Fraud Detection and Monitoring of Water Tankers using IoT

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***Abstract*—During the water crisis, water supply through tanker is a common scenario in India. Most of the time, Government hires private tankers on contract basis to distribute the water and pays them based on the number of trips. It is observed that the tanker contractors show fake trips and fraudulently charge for it. To avoid so, roster is maintained which has entry for each trip. Yet this is not sufficient to control the malpractices. It might be possible that, from the source, the entry for the tanker trip is made in roster but there is no guarantee that tanker will reach to the specified destination. In between the tanker driver can sell that water to someone else. Sometimes the tanker reaches to the desired destination but in between half of the water is sold. Thus, the intended beneficiaries don't get enough water. Many times, muddy and contaminated water is being distributed which may lead to many health issues. Thus, there is a need of some automated mechanism using which Government officials can keep track of tanker movement, check the quantity and quality of the water. This motivated us to come up with IoT based solution which comprise of various sensors to collect the data such as GPS location of tanker, level of water, pH and turbidity value of water. This data is stored over a cloud and made available through a web application. This way the Government officials can get consolidated report as well as alerts if any malpractice is carried out.**

Keywords— Water distribution, water tanker, malpractices in water supply, IoT, GPS tracking, Water pH, Turbidity, Water level

I. Introduction

As the population of the country is increasing every year, so as the drinking water demand is also increasing rapidly. To meet this growing demand of drinking water across the nation, the drinking water is provided to the citizens through multiple sources such as pipelines, wells and ponds and water tanker trucks. The demand for water is more during the summer season. Thus, in summer, the problem of water shortage is becoming very grave. This is because though the water demand is increasing, there are limited resources to meet the demand. Thus, water tankers play a very important role in fulfilling this ever-increasing demand of drinking water supply. The water tanker usually involves rural to urban water transfer. Through water tanker, water is supplied not only to the residents, but it is also supplied to the small and medium scale private and public industries as well. This process of water transfer consists of two main stages, viz, fetching the water from the water sources and delivering the water to the destination. The price of the tanker water is determined from the following factors: Type of the water source, distance between the water source and the destination location and size of water tanker. The distribution network of the tanker operators is so huge that they form a different sector in itself. But currently, this sector has many irregularities in its working and is completely unorganized. There is no computer-aided system available to monitor the working of this sector. Due to which, the tanker operators get the opportunity to follow many malpractices in their operations such as:

- Not delivering good quality of water to consumer
- Manipulating the number of trips
- Not delivering the right quantity of water to consumer
- Delivery of water to preferred consumer
- Overcharging the consumers
- Diverting the water to industries for higher profits

Currently, there is no provision where these stakeholders can themselves verify the water quality and quantity provided to them. So, there is a need of a system to monitor the working of water tanker operations to stop such malpractices. Thus, we have proposed an IoT based solution to regularize the operations of water tanker where the quality and the quantity of the water supplied to the consumers and the movement of the water tanker can be monitored and hence the fraud carried out by the water tankers can be detected. The major objectives of our study are

- To perform quality check of the water
- To monitor the water quantity being delivered to the end consumer
- To monitor the movement of the water tanker using GPS
- Keeping log of unusual activity observed and sending alerts to the concerned authorities.

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II. BACKROUND STUDY

In 2015, in Karnataka State, the City Municipal Corporation (CMC) of Kolar District had initiated the efforts of first ever kind of monitoring the movement of water tanker through GPS [1]. In Kolar district there are 35 wards and, 85 tankers supply water to these wards. CMC observed that the tanker owners charged payment for more water than the actual water supplied by the tanker. So, CMC used GPS to track the movement of water tankers due to which it was able to save 30 lakh rupees. Similar action was taken by Pune Municipal Corporation (PMC) in 2017. PMC has 80 water tankers. The size of these tankers ranges between 10000-15000 litres. The charges are between Rs. 1050-1400 per tanker. Consumer is charged based on the distance travelled by the water tanker from the water source to the destination delivery location. PMC received complaints that the water tanker vehicles were being misused for personal work and the number of trips were being manipulated. So in order to monitor the movement of the tanker vehicles, PMC made it mandatory to install GPS in the water tanker vehicle and linked it with the payment [2].

