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WIRELESS SENSOR BASED POTABLE WATER QUALITY MONITORING AND ANALYSIS USING INTERNET OF THINGS(IOT)

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Abstract-Water is the most prominent resource needed to lead a healthy life. Hence, it is pretty important to ensure the quality of drinking water and it must be monitored in real time. Internet of things (IoT) is the mesh of real-time devices, where those devices are sensed, controlled remotely and share their data to cloud-based approaches. IoT based smart devices are designed in a manner that they utilize every bit of data available in everyday life and these devices will use the data to interact with real-time systems. In this paper, we proposed a prototype for water quality monitoring system using IoT which constantly monitors the quality of water and controls it in order to provide potable water. This system uses pHsensor's ,levelsensor's and gas sensor's parameters to measure the water quality. The measured values from the sensors are transmitted to the cloud via the IoT module and the sensor's data can be viewed on system application from anywhere. This project also includes monitoring water quality through mobile devices in the internet via an android application.
Index terms-IoT, WSN, real-time, potable, cloud, Water quality monitoring.

1. INTRODUCTION

IoT enables the objects to be connected in order to computerize complex tasks. When devices can represent themselves digitally, they can be controlled remotely as shown in Fig. 1. The connectivity then helps to make sure the ways of increasing productivity of the system and accuracy [7].Water being the source of survival of all the living beings can also cause diseases that can compromise with the lives of human beings. Due to lack of constant monitoring of water, most of the deadly water-borne diseases are caused by the contaminated water. To overcome this issue, we proposed a system that constantly monitors the water making it potable using IoT.

Figure 1.IoT Architecture

The rest of this paper is structured as follows. Section II analyses the related works that were that were scrutinized and considered important to this article. Section III provides a brief overview of the system architecture. Section IV deals with the qualification criteria that were taken into account while designing the system. Section V describes the analysis of the real-time system .Section VI provides results and conclusionsSection VIII provides acknowledgentand finally, the paper concludes with section VII.

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2. RELATEDWORKS

In this section, a detailed review on the work related to water quality monitoring and analysis using various technologies is presented.

CH Sowmya et.al [5] worked on monitoring the water quality using wireless sensor networks and ZigBee. ZigBee technology is used for mesh networking which can be configured as coordinator, router, and end device. But the end device can only connect to their parents and not with other end devices. By using a variety of simulation tools any deviation in the water parameters are checked and finally, the graphical user interface is provided for users to analyse these data.

Prashant Salunke et.al [4] presented smart sensor interface for monitoring the quality of water using both wired as well as wireless networks.Machine to Machine (M2M) communication bridges both wired and wireless systems. Intel Galileo Gen 2 board as an interfacing device plays a vital role in data acquisition systems and provides genuine communication system.The system performance is tested on water environment and related results were obtained.

Theofanis P. Lambrou et.al [2] proposed a system to monitor the quality of the water, which consists of three subsystems: a central measurement node which gets information from the sensors and transmits the data to the control node which gives notification through SMS /email and finally a small notification node provides local near-tap notifications to the user via interfaced peripherals.

Niel Andre Cloete et.al [1] propounded the design of physiochemical sensors for monitoring the water quality. ZigBee technology is used for communication between the measuring and notification nodes. Data collected from sensors are transmitted to the notification node by the measurement node. Notification nodes give an audio alert when the water reaches hazardous level. Several quality tests are made to certify the parameters of water.

SoundaryaPappuet.al [6] suggested a system that consists of an Arduino microcontroller, which provides sensor values and the raspberry pi 3 which receives the data via serial communication from Arduino. The water quality parameters are estimated using K-means clustering algorithm. The data present in the cloud server can be viewed from mobiles.

From the related works, most of the water quality monitoring systems has sensors that only monitor the quality making the system unreliable such as effusing false alarms, covering an only short range of communication and the setup cost is also high. Our effective proposed system is designed such that it also controls the environment and is suited for long-range connectivity at a fair cost. This system also analyses the history of data to infer meaningful results which in turn helps in maintaining the quality of water in future.

