IoT based smart water quality monitoring system

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Abstract

Internet of Things (IoT) had emerged as a technology critical for environmental applications. Water is a natural resource and is the basic need for living things. In the current world, there is a scarcity of water due to overpopulation and also contamination of water resources. It is very crucial to save our drinking water for current and future generations. IoT based smart water quality monitoring system is proposed to monitor the quality of water. Different sensors are used to monitor various parameters like pH value, turbidity in the water. The microcontroller unit is interfaced with the sensors to process the data and GSM is used to send information to the monitoring centre for further actions to be performed. Results proved that the quality of the water is verified and SMS is sent to a higher authority.

Keywords: Index Terms-pH sensor, GSM module, monitoring, pollution.

1. Introduction

WATER is the one of the natural resource, very essential for human beings, plants and animals to survive. In our earth most part (70%) is drained, only 3% is fresh water. Most of this fresh water is trapped as glaciers and ice caps not suitable for drinking. According to the statistics, only 0.4% of fresh water is suitable for drinking and is shared by the entire world population. Hence water is very precious resource. This resource is contaminated in various places by human beings through contamination, pollution etc [1]. In India, population is growing exponentially and there is scarcity of water. If this condition prevails, water resource will be very expensive and common people cannot afford it. Due to global warming, water resources may be polluted and the organization World Water Council(WWC) is predicting a rapid increase in global population and water scarcity over next 50 years. Extensive measures need to be taken to preserve the existing water resources for

each and every individual. In traditional methods, Water quality is checked manually by collecting samples and testing it in laboratories. In recent days many cost effective mechanisms are proposed to check the quality of water. The quality of water is analyzed with different parameters like pH level, turbidity, chemical oxygen content etc.

2. Related Work

Many modern commercial systems for water monitoring are developed and these systems showed improvement than previous systems tied around traditional or older technologies. Ali et al. [2] studied about various leakage monitoring system developed using wireless sensor network. Jayti Bhatt and Jignesh [4] proposed an IoT based quality monitoring system that consists of sensors to measure various parameters of water and the data is processed by the controller using zigbee protocol for communication. Pule et al [13] presented a survey paper on WSN technology for environment monitoring with a focus on water resources. In Singapore [11], smart water monitoring system was implemented successfully. Smart water system was reviewed by Pujar et. al [12] presented a survey paper on WSN based water monitoring system. The main focus is on the various contamination of river water through sewer, agricultural and industrial wastes. Bichai and Ashbolt analyzed the approach on storm water reuse integrating with monitoring and auditing protocols [5].

Mo et al [6] study has resulted in the development of a Prepaid Water Meter System that allows for prepaid invoicing of water consumption via remote monitoring without the need for human participation. This technology guarantees accurate and timely water billing as well as the prevention of water misuse. However, Seema varma [14] created a water metre reading system that uses a GSM network and is ideal for monitoring water metre readings in remote locations prior to any billing procedure. This could cut the amount of time it takes to read the metre and generate a charge. Dong He [8] also offered a project to monitor electrical metre readings using a GSM network. The technology was capable of monitoring metre readings and sending a billing SMS to the authorised centre. When the authorised person is unable to reach the metre, this could minimise the number of estimated readings. Another project presented by Nazleeni [7] used a wireless text messaging system to send consumers early warning SMS messages encouraging them to minimise their power consumption before the system capacity is reached and the system is shut down. For non-emergency conditions, this could result in a more cost-effective wireless distributed load shedding system. The work presented by Xiwu [9] in the smart home application He was working on a system that would allow him to operate home appliances remotely and offer security while the owner was away. Paul et al. [10] investigated waste water in Solapur. Sulphide concentrations are extremely high, according to the study.

