Water quality monitoring and Water pipe Leakage Detection

Eliganti RamaLakshmi
Assistant Professor
Department of Information Technology,
Chaitanya Bharathi Institute of Technology,
Hyderabad, India.
Email: eramya2@gmail.com
Contact No: 9553602042

Kavya Nannapaneni
Assistant Professor
Department of Information Technology,
Chaitanya Bharathi Institute of Technology,
Hyderabad, India.
Email:kavya.nannapaneni@gmil.com
Contact No: 7702213687

***Abstract*— Water quality monitoring is one of the important aspects which are used to save people from diseases as water is one of the basic resources for human beings. This paper discusses about an IoT application, developed to check quality of water, water level detection and water pipe leakage using IoT technology. Water quality can be measured by using Temperature, pH and Turbidity sensors. In this application these three aspects are considered for quality measurement. Nowadays water is pumped from ground storage to fill the overhead tank. It becomes a hectic task to always go and check the level of water in the tank. This may sometimes lead to wastage of water due to overflow and even consumes more electricity. This issue can be solved by indicating water level in the tank and sending notification to the specified person. Water Pipe Leakage is another important issue to avoid wastage of water. There are many techniques to detect water pipe leakage. In this paper we implemented a new technique based on rate of flow of water. When leakage is detected a notification is sent to concerned person that helps in saving water and electrical consumption. Results are published in cloud. Data is Analyzed using R tool.**

Keywords: Arduino UNO, IoT, Embedded C, GSM, Thing speak, R tool.

I. INTRODUCTION

IoT is a new revolution in communication technology by which everything connected to other things and exchange information [14][15]. This requires no human involvement. Internet of Things is the interconnection of physical objects with electronics embedded within their architecture to communicate and sense interactions amongst each other and with the external environment.

Water is an important resource for all the living things on the earth. It is necessary to avoid the wastage of water during the distribution period. In the previous method, the employee will go to that place and check whether tank is full or not. The proposed system is fully automated. Here human work and time are saved. To ensure the safe supply of drinking water the quality should be monitored in real time for that purpose IoT based water quality monitoring systems were proposed[16][17]. This system consists of some sensors which measure the water quality parameter. Water pollution is one of these problems. Many parameters like CO2, NO2, oxygen, Carbide levels etc cause pollution of water. Generally to detect these parameters, samples are manually collected and then send them to laboratory for analyzing. This method wastes too much man power and material resource [18].

Sensors play major role to solve these problems. Sensor is an ideal detecting device which converts no power information into electrical signals. Sensors can easily transfer process, transform and control signals. There are many advantages with these sensors like good selectivity, high, fast response speed and so on. So sensors are used to measure these values. The core controller processes the measured values from the sensors. Finally, the output data is displayed on the serial monitor and also an alert message is sent through the GSM module.

There are various ways through which water get wasted. Different situations like water overflows when tank get full. Also, leakage is another concern i.e., whenever there is leakage somewhere we couldn't get it in initial stage but when it becomes a huge problem causes large wastage of water.

II. RELATED WORK

Water Level and Leakage Detection System with its Quality Analysis based on Sensor for Home Application [9] [10]. The proposed system which indicate user about the level of water in tank makes use of microcontroller and notification is given through mobile network to the mobile. Water quality is measured, if it is less than or more than normal values then notification is sent to user as SMS. Leakage detection takes place by using the pressure sensors which detects the pressure of flow of water. If there is a low pressure then it notifies the user by calling on mobile similar to water level detector notification. So that water and electrical consumption can be saved.

IoT Based Water Management System for Smart City [19], An IoT design for water monitoring [13] and control approach [3] which supports internet based data collection on real time bases is presented. These types of systems address new challenges in the water sector flow rate measuring. There is a need for a study

of the supply of water to control water wastage and support its conservation [4]. We also measure the quality of water distributed to every household by deploying pH and conductivity sensors [1,2]. The traditional water metering systems require periodic human involvement for maintenance, making it inconvenient and not effective. These systems are useful to implement on water tanks for waste less consumption. After the satisfactory quality check of water if the tanks are full than valves of the tank will be opened and water will be distributed. This whole data is sent from Wi-Fi to the Web page so that system can be accessed remotely from a computer.

Leak Detection in Pipe Networks using Hybrid ANN Method [20], the idea of Hydro informatics is applied for determining the assignment dilemma accompanied to water based mechanism [5]. Hydro informatics is useful to assist for hydraulics, hydrology and mechanical engineering. Hydro informatics applies software based artificial technology for determining these consequences accompanied to water based approach. The brief prototype explaining water flow in pipelines is showed along with depicted utilizing MATLAB. The proposed method leads an innovative approach for leak detection in pipelines. To get the precise position of a leak point the weighted average localization algorithm has been introduced. The proposed hybrid ANN approach significantly boosts the accuracy in pipeline leak detection process depicted by computational outcomes and minimizes dilemma of complicated decision-making [6].