Though installing GPS was useful in curtailing the mismanagement of the number of trips upto certain extent, still it failed to identify whether the consumers were being overcharged or water was diverted to industries for higher profit [3]. In 2018, PMC found that, though PMC charged Rs. 300 per tanker, the housing societies were charged between 700-1200 Rs. per tanker based on the distance of the housing society from the filling station. PMC saw significant increase in the number of trips of the water tankers. For each tanker with an average capacity of 10000 litres, the demand had increased from 1.42 lakh tanker trips in 2012-13 to 1.98 lakh tanker trips in 2017-18 as shown in Fig. 1. From Fig. 2, it is observed that the average number of trips is more in the dry season as compared to the off-season. PMC also received complaints from the residents that not only are they charged with inflated prices but the water quality is also very poor.

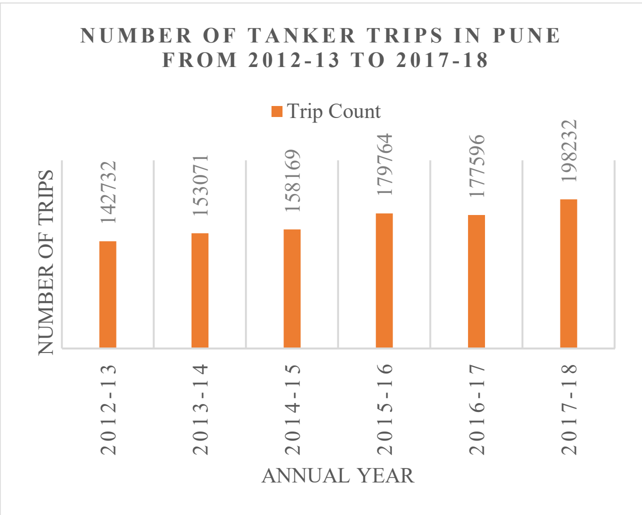

Fig. 1. Rise in the water tanker trips in Pune [3]

Yet in another case of cheating, in Mumbai, BMC busted water tanker racket where it found that the water was provided to the tanker owners from illegal water source without the permission of BMC at the cost of Rs. 300 per tanker [4].

