 1×10^7 CFU/mL. It is evident that TU and EC sensors responded well when microbiological contaminants injected in chlorinated potable water. ORP sensors has responded with delay and pH sensor has a spiky type of response. Fig. 7(b) presents the output signals of the Vector Distance Algorithm (VDA) and Polygon Area Algorithm (PAA). According to WHO guidelines & EU Drinking Water Directive E.coli parametric value is 0 CFU/100mL.

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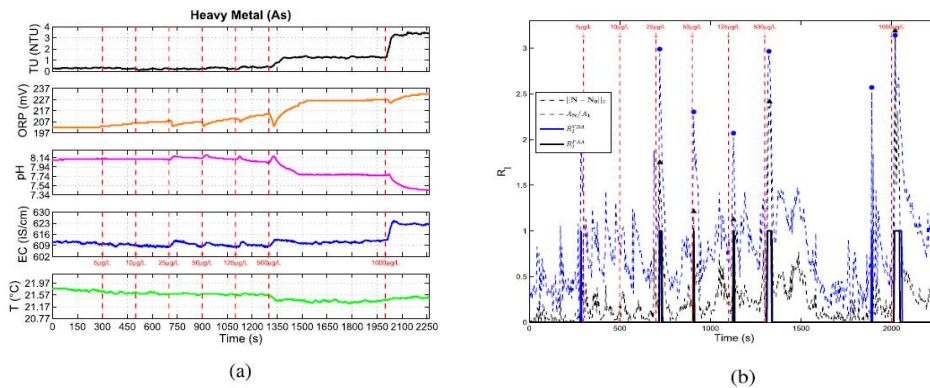


Fig. 8: Experiments with Heavy metals (As) contaminated water. (a) Sensors responses to Heavy metal (As). (b) Heavy metals (As) contamination detection.

Chemically (Arsenic) Contaminated Drinking Water: Water contamination by toxic heavy metals and especially arsenic contamination is a common problem encountered in many countries due to undue deposition of mining, agricultural, industrial and urban wastes in water resources. According to WHO guidelines & EU Drinking Water Directive Arsenic parametric value is 10µg/L.

Fig. 8(a) presents the measurements received using the developed sensor node when the following concentrations of Arsenic were injected: 5, 10, 25, 50, 125, 500, 1000 µg/L. Arsenic solutions created from a standard solution of 1000mg/L As. However, at concentrations above 25 µg/L ORP and pH sensors have responded and at higher concentrations (above 500 µg/L) all sensors responded well. Fig. 8(b) presents the output signals of the Vector Distance Algorithm (VDA) and Polygon Area Algorithm (PAA). The results of Fig.8(b) indicate that both algorithms miss the detection of 5 and 10 µg/L because sensors responses were very sluggish and close to background levels and that the VDA algorithm exhibits two false alarms.

Finally, it should be noted that the signatures of normalized sensor outputs can be further processed to minimize false alarms and to identify the type of contaminants, given that a contamination library is available/developed.

V. CONCLUSION

In this paper, the design and development of the real-time monitoring of the water quality parameters in IoT environment is presented. The proposed system consists of several water quality parameter sensors, Raspberry PI B+ core controller and an IoT module. These devices are low cost, more efficient and capable of processing, analyzing, sending and viewing the data on cloud and also through WIFI to mobile device. Unlike commercially available analysers, the developed system is low cost, low power, lightweight and capable to process, log, and remotely present data. This can implement is suitable for environment monitoring, ecosystem monitoring, etc and the data can be viewed anywhere in the world.

In the future, we plan to implement biological parameter of the water and install the system in several location of pond and also in water distribution network to collect water quality data and send to water board.

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