Water Tank Monitoring and Visualization System Using Smart-Phones [7]. A new method is proposed in this paper to monitor water tanks on a smart phone. In the implementation of a monitoring and visualization system using smart-phones the analysis of the water tank sensor data is used. Smart-phones usually do not have enough memory to store real time sensor data, which may cause substantial loads [8]. It is good practice to store sensor data in an external database rather than a smart-phone. The visualization program was written in a Windows environment. This was because easy access to this environment. The database schema of the water tank, valves and pumps are stored in databases. When there are large vessels, multiple devices are connected. Then tag names for each device should be stored in database. The sensor data in our current database incurs a slight delay, this delay is due to two factors[11][12]. The first is the delay in accessing the Web page. The second is due to the monitoring of the parsing data.

Water Tank Monitoring and Visualization System Using smart phones A new method is proposed in this paper to monitor water tanks on a smart phone. The analysis of the water tank sensor data is used in the implementation of a monitoring and visualization system using smart-phones. Smart- phones usually do not have enough memory to store real- time sensor data, which may cause substantial loads. Hence, sensor data should be stored in an external database rather than a smart-phone. The visualization program was written in a Windows environment. This was because easy access to this environment. The database schema of the water tank, valves and pumps are stored in databases. In the case of large vessels, multiple devices are connected. The database should store tag names for each device. The sensor data in our current database incurs a slight delay, this delay is due to two factors. The first is the delay in accessing the Web page. The second is due to the monitoring of the parsing information.

III. SYSTEM DESIGN

A. System Architecture of the project

Architecture of the proposed system is as shown the Fig. 1 and Fig. 2.

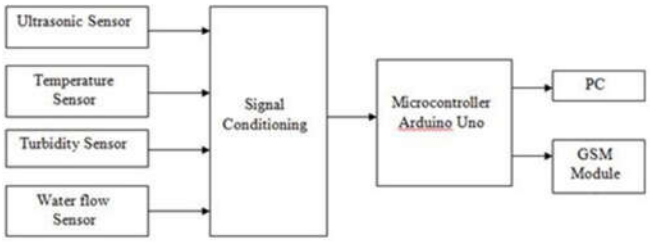

Fig. 1: System Architecture.

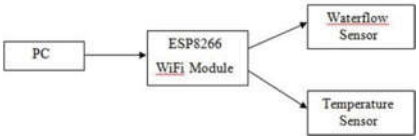

Fig. 2: Data Analysis Architecture.

B. System Flow diagrams

Flow diagram for water level indicator is shown in the Fig. 3.

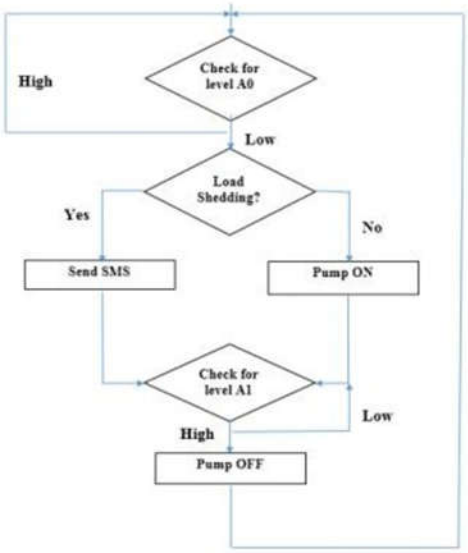

Fig. 3: Water level Indicator.

Flow diagram for water level indicator is shown in the Fig. 4.

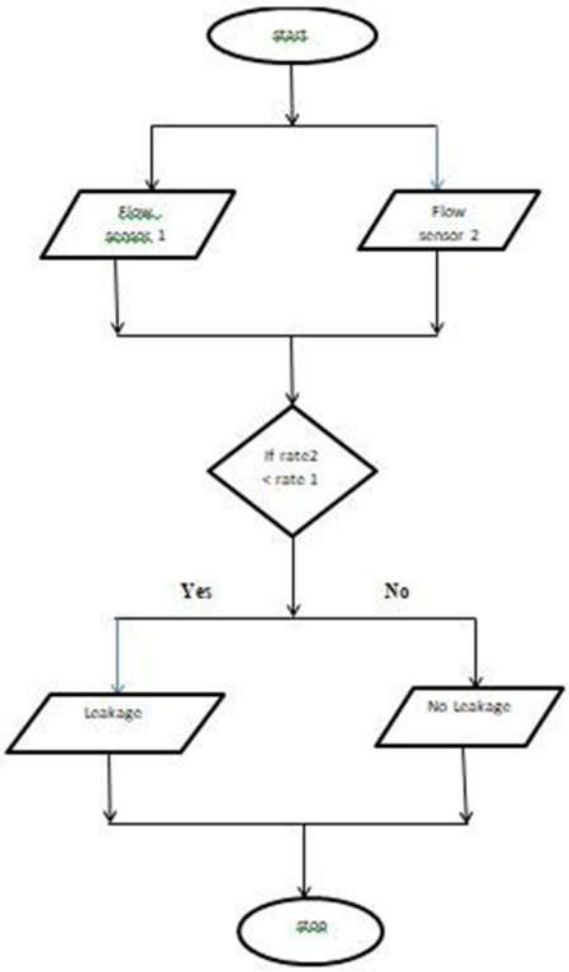

Fig. 4: Water pipe Leakage Detection.