2.1. Other Recommendations

Tirupur is a city in the region of the Indian state of Tamil Nadu formed in February 2009 (Fig 1). Tirupur is the Sixth largest urban agglomeration in Tamil Nadu and is situated between $11^\circ 10' N$ to $11^\circ 22' N$ latitude and $77^\circ 21' E$ to $77^\circ 50' E$ longitude. Tirupur lies on the banks of Noyyal River, a branch of Cauvery river. The district is well-developed and industrialized. Tirupur is a major textile and knit wear hub contributing to 90% of total cotton knit wear exports from India. It is popularly known as “Banian City” of south India. The textile industry provides employment to over six lakh people and contributed to exports worth 200 billion (US$3.0 billion) annually and also provided its contribution in the domestic market.

Tirupur is renowned as the country’s textile centre. Tiruppur’s banian industries support a thriving economy. The Tirupur cluster consists approximately 5000 units that are involved in one

Figure 1: Tirupur Map

Figure 2: Noyyal river pollution

or more aspects of the textile value chain. Nearly 90 million litres of effluent are discharged on land or into the Noyyal River, contaminating ground and surface water and soil in and around Tirupur and downstream. For dyeing and bleaching, Tirupur's textile industry employs bleaching solutions, soda ash, caustic soda, sulphuric acid, hydrochloric acid, sodium peroxide, and different dyes and chemicals. Other potentially dangerous compounds include a variety of colours, many of which are based on benzidine molecules, as well as heavy metals, both of which are known to be toxic. The majority of these chemicals are discarded as wastewater rather than being kept in the finished hosiery goods. The wastewater is acidic, stinks bad, and has dissolved particles, all of which raise the biological and chemical oxygen demand in the water. The Orathupalayam dam on the Noyyal River was built at a cost of Rs.16.46 crores to irrigate 500 acres in Erode and 9875 acres in Karur districts. Instead, in this dam, of storing fresh water, it has became a storage tank for waste water as the textile units started releasing their effluent into the dam's reservoir as shown in fig 2.
With no freshwater available for dilution the groundwater from Coimbatore and Tirupur is no longer suited for irrigation.

3. Proposed Work

Water quality detection has traditionally been done by hand, with water samples being collected and sent to laboratories for analysis. Because these approaches failed to offer real-time data, a smart

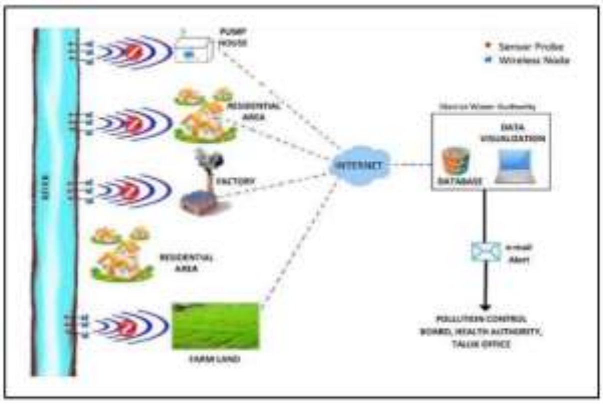

Figure 3: Water Monitoring System

IoT-based water quality monitoring system based on a wireless network was developed in India, as illustrated in fig 3. It allows for continuous and remote monitoring of water quality data.

The monitoring scenario is separated into four general sections, each creating a cluster of multiple wireless sensor nodes responsible for sensing, data collecting and processing, and communication. The system's wireless sensor node is designed to monitor three of the most important characteristics that determine water quality: pH, conductivity, and temperature.

The continuous monitoring on the dye that gets mixed into the river water is carried out because the quality of water varies from dye that is mixed into the river. Consider if a dye 'A' of 20L is mixed to the river, reduces the purity of water by 25% and if a dye 'B' of 50L is mixed to the river, reduces the purity of water by 25%. It is essential to monitor the dye that is sent to the water.

A periodical recording of amount of dye mixing in water is done and if the reduction in the purity of water per day exceeds the limit (i.e., purity reduced by 25%) then an alert mail is sent to the corporation.

Here wireless sensors are used in finding the purity of water in depth-wise to monitor whether any aquatic animals are affected.(i.e., up to 50 meters what is the purity of water and up to 100 meters what is the purity of water).

4. Experimental Set Up

The modules of the water monitoring system shown in fig. 4 are discussed in brief in this section.