Motivation-India is a peninsula (i.e. covered by water on all the three sides).We has so much of water around us but still, we face water scarcity during the summer and even in the 21st century we can see many people suffer and die from the diseases due to the polluted water. We proposed this system in order to create the social awareness among the people about the quality of the water they are drinking.

3. SYSTEMARCHITECTURE:

In this section the system architecture of the proposed work is presented. The architecture presented below as shown in Fig. 2 comprises of three nodes. A measurement node that gathers data on water quality parameters from sensors and evaluates the water quality using the parameters observed above and transmits those data to the IoT module, A transmission node (IoT module based board) that displays the information on a web page and sends the data to the cloud via GSM technology and a notification node that sends notification to the users regularly via alerts in the android application. This application can also be accessed from remote areas.

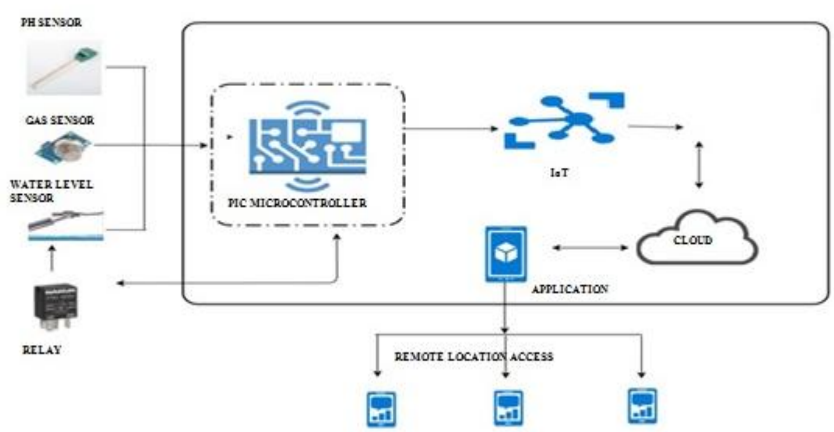
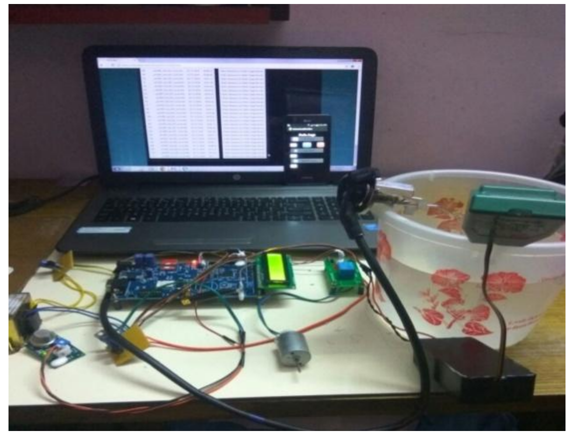


Figure 2. System architecture

4. SYSTEMDESIGN

In this section the system design and modules of the proposed work is presented. When the water is ingested by an organism, it must not result in any kind of health issues. For the water to be potable, it must satisfy certain water quality standards. Quality of the water is validated with respect to the proportion of constituents present in the water. In order to validate the quality standards, the quality of water ought to be monitored regularly and controlled if any of the parameters violate the quality standards. This process is depicted in Fig 4. Fig 3.Shows the permissible limits of various constituents present in water.

4.1 Criteria For Quality Standards:



The initial step to start with is to determine the parameters required to assess whether the quality of water is within the prescribed standards of WHO (world health organization) [8]. Instead of using costlier parameters like ORP, Turbidity and amount of nitrates, the aqua quality can be estimated with simpler and cheaper parameters. The parameters used should be realistic for the real-time monitoring system. The aqua parameters which form the basis of this article are pH, gas, and a level sensor.