IV. METHODOLOGY

This application has 3 modules. Firstly the quality of water is checked. Water quality is measured by using sensors like temperature, PH and turbidity and the values are displayed on serial monitor. After that the water is pumped into overhead tank and water level is measured and displayed using ultrasonic sensors. Since this water is sent to houses for household purposes during which leakages may occur and this leakage is detected using water flow sensors. If there is any change in quality or any leakage then alert message is sent to mobile phone using GSM module. This data from the sensors is pushed into thing speak cloud using Wi-Fi module and data is extracted as CSV file. Then Data Analysis is performed using R tool.

A. WATER QUALITY MONITORING

The quality of water can be measured by using different sensors. Some of the quality aspects which are taken into consideration are temperature, pH and turbidity.

1) Temperature: The temperature of water is measured using Temperature Sensor. DS18B20 temperature sensor is used for this purpose. It is also called as one wire digital temperature sensor. It measures the room temperature and also acts as a water proof sensor. It consists of 3 pins vcc, dq and gnd. Vcc of sensor is connected to 5v in arduino, data wire in sensor is connected to pin 2 in arduino, gnd of sensor is connected to gnd in arduino. A 4.7k ohm resistor is used to pull up the voltage to 5v. One wire.h and Dallas Temperature libraries are used. Onewire library lets you access one wire devices. To work with temperature sensors DallasTemperature library is used. In order to get the temperature in Centigrade we use getTempC By Index method and to get the temperature in Farenheit scale we use getTempFByIndex method. If the temperature is too hot or too cold and whether the water is safe to drink or not is based on the values specified in the code and if the conditions are not satisfied, then alert message is sent to phone using sendmsg() method of GSM module.

2) Turbidity: It is said that if turbidity of water is less than 5 it means that the water is not safe to drink. Turbidity sensor consists of 4 pins Vcc, data line, gnd. Here a 200 ohm resistor and an LED is used to indicate the severity. Long pin of LED is connected to one end of resistor, vin in arduino is connected to short pin of LED, other end of resistor is connected to pin 11 in arduino, red wire of sensor is connected to 5v in arduino, white wire of sensor is connected to A0 in arduino, yellow wire of sensor is connected to gnd in arduino. A turbidity probe sends a light beam into water. The light will be scattered by any suspended particles. A light detector is placed at 90 degree angle to the light source and detects the amount of light reflected back at it. This determines the particle density within the water. More light is detected means more particles are present in water. If turbidity is less than 5 then alert will be sent.

B. WATER LEVEL MONITORING

Basically an Ultrasonic Sensor is used to measure the distance of objects using Sound Navigation and Ranging (SONAR). An Ultrasonic Sensor is used to find the level of the water in a container. Ultrasonic sensor used here is HC-SR04. Ultrasonic sensors uses SONAR to determine the distance of objects just like bats do. It consists of 4 pins Vcc, trig, echo, gnd. Vcc of ultrasonic is connected to 5V in Arduino, gnd pin of sensor is connected to gnd of Arduino, trig pin of sensor is connected to digital pin 2 of Arduino, echo pin of sensor is connected to digital pin 11 of Arduino. Ultrasonic sensors emit short, high frequency sound pulses at regular intervals. If they strike an object they are reflected back as echo signals to the sensor. Distance is measured by time of flight and microseconds are converted to centimeters as microseconds/29/2.

Sound travels 343meters per second i.e., 29.155 microseconds per centimeters. So divide duration by 29 and then by 2 because sound has to travel the distance twice, travels to the object and back to the sensor, trigger pin generates ultrasonic waves and echo is a reflection signal. Here the level of tank is given as input from the user. Distance from sensor to the top of water level is measured and subtracted from the height of tank through which we get the level of tank. If level of water is equal to level of tank it means that the tank is full and it sends an alert message to specified mobile.