The modules in IoT based water monitoring and alert system are

PIC microcontroller PIC16f877a

PIC Microcontroller, a 40 pin package is used in water monitoring system that operates in 4.2 volts -5.5 volts power supply with the operating frequency of 20MHz. This microcontroller has input and output ports suitable to connect to any peripheral device either in anlog or in digital mode.

Power Supply

Power supply module can be operated in regular power supply or in batteries. In this system, 230 volts regular current supply is used. A step 1 transformer is connected to the circuit to convert high volt current supply to low volt supply.

Rectification

In this module AC current is converted into DC. This conversion is done because all electronic components work under DC current. Four diodes are used as rectifiers and a capacitor is used to get pure DC and a fixed volt regulator is used to regulate the current flow in fixed amount. Then LED is used as intimation for power supply.

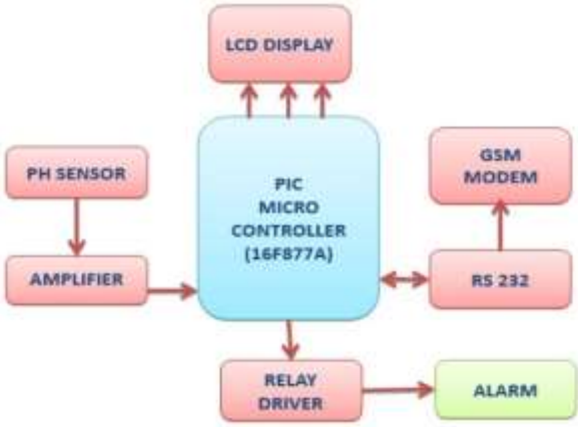

Figure 4: System Block Diagram

Figure 5: pH Sensor

GSM module

A GSM modem is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. An external GSM modem is connected to a PC through a serial cable, a USB cable, Bluetooth or Infrared.

For sending and receiving sms a mobile module is used. A sim is inserted and the power supply needed for GSM is given in form of the DC. Two LEDs are used as intimation one for power supply and other for signal tower. DC Adapter can be used for modem verification.

Sensing unit

The pH of hydrogen ion in water is the negative measure. The pH source [3] for safe drinking water is from 6.5 to 9.5 The source of pH is within the range of 0-14. The low value 0 is for acidic and the value 14 is for alkaline solutions. For each increase in pH value, the concentration of hydrogen ion decreases and hence water becomes less acidic. PH sensor shown in fig 5 is used for checking the purity of water.

Three different states of water is checked

1. High quality
2. Medium quality
3. Low quality

And the condition of water is displayed in LCD display as High, Mid, Low and that status is send as an SMS.

LCD Display

LCD display is used to display the quality of the water that is monitored. LCD display unit operates at 4.7V to 5.3 V. LCD display consists of two registers to data and command register.

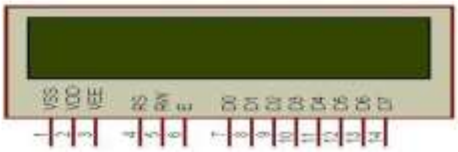

Figure 6: LCD Display

Figure 7: Prototype Model

Alarm unit

Alarm unit is connected to microcontroller with the help of a driver unit. Here transistor driver unit is used and that output is given to a buzzer. Whenever the SMS is sent the alarm will sound.

5. Results and Analysis

The prototype model of IoT based water monitoring system is developed. The model setup consists of an MCU with a sensor network that takes samples from the water outlet to rivers and the parameters are displayed on the LCD display and SMS is also sent to higher officials.
Prototype model of an IoT based water monitoring system as shown in Fig. 7 specify the quality of the water ass High in Quality or Medium in Quality or Low in Quality as Output.

The pH sensor is used to sense the pH value of the water. The pH value sensed is forwarded to the microcontroller for processing. Based on the pH value, display message is sent to LCD display as in Fig.8.

The SMS alert message indicating the quality of the water is also sent to higher officials.