(i) pH sensor is similar to traditional pH meter; however, it has automated data collection, plotting, and data analysis in addition to the traditional pH meter. Typical activities of using pH sensor include Acid-base titrations, Monitoring pH change during chemical reactions, Investigations of acid rain and buffering, Analysis of water quality in streams and lakes.

(ii)Gas leak detection is the process of identifying potentially hazardous gas leaks by sensors. These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected. Gas sensors applications include gas detecting equipment for carbon monoxide (CO) in industries.

(iii)Water level sensor rings a buzzer to notify deficit water. Level sensors detect the level of substances that flow, including liquids, slurries granular materials and powders.

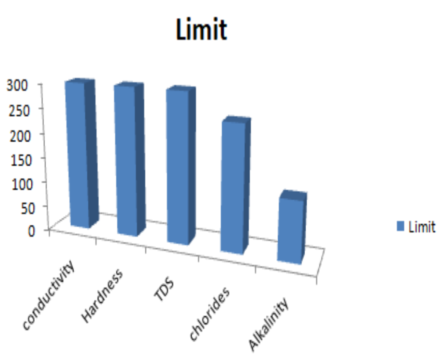


Figure 3.Quality Standards

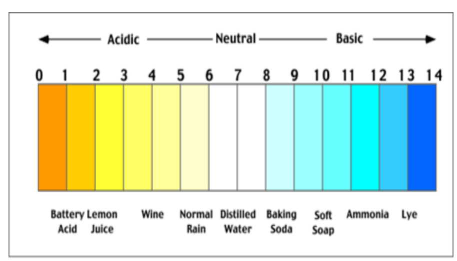


Figure 4. Process

4.2 Sensor Specification:

(1)pH sensor

Figure 5.pH sensor

Figure 6. pH range from acidic to basic

The most conventional water quality measurements considered is pH.pH is the amount of free hydrogen and hydroxyl ions in the water. Water that has supplementary hydrogen ions is acidic, and water that has supplementary hydroxyl ions is alkaline. pH is measured using pH probes immersed in the solution for which the pH is being measured. Its value ranges between 0 and 14. The EPA recommends that public water systems must maintain pH levels between the range 6.5 and 8.5[9]. The above chart explains the various pH levels of water as shown in Fig. 6.
(2) Gas sensor:

Figure 7.Gas sensor Figure 8. Tabulation of permissible range of gases in water

A gas sensor as shown in Fig. 7 is a gadget that detects the presence of hazardous gases in potable water with the idea of providing safety.In drinking water, hazardous gas includes chlorine, sulphur dioxide, ammonia, ozone, and chlorine. This tool is used to detect to a gas leak is interfaced with a control system. A gas sensor outputs an alarm when it detects hazardous gas. This estimation is important as there are gases that can be harmful to organic life.Fig . 8 shows the permissible ranges of gas in drinking water.
(3) Level Sensor:

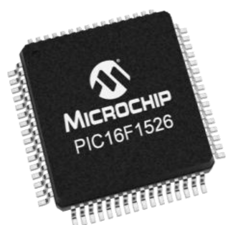


Figure 9. Water level sensor

Water level sensors as shown in Fig. 9 are used to detect the level of water present in the tanks. It trips an alarm when it reaches excess or deficit level. The measurement of level can either be continuous or point values.

4.3 System Modules:
sensing module
A sensor is a sub component of this module whose work is to identify variations in the environment and sends the data to other device .Wireless Sensor Network is a group of sensors used for monitoring the physical conditions of the environment.WSN are the key technology for IoT. This module involves collection of data from various wireless sensors such as pH, gas and level sensors which detect the changes in the water environment and report it continuously to the PIC microcontroller.
transmission module
The major components involved in this transmission include PIC16F1526 and the IoT module.PIC 16F1526 is embedded in the IoT module. (a) PIC 16F1526:

	Permissible ranges (ppm)			
Analytes	**IBWA**	**FDA**	**USEPA**	**WHO**
Cl	250	250	250	250
SO_4	250	250	250	500
PO_4	Na	Na	Na	5
NO_3	45	45	45	50
NO_2	3.3	3.3	3.3	3
Na	Na	Na	Na	200
K	Na	Na	Na	12
Ca	Na	Na	Na	75
Mg	Na	Na	50	Na
Al	0.20	0.20	0.20	0.20
PH	6.5 – 6.8	Na	6.5 – 6.8	6.5 – 6.8
EC(μs/Cm)	Na	Na	Na	400

Figure 10. PIC Microcontroller Figure 11. IoT Module

PIC 16F1526 as shown in Fig. 10 receives data from the sensors available regarding the quality parameters of water. This controller is very reliable to use, with low cost and a flash program memory with self-read/ write capability. However, the readings observed by the sensors are available as an analog value. For easy and better computation the analog values have to be converted into digital values. This is done here with the help of inbuilt ADC present in PIC 16F1526.

(b) IoT MODULE:

An IoT module as shown in Fig. 11 is an electronic gadget embedded in devices that connect to wireless networks used to send and receive data. It is otherwise known as a "radio Chip". It provides" always on" connectivity because these applications must send data automatically, in real time. In addition, they are built to function uninterruptedly for a decade or more.

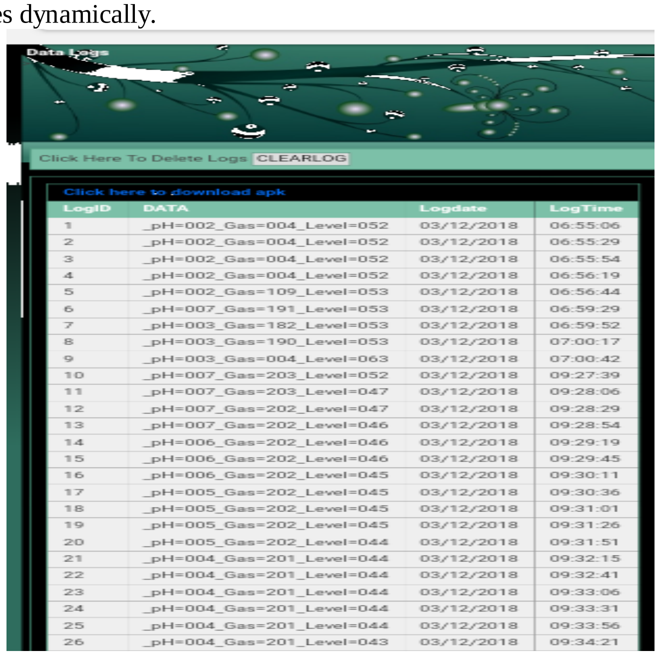
Process-The sensors send data to the pic microcontroller using a device named PICKIT which acts as a mediator to send the embedded coding to the pic microcontroller where the LCD displays the value of pH, gas, and level of water in the tank. The data is sent from the microcontroller to the IoT module through pin 25 and pin 26.

notification module

IoT board receives measurements from the measurement node PIC 16F1526 which is interfaced with the IoT board. Notification module is further sub-divided into 3 sections namely IoT webpage, control view and android application.

(a)IoT Webpage:

The measured parameter's value being displayed in the IoT board is now sent to IoT webpage through the GPS modem SIM800,a complete GSM/GPRS solution embedded in the IoT board. This page as shown in Fig .12 displays the sensed values and updates dynamically.