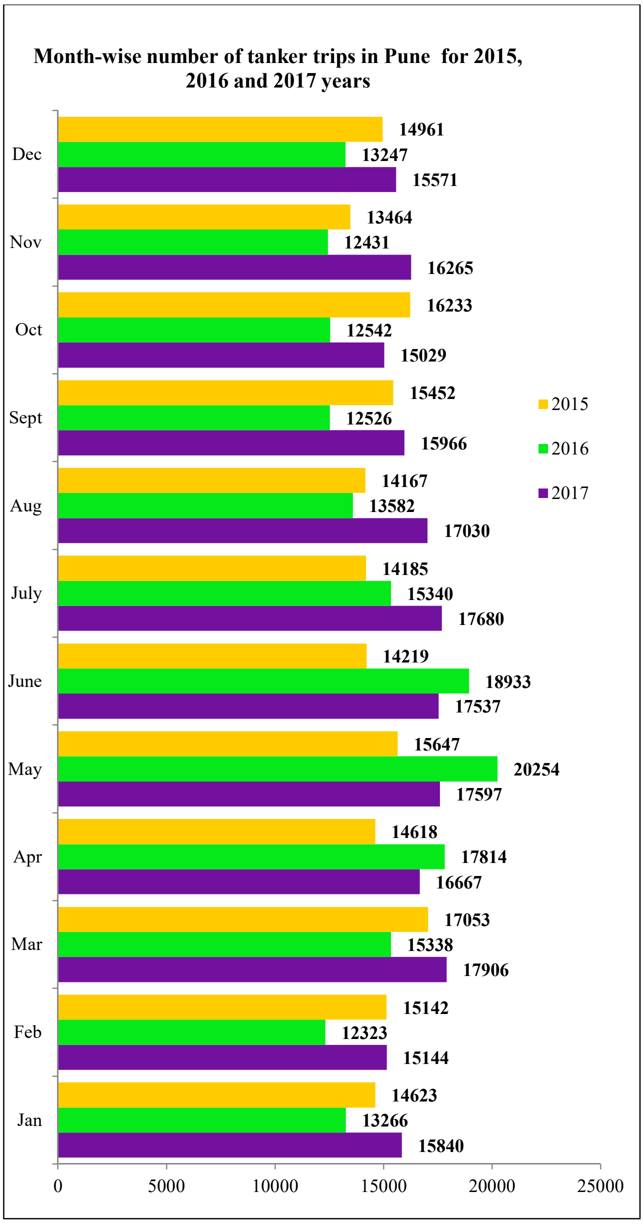

Fig. 2. Month-wise number of tanker trips in Pune in the year 2015, 2016 and 2017

The Municipal Corporation Gurugram (MCG) caught tankers that illegally extracted groundwater for commercial use [5]. They found that there were around 500 such water tankers that illegally supplied water. In Bengaluru, Bruhat Bangalore Mahanagara Palike (BBMP) observed that the tanker operators were using groundwater from borewells drilled illegally in public places and were making profit in wrong way. The Bangalore Water Supply and Sewerage Board (BWSSB) owns 69 water tankers. But there are around 3000-4000 water tankers with an annual turnover of 1 lakh rupees that are being illegally operated in Bangalore [6]. In Maharashtra, there was a damage of Rs.222 crore caused due to the illegal extraction of water from two wells in South Mumbai for 11 years. To tackle this problem of illegal extraction of groundwater from illegal sources in the state of Maharashtra, the State Government has designated Maharashtra Water Resources Regulatory Authority (MWRRA) to implement the Groundwater Act. Once the rules are formed, one will require to get MMRA's approval to dig a well of more than 60 meters deep [7].

Thus, the menace of water tanker operators has been increasing every year and the Government have started feeling the urge of the system to monitor their working. As initial efforts the Government has tried to implement the GPS system to monitor the movement of the water tanker. But currently, there is an urgent need felt for a system to monitor and regularize the complete working of the water tanker supply process

We have also studied the problem of regularization of water tanker operations across different nations and the possible solution suggested. Table 1 gives statistics related to percentage of usage of tanker and total amount spent on it in 2016 [8].

TABLE I. SPENDING ON TANKER REGION WISE [8]

SN	Region	%using tankers regularly	Total amount spend on tankers (in millions)
1.	Mid. East and N. Africa	2.6%	$1059m
2.	Sub-Saharan Africa	1.0%	$621m
3.	Latin am. and Carib	1.2%	$564m
4.	Europe and C. Asia	0.9%	$241m
5.	E. Asia and Pacific	0.6%	$894m
6.	South Asia	3.3%	$3671m
Average		**1.6%**	**$7051m**

In Ghana public water supply distribution is done by Ghana Water Company Limited (GWCL). But due to rapid growth in urban population and slow pace of expanding water distribution systems, people in major cities like Accra and Kumasi are facing water crisis. Thus they are highly dependent on the tanker water supply. In 1992, they formed the Private Water Tanker Owners Association (PWTOA) to regulate the process of water supply through tankers. Still there are certain problems like limited number of PWTOA water depot, complex process to order water tanker and lodge complaint, dishonesty on the part of most drivers, illegal water tankers who are not a member of PWTOA etc. There are certain suggestions given by Odai et. al. [9] like, membership of PWTOA should be mandatory for all tanker owners, spreading awareness among tanker drivers, strict supervision on dishonesty done by tanker service providers or drivers. But there are no evidences for use of any automated system, neither they have discussed how these suggestions are being incorporated.

In war affected country like Yemen, due to destruction of domestic water supply pipelines, water tanker has occupied the major portion of water supply management. But they are facing problems like water supply from illegal water sources, prices inflation by water tanker operators and rise in the rate of waterborne diseases due to lack of water quality checking mechanism. They have suggested for some organization among the independent tanker owner and water source authorities to have some kind of uniformity in the tanker water supply chain [10].