6. Conclusion

The system proposed is an efficient, low cost IoT solution for river water quality monitoring. The system used microcontroller and interfaced with sensors to measure the vital values to monitor the quality of water. The alert message is delivered to respective department officials for further actions. In future, other parameters like dissolved oxygen level, electrical conductivity, chlorine level etc can also be monitored.

Figure 8: LCD Display Message

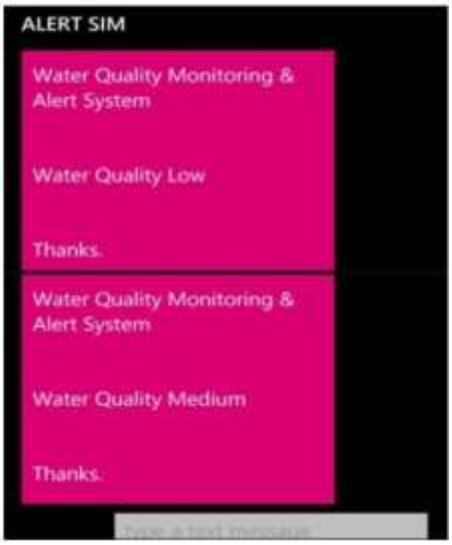

Figure 9: SMS Alert Message

References

[1] U. Ahmed, R. Mumtaz, H. Anwar, S. Mumtaz and A.M. Qamar, *Water quality monitoring: From conventional to emerging technologies*, Water Sci. Technol. Water Supply 20 (2020) 28–45.
[2] H. Ali and J.H. Choi, *A review of underground pipeline leakage and sinkhole monitoring methods based on wireless sensor networking*, Sustainability 11 (2019) 4007.
[3] P.N. Bande and S.J. Nandedkar, *Low-cost sensor network for real-time water quality measurement system*, Int. J. Innovat. Res. Sci. Eng. Technol. 5 (2016) 20691–20696.
[4] J. Bhatt and J. Patoliya, *Iot Based Water Quality Monitoring System*, IRFIC, 4(4) (2016) 44–48.
[5] F. Bichai and N. Ashbolt, *Public health and water quality management in low-exposure stormwater schemes: A critical review of regulatory frameworks and path forward*, Sustain. Cities Soc. 28 (2017) 453–465.
[6] M. Deqing, Z. Ying and C. Shangsong, *Automatic measurement and reporting system of water quality based on GSM*, 2012 Int. Conf. Intell. Syst. Design . Engin. Appl. (2012) 1007–1010.
[7] N.S. Haron, M.K.B. Mahamad, I. Abdul Aziz, M. Mehat, *A system architecture for water quality monitoring system using wired sensors*, 2008 Int. Symp. Inf. Technol. (2008) 1–7.
[8] D. He and L.-X. Zhang, *The water quality monitoring system based on WSN*, 2nd Int. Conf. Consumer Elect. Commun. Networks (2012) 3661–3664.
[9] Y. Liu and X. He, *Design of automatic control system for waterworks based on PLC*, 2nd Int. Conf. Artif. Intell. Manag. Sci. Elect. Commerce (2011) 4996–4998.
[10] S.A. Paul, S.K. Chavan and S.D. Khambe, *Studies on characterization of textile industrial waste water in Solapur city*, Int. J. Chem. Sci. 10(2) (2012) 635–642.
[11] Public Utilities Board Singapore, *Managing the water distribution network with a smart water grid*, Smart Water 1(4) (2016).
[12] P.M. Pujar, H.H. Kenchannavar and U.P. Kulkarni, *Wireless sensor network based water monitoring systems: A survey*, Proc. 2nd Int. Conf. Appl. Theor. Comput. Commun. Technol. iCATccT 2016, Bangalore, India, (2016) 155–159.
[13] M. Pule, A. Yahya and J. Chuma, *Wireless sensor networks: A survey on monitoring water quality*, J. Appl. Res. Technol. 15 (2017) 562–570.
[14] S. Verma, *Wireless sensor network application for water quality monitoring in India*, National Conf. Comput. Commun. Syst. (2012) 1–5.