LogID	DATA	Logdate	LogTime
1	_pH=002_Gas=004_Level=052	03/12/2018	06:55:06
2	_pH=002_Gas=004_Level=052	03/12/2018	06:55:29
3	_pH=002_Gas=004_Level=052	03/12/2018	06:55:54
4	_pH=002_Gas=004_Level=052	03/12/2018	06:56:19
5	_pH=002_Gas=109_Level=053	03/12/2018	06:56:44
6	_pH=007_Gas=191_Level=053	03/12/2018	06:59:29
7	_pH=003_Gas=182_Level=053	03/12/2018	06:59:52
8	_pH=003_Gas=190_Level=053	03/12/2018	07:00:17
9	_pH=003_Gas=004_Level=063	03/12/2018	07:00:42
10	_pH=007_Gas=203_Level=052	03/12/2018	09:27:39
11	_pH=007_Gas=203_Level=047	03/12/2018	09:28:06
12	_pH=007_Gas=202_Level=047	03/12/2018	09:28:29
13	_pH=007_Gas=202_Level=046	03/12/2018	09:28:54
14	_pH=006_Gas=202_Level=046	03/12/2018	09:29:19
15	_pH=006_Gas=202_Level=046	03/12/2018	09:29:45
16	_pH=006_Gas=202_Level=045	03/12/2018	09:30:11
17	_pH=005_Gas=202_Level=045	03/12/2018	09:30:36
18	_pH=005_Gas=202_Level=045	03/12/2018	09:31:01
19	_pH=005_Gas=202_Level=045	03/12/2018	09:31:26
20	_pH=005_Gas=202_Level=044	03/12/2018	09:31:51
21	_pH=004_Gas=201_Level=044	03/12/2018	09:32:15
22	_pH=004_Gas=201_Level=044	03/12/2018	09:32:41
23	_pH=004_Gas=201_Level=044	03/12/2018	09:33:06
24	_pH=004_Gas=201_Level=044	03/12/2018	09:33:31
25	_pH=004_Gas=201_Level=044	03/12/2018	09:33:56
26	_pH=004_Gas=201_Level=043	03/12/2018	09:34:21

Figure .12

(b)Control View:

Control View as shown in Fig .13 is the webpage used to control the IoT environment via switches. When the switch is controlled here, the corresponding behaviour is reflected in the sensing module.

Figure .13

(c)Android Application:

This system is also associated with an android application as shown in Fig .14 , fetches data from the cloud and provides results in monitoring the tanks and controlling the system when it reaches hazardous levels.

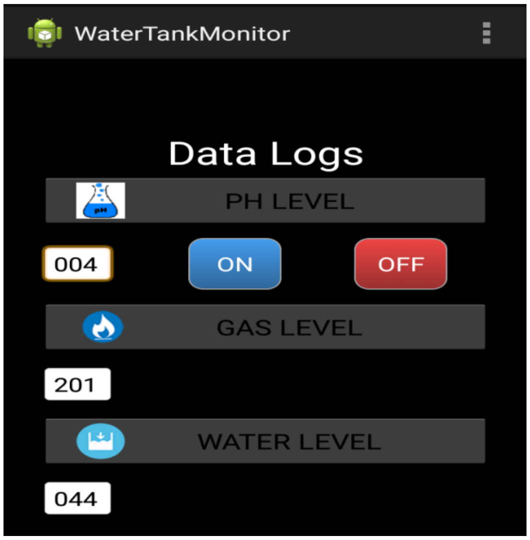


Figure . 14

5. SYSTEM ANALYSIS

In this section, analysis of the measured data is done using Fuzzy c means algorithm. System analysis is the process of observing systems for troubleshooting purposes. This project analyses the sensed values and provides results based on the observed readings to improve the system performance and to take appropriate measures to increase the quality of water.Real-time system must respond to the real world.It must operate under rigorous performance constraints as well as design issues. Hence it is imporatant to analyse the system.

One of the most widely used algorithm is the Fuzzy C-means clustering Algorithm.The fuzzy c-means algorithm is very similar to the k-means algorithm:

- Choose a number of clusters.
- Assign coefficients randomly to each data point for being in the clusters.
- Repeat until the algorithm has converged .
- Compute the centroid for each cluster.
- For each data point, compute its coefficients of being in the clusters.