In Nepal, in Kathmandu, the annual transaction of water tanker operators is approximately Nepal Rupees 1,015 million (US $ 14.5 million). The Government is facing the problem of the regulation of price and water quality. Thus it has formed Kathmandu Valley Water Supply Management Board (KVWSMB) to regulate the processes of the water tanker operations. Apart from this, the private water tankers have formed their own association called, Kathmandu Valley Drinking Water Tanker Entrepreneurs Association. As per the association, 217 tankers have registered with them but there are around 400-450 tankers being operated [11]. Thus all over the world, people and administration are facing the problem of mismanagement in tanker water supply and thus there is an acute requirement for some automated solution to monitor the tanker water supply process.

III. METHODOLOGY

The first objective of this study is to check the quality of the water being delivered. The quality of the water is checked by measuring the pH and turbidity. Through pH, one can determine whether the water is acidic or alkaline. The pH value ranges between 0-14. The classification of water quality based on the pH value is given in table 2.

TABLE II. PH LEVELS FOR DIFFERENT TYPE OF WATER

pH Value	Type of water
7	Pure Water
0-6	Acidic
8-14	Alkaline
6.5-8.5	Drinking Water

Turbidity is the measurement of the cloudiness of water. It is measured in terms of Nephelometric Turbidity Units (NTU). As per the World health organization, turbidity of drinking water should be less than 5 NTU and ideally it should be less than 1 NTU. For measuring pH and turbidity, analog pH sensor and analog turbidity sensor is used.

The second objective is to monitor the water quantity being delivered to the end consumer. After filling the water in the water tanker, the level of water in the water tanker is monitored using Ultrasonic sensor and Float sensor. The ultrasonic sensor consists of speaker which discharges a specific sound wave and a mic which recognizes that sound wave. Float sensor is an electromagnetic switch which switches ON/OFF whenever the water level rises or drops. Third objective is to monitor the movement of water tanker for which GPS module is used.

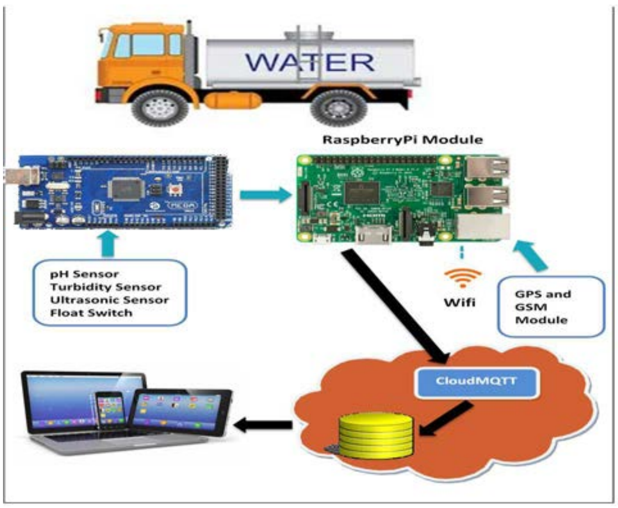

Fig. 3. System Architecture

Figure 3 depicts architecture of the proposed system. All the sensors (pH analog sensor, turbidity sensor, ultrasonic sensor, floating sensor) are connected to the Arduino ATMEGA 2560. The data from Arduino is sent to Raspberry Pi using USB cable. GPS and GSM Hat is connected to Raspberry Pi. Raspberry Pi sends data to CloudMQTT server using publish and subscribe mechanism. From CloudMQTT broker, the data is stored in Firebase cloud. And finally from Firebase cloud, the data is fetched into the web application and necessary alerts are sent if any unusual activity occurs.

For experimentation purpose, the water level measurement was carried out using ultrasonic sensor with a horizontal elliptical water container having height of around 29cm in which there was water filled upto 11cm. Considering the sensor height as 1 cm, theoretically the overall distance of ultrasonic sensor and water level is calculated as given in equation (1).

$$Dist = Ch - Sh - F \tag{1}$$

Where,
Dist = Distance between ultrasonic sensor and water level, Ch = container height, Sh = sensor height, F = filled water level

Using equation (1), the total distance between the sensor and water level is 17 cm theoretically.

Now when the actual experiment is performed, it is observed that when the water is still, the sensor reading obtained for the distance between ultrasonic sensor and water level is around 17 cm as demonstrated in Fig. 4. Using equation (1), filled water level 'F' is calculated as 11 cm.