C. WATERPIPE LEAKAGE DETECTION

The concept to detect the leakage of water pipe is using water flow sensors. The setup consists of 2 taps where in one tap is considered as opening and other tap is considered as leakage point. One water flow sensor is placed just beside the opening tap and one water flow sensor is placed at any point in the pipe. Now the logic applied here is if the rate of flow of water at sensor 2 is less than rate of flow of water at sensor 1 then a leakage is detected at that point. Coming to hardware connections data wire of sensor 1 is connected to pin 2 of Arduino, data wire of sensor 2 is connected to pin 3 of Arduino, Vcc of sensor 1 is connected to 5V in Arduino, Vcc of sensor 2 is connected to IOREF pin in Arduino, gnd of sensor 1 is connected to gnd in Arduino, gnd of sensor 2 is connected to gnd in Arduino. Calibration Factor value is taken as 4.5. C.F of 4.5 means 4.5 pulses are generated per second for each liter of water passed through the sensor per minute. Each pulse is approximately 2.25ml And finally an alert message is sent to the registered mobile number through GSM Module by using sendmsg() method if any leakage in the pipe is detected.

D. GSM MODULE

Global System for Mobile Communication (GSM A miniature of GSM modem).One can use this module to accomplish almost anything a normal cell phone can like SMS text messages, make or receive phone calls, connecting to internet through GPRS. The type of GSM module used here is SIM800L. Interfacing GSM module to Arduino- Send and Receive SMS is as follows.

If the communication between GSM Module and Arduino is Serial then the connections are as follows

i. TX pin of GSM Module to RX pin of Arduino.
ii. RX pin of GSM Module to TX pin of Arduino.
iii. Ground pin of GSM Module to Ground pin of Arduino.

Booting the GSM Module

i. Insert the SIM card to GSM Module and lock it.
ii. Connect the adapter to GSM Module and turn it ON.
iii. Wait for 1 minute and see the blinking rate of Network LED.
iv. Once the connection is established the LED blinks continuously and we can make call to the mobile number which is inside the module. GSM can only understand AT commands. AT commands are used to control the modem.

E. DATA ANALYSIS USING THINGSPEAK AND R STUDIO

The Wifi module used here is ESP8266 to push the data into cloud. For that purpose, the server used is Thing speak. It is basically an open source IoT application and API to store and retrieve data from sensors. Thing speak allows users to analyze and visualize uploaded data. In order to upload data to thing speak first we need to create a thing speak account and login to that account. Then create a new channel as shown in Fig. 5.

Fig. 5: Creating a channel.

Then name the channel created and mention the field and then click on create channel which is shown in the Fig. 6.

Fig. 6: Naming the channel.

Next step is to generate API key as shown in the Fig. 7. Copy the API key and the channel ID. Connect the module to PC using USB cable.

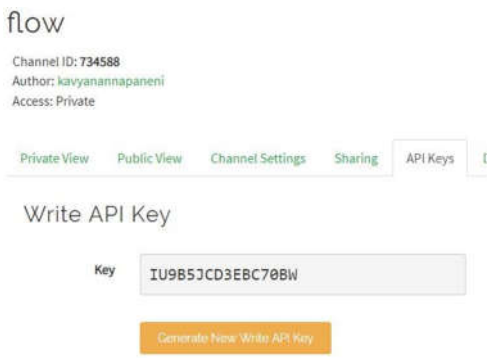

Fig. 7: Generation of API keys.

Now this data is pushed into cloud and a graph is obtained in Thing speak. After that this data is exported into the PC in the form of a CSV file. Now this CSV file is used in R tool to

perform Data Analysis. The code snippet for R tool is shown in the Fig. 8.

```
library(ggplot2)
data1 <- read.csv(file = "C:\\Users\\KAVYAN\\Desktop\\data\\feeds.csv", header = T
summary(data1)
names(data1)
p<-ggplot(data = data1, aes(x = entry_id, y = field1)) +
  geom_bar(stat="identity") +
  labs(x = "entry_id",
       y = "centigrade",
       title = "TEMPERATURE")
p+ xlim(5, 20) + ylim(0, 50)
```

Fig. 8: Code for Data Analysis in R-Tool.

RESULTS

A. WATER QUALITY

1) TEMPERATURE: The temperature of water is detected using the Temperature Sensor. The sensor is placed in a container as shown in the Fig. 9. through which value is displayed on serial monitor whether water is hot or cold based on the condition given in the code is shown in the Fig. 10.Then an alert message is sent to the mobile from which it is called to the mobile number in the GSM module as Water is too hot if the condition is not satisfied as shown in the Fig. 11.

Fig. 9: Temperature sensor placed in a container.

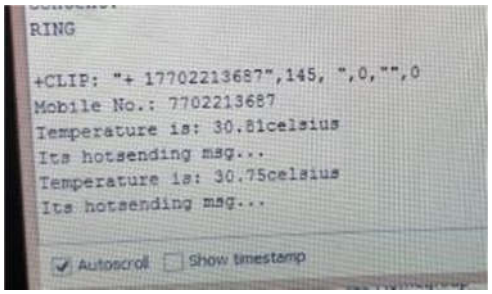

Fig. 10: Output on serial monitor.