Fuzzy clustering is a type of clustering in which each data belongs to more than one cluster.Clustersare identified using similarity measures such as physiochemical parameters. By dividing the data points into clusters, it is easy to analyse the data in which it lies. On the basis of these clusters, water is determined as potable or not and the reason for being not potable. It provides best results for overlapping data points.

6. RESULTS ANDDISCUSSIONS

In this section, results of the analysis is presented and discussed. This results provide needful information to the public regarding the available drinking water.Hence, this creates a social awareness among the people.

From the readings of below graph, it is clear that potable drinking water is very precious and it is hard to find the potable drinking water. It contains methane gases in a very high proportion at times. It is understood from the above graph that if any one of the constituents present in water does not meet thequalitystandards , it is not potable. Fig .15 shows the readings of the tank at different times and depicts whether the water is potable or not.

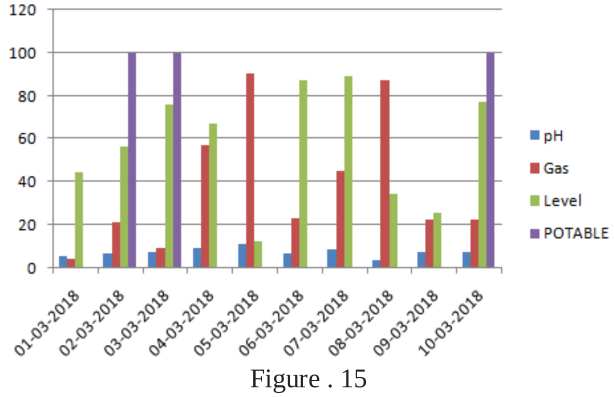


Figure . 15

From the readings of below graph, it is known that the quality of drinking water is monitored all over Chennai using the proposed system. . The analysis indicates the possibilities of diseases in the areas where the water is not potable Fig .16 presents the readings taken in various places across chennai which is very much required in today's life.

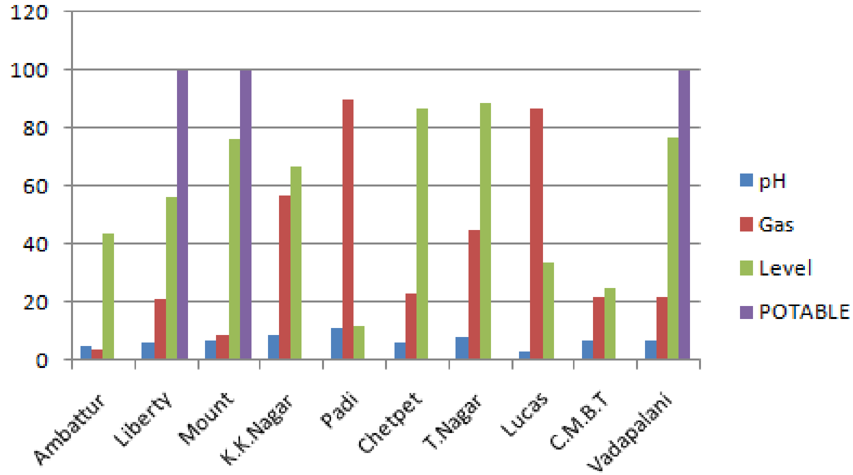


Figure . 16

7. CONCLUSION AND FUTURE SCOPES

In this paper, a cost-effective, real-time water quality monitoring system is presented. Water is essential for the survival of human beings. Hence, this paper deals with monitoring the quality of potable water. This system uses three sensors namely pH sensor, gas sensor, a level sensor to ensure sustainability of water using IoT that in turn is also monitored using IoT webpage from anywhere and at anytime and controlled using control view .This paper also includes an android application which dynamically displays the sensed values and controls the system . In future, this real time system can be implemented with further more sensor readings such as turbidity, ORP,temperature and conductivity and can be used to test the quality of water throughout tamilnaduinorder to improve the quality of water . Since tamilnadu is a water scarce state, as citizens we have the responsibility to ensEure the usage and quality of water.

8. ACKNOWLEDGEMNT

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