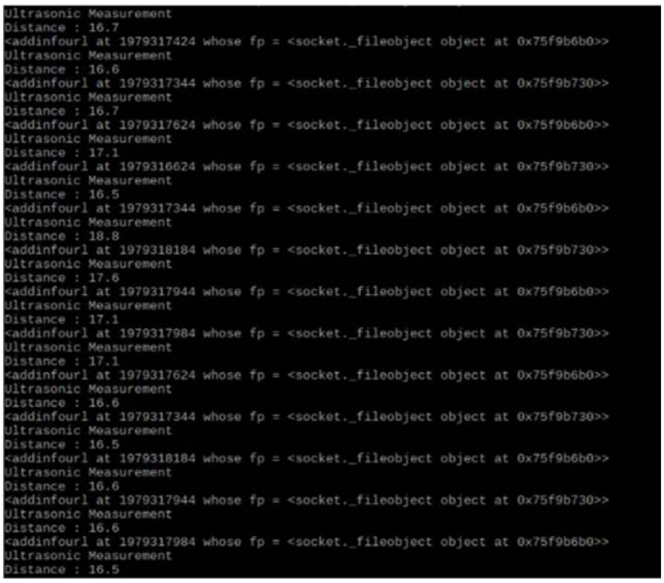

Fig. 4. Ultrasonic sensor readings to measure water level

Further the volume of filled water (V_filled) in an elliptical horizontal water container of length 'L', width 'W' and height 'H' having filled water level as 'F', is calculated using equation (2)

$$V\_filled = \frac{LWH}{4} E \tag{2}$$

where

$$E = \left\{ cos^{-1}\left(1 - \frac{2F}{H}\right) - \left(1 - \frac{2F}{H}\right)\sqrt{\left(\frac{4F}{H} - \frac{4F^2}{H^2}\right)} \right\}$$

When the water container is fully filled with water, the water level 'F' is equal to height 'H' of the water container. Thus the volume of water tanker when it is completely full (V_full) is calculated by substituting F = H in equation (2), as given in equation (3)

$$V\_full = \frac{\pi}{4} LWH \tag{3}$$

Next, float level sensor switch is used to determine whether the water container is completely filled with water or not. It gives the readings as follows:

- Water container is full - output reading as "high"
- Water container not full - output reading as "low"

To determine the location of water tanker, GPS and GSM Hat for Pi, is used. The circuit connections for the GPS and GSM Hat are shown in Fig. 5. This experiment was carried out at K. J. Somaiya College of Engineering, Bhaskaracharya building, in Somaiya Vidyavihar Campus. The GPS location reading obtained using GPS and GSM Hat, is shown in Fig. 6. This reading is then mapped with google maps,which demonstrates that the accuracy of the module is good, as shown in Fig. 7.