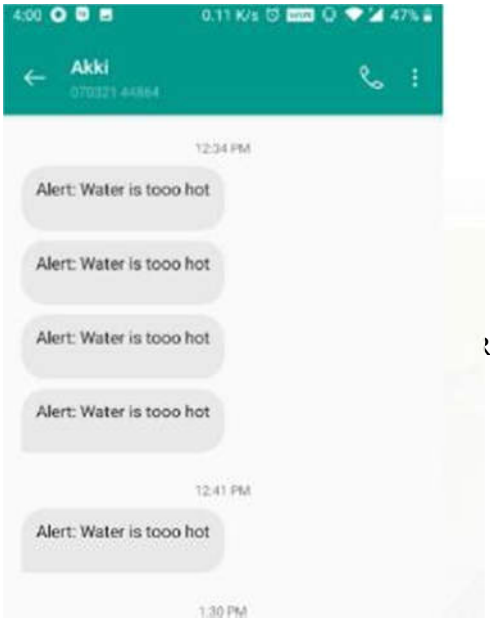

Fig. 11: Alert message.

2) Turbidity: The turbidity of water is measured using the Turbidity Sensor. The sensor is placed in a container once with clean water and once with mud water as shown in the Fig. 12. If pure water is used then water is safe to drink else the water is not safe message will be displayed. If the value of turbidity is equal to 5, then the output is displayed as Water is safe to drink. If the value of turbidity is less than 5, then the output is displayed as Water is not safe to drink. An alert message is sent using the GSM module as shown in the Fig. 14.

Fig. 12: Turbidity sensor placed in a container.

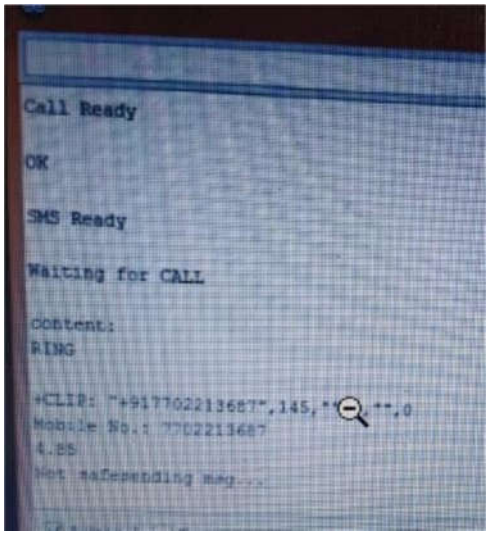

Fig. 13: Output on serial monitor.

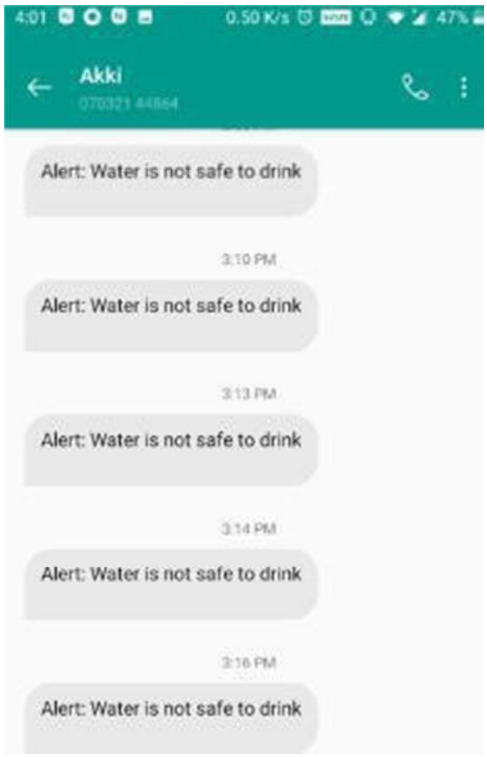

Fig. 14: Alert message.

B. *WATER LEVEL DETECTION*

The level of water in a container is measured using an Ultrasonic Sensor. The user decides the level of the container. When the Ultrasonic Sensor detects the level of water, the water level is displayed which is shown in the Fig. 15. If the level of water is equal to the level of the container, then the alert message is sent as Tank is full, switch off the motor as shown in Fig. 16.

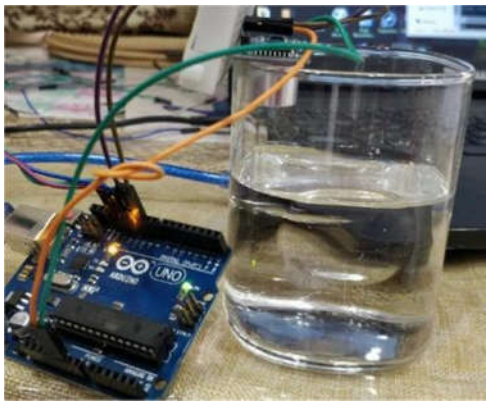

Fig. 15: Ultrasonic sensor placed on the container.

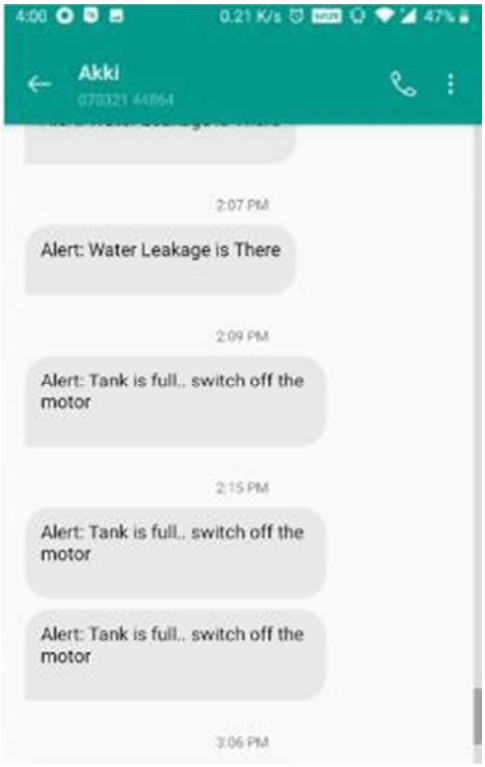

Fig. 16: Alert message.

C. *WATER PIPE LEAKAGE DETECTION*

Water pipe leakage is detected using the Water Flow Sensor. Fig. 17 shows water pipes and two water flow sensors one is placed at the inlet and the other is placed at the outlet of the water pipe. The flow rate of Sensor1 and flow rate of Sensor2 is measured and If the flow rate of Sensor2 is less than the flow rate of Sensor1, then the water pipe leakage is detected before the Sensor2 which will be shown on serial monitor as in Fig. 18 else no leakage is detected, the output is as shown in Fig. 19 and alert message is sent to phone as shown in Fig. 20.

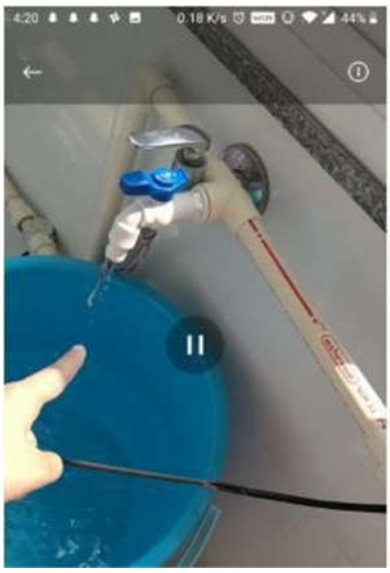

Fig. 17: Water pipes.

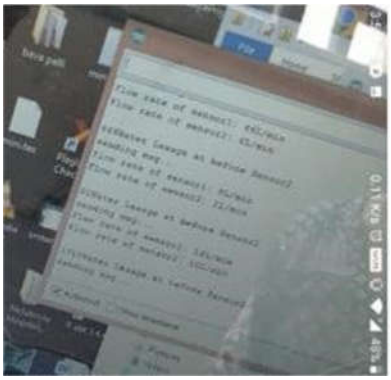

Fig. 18: Output for leakage detection.

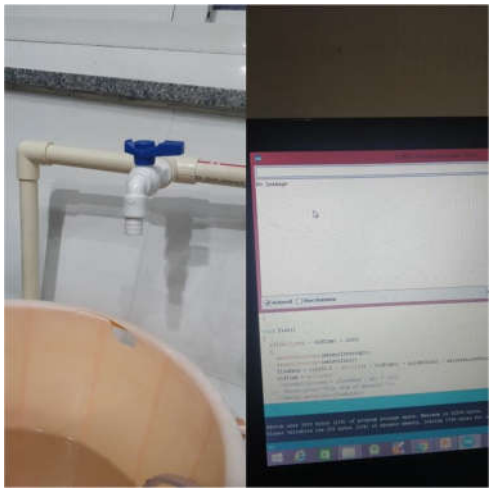

Fig. 19: Output for No Leakage.

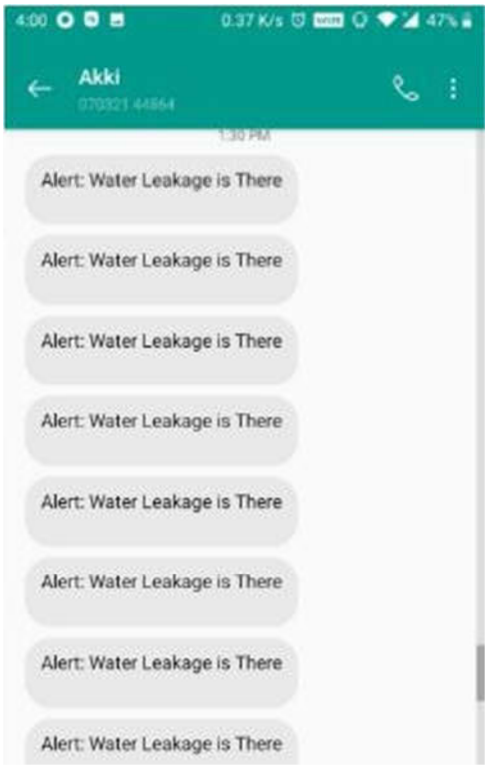

Fig. 20: Alert message.

D. DATA ANALYSIS

1) Temperature: After the data is pushed into the cloud, a general visualization graph is obtained in the Thing speak as shown in Fig.21.

Fig. 21: Graph from Thing speak.

The data is exported into our PC as a CSV file as shown in Fig.22.

	A	B	C
1	created_at	entry_id	field1
2	2019-03-19 10:30:17 UTC	1	32.88
3	2019-03-19 10:30:33 UTC	2	32.81
4	2019-03-19 10:30:50 UTC	3	33.25
5	2019-03-19 10:31:06 UTC	4	33.06
6	2019-03-19 10:31:23 UTC	5	35.06
7	2019-03-19 10:31:39 UTC	6	35.56
8	2019-03-19 10:31:55 UTC	7	35.63
9	2019-03-19 10:32:12 UTC	8	34.13
10	2019-03-19 10:32:28 UTC	9	33.63
11	2019-03-19 10:32:45 UTC	10	33.56
12	2019-03-19 10:33:01 UTC	11	33.50
13	2019-03-19 10:33:18 UTC	12	33.38
14	2019-03-19 10:33:34 UTC	13	33.25

Fig. 22: CSV File.

Visualization graph obtained for temperature sensor in R-Tool is as shown in Fig. 23. X axis is taken as entry ID and Y axis is taken as Temperature value in centigrade.

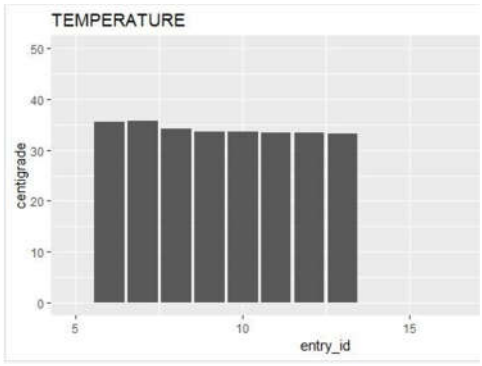

Fig. 23: Plot for temperature.

2) Water pipe Leakage: To plot the graph for water leakage analysis we need to plot two graphs for flow rate sensors. Since we detect the leakage based on the rate of flow of water, we push the flow rate data of both the water flow sensors into the cloud. From the graph, if flow rate value in sensor two is less it means that there is a leakage, else there is no leakage. Fig. 24 shows the visualization graph obtained in Thing speak.

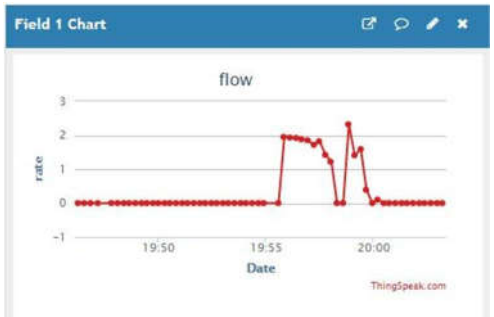

Fig. 24: Graph from Thing speak.

The CSV file exported into PC for water flow sensors is shown in the Fig. 25.

	created_at	entry_id	field1	field2
2	2019-03-19 14:24:23 UT(	1	0.00	0
3	2019-03-19 14:24:39 UT(	2	0.00	0
4	2019-03-19 14:24:56 UT(	3	0.00	0
5	2019-03-19 14:25:35 UT(	4	0.00	2.35
6	2019-03-19 14:25:51 UT(	5	1.95	1.45
7	2019-03-19 14:26:07 UT(	6	1.93	1.87
8	2019-03-19 14:26:24 UT(	7	1.92	1.85
9	2019-03-19 14:26:40 UT(	8	1.88	1.73
10	2019-03-19 14:26:56 UT(	9	1.85	1.5
11	2019-03-19 14:27:13 UT(	10	1.72	1.22
12	2019-03-19 14:27:29 UT(	11	1.82	1.65
13	2019-03-19 14:27:46 UT(	12	1.42	1.32
14	2019-03-19 14:28:02 UT(	13	1.22	3.5
15	2019-03-19 14:28:18 UT(	14	0.00	0
16	2019-03-19 14:28:35 UT(	15	0.00	0

Fig. 25: CSV File.

R studio is used to get the data visualization plot. We can compare the flow rates of both the sensors through which can know the leakage as well as the rate at which the water is flowing in the pipe. This plot is shown in Fig. 26.

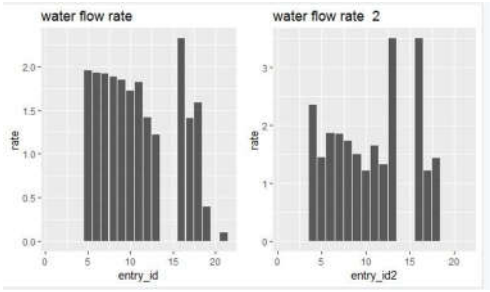

Fig. 26: Plot for Leakage Detection.

VI. CONCLUSION

IoT is creating opportunities for more direct integration of the physical world into computer-based systems which plays a very important role in case of daily activities appearing around us and to make life easier and secured. Firstly WATER QUALITY MONITORING AND LEAKAGE DETECTION is a new concept introduced to detect water leakage , has been successfully implemented. Every module has been tested and verified thus contributing to the best working of the unit. Secondly, this application has been successfully designed and tested, and also working of water pipe leakage detection has been observed. This system is reliable and simple and it can be extended to measure air pollution and so on. It has widespread application.

REFERENCES

[1] Prof. Rucha Dixit, Harshali Chaudhari, Shital Jadhav, Komal Jagtap, Water Level and Leakage Detection System with its Quality Analysis based on Sensor for Home Application, Volume: 04- Issue: 11, no. 4, pp. 1721-1724, 2017.

[2] T. Lambrou, C. Anastasiou, C. Panayiotou, and M. Polycarpou, A low-cost sensor network for real-time monitoring and contamination detection in drinking water distribution systems, IEEE Sensors Journal, vol. 14, no. 8, pp. 27652772, 2014.
[3] L.A. Gama-Moreno, A. Corralejo, A. Ramirez-Molina, J. A. Torres-Rangel, C. Martinez-Hernandez, M.A. Juarez , A Design of a Water Tanks Monitoring System Based on Mobile Devices, IEEE 2016.
[4] Eka Cahya Primaa, Siti Sarah Munifahab, Robby Salamb, Muhamad Haidzar Azizb,Agustin Tia Suryanic , Automatic Water Tank Filling System Controlled using ArduinoTM based Sensor for Home Application, Elsevier 2017.
[5] Salma A S. Alarefi, Prof. Stuart Walker, Innovative Shunt Measurement for Residential Water Micro-Leakage Detection, IEEE 2017.
[6] Sanam Pudasaini, Anuj Pathak, Sukirti Dhakal, Milan Paudel, Automatic Water Level Controller with Short Messaging Service (SMS)Notification, IJSRP, Volume 4,Issue 9, 2014.
[7] Wang Youshun, Lv Yang,The application of GSM module in smart home system, Yunnan University, pp. 119-121, 2009.
[8] [8] Zulhani Rasin and Mohd Rizal Abdullah- Water quality monitoring system using Zigbee based wireless sensor network International Journal of Engineering and Technology, vol :09 No :10.
[9] Shifeng Fang, LiDaXu An Integrated System for Regional Environmental Monitoring and Management Based on Internet of Things, IEEE, Volume: 10, no. 2, pp. 1596-1605, May 2014.
[10] V.C. Sharath, S. Suhas, B.N. Sachin Jain, S.B. Vinay Kumar, C. Prasanna Kumar, Smart aqua meter, in Advances in Electronics, Computers and Communications (ICAECC), pp. 1-5, 2014.
[11] L. Atzori, A. Iera, and G. Morabito, The internet of things: A sur-vey,Computer Networks, vol. 54, no. 15, pp. 2787 2805, 2010.
[12] Zhou Na, Zhu Yantao, Sensors in the application of water quality monitoring, Environmental Science Tribune, 2009 , 28 (Supplement): 119- 123.
[13] D. Giusto, A. Iera, G. Morabito, and L. Atzori, The Internet of Things. Springer-Verlag, 2010.
[14] Ashton Kevin That Internet of Things Things in the real world things matter more than ideas, RFID Journal, 2009.
[15] Dave Evans, Cisco, The Internet of Things, How the Next Evolution of the Internet Is Changing Everything, IBSG, 2011.
[16] Jayavardhana Gubbi,a Rajkumar Buyya,b Slaven Marusic,a Marimuthu Palaniswamia, Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions,, Elvisier, 2013.
[17] Muhammed ali Mazdi Janice Gillispie 8051 Microcontroller embedded system 3rd edition pearson.
[18] Mijovi S. and Palmar B, "Continuous water quality monitoring on river Kolubara" ,30th scientific professional meeting with international participation, 2009.
[19] Chen Tao, Xu Ling, Su Guofeng, Yuan Hongyong, Huang Quanyi, Architecture for Monitoring Urban Infrastructure and Analysis Method for a Smart-safe City.
[20] Uttam Roy, Leak Detection in Pipe Networks using Hybrid ANN Method,Springer, Volume: 02, Issue: 4, no. 08, pp. 145-152, December 2017.