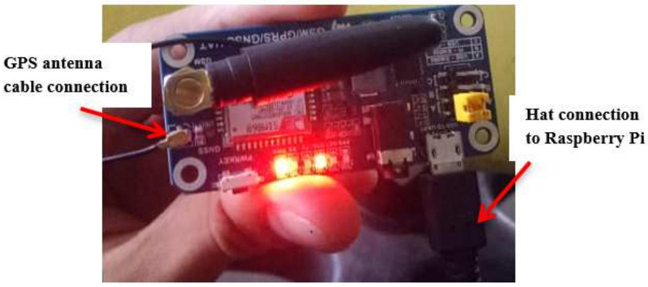

Fig. 5. Connections for GPS and GSM Hat

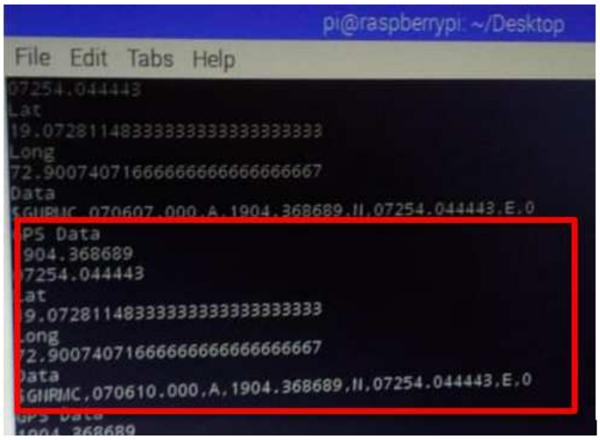

Fig. 6. GPS and GSM Hat readings

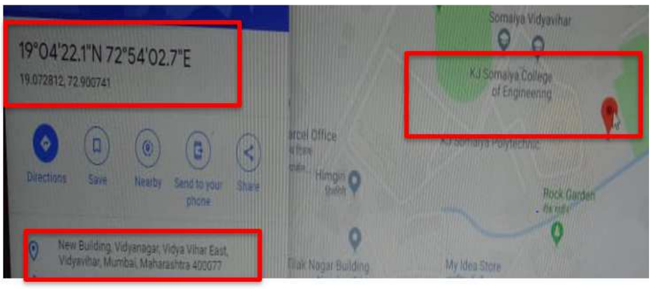

Fig. 7. Mapping GPS reading with Google Maps

The readings of ultrasonic sensor and float switch and the location longitude and latitude values obtained from GPS module are published on CloudMQTT server as shown in Fig. 8. These readings are accessed from CloudMQTT server using web application and are also stored on firebase cloud as well.

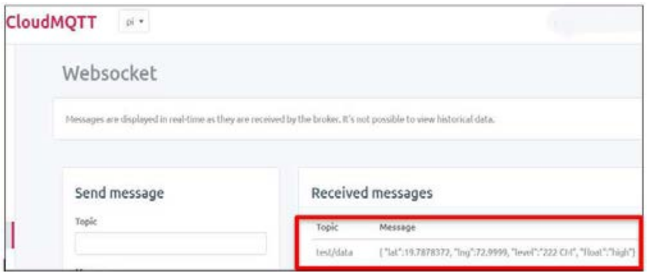

Fig. 8. Water level sensors and GPS readings published on CloudMQTT server

IV. Result and Discussion

For the experiment carried out, the results of pH sensor are recorded for initial pH sensor reading, rain water, drinking water and borewell water as demonstrated in Fig. 9.

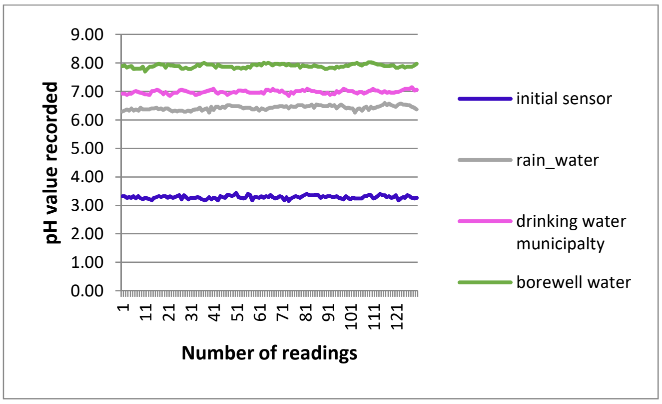

Fig. 9. pH values recorded for different type of water sources

The average pH value recorded for different types of water sources is given in table 3.

TABLE III. Average pH value recorded for different type of water sources

Sr. No.	Type of water source	Average reading recorded
1.	Drinking Water	6.98
2.	Rain Water	6.42
3.	Borewell Water	7.89

Next, the turbidity of water is measured in terms of voltage. According to sensor specification, 4.21 volt corresponds to 0.5 NTU. The average turbidity measurement readings for different types of water sources are given in table 4 and the results are plotted in Fig. 10.

Further, in order to measure water level, the experiment is carried out in a horizontal elliptical water container having height of 29 cm. The results of measuring the level of water using ultrasonic sensor is shown in Fig. 11.

TABLE IV. Average turbidity value recorded for different types of water sources

SN	Type of water source	Average reading recorded (in Volt)
1.	Drinking Water	4.15
2.	Rain Water	4.16
3.	Borewell Water	3.45
4.	Little muddy water	3.74
5.	very muddy water	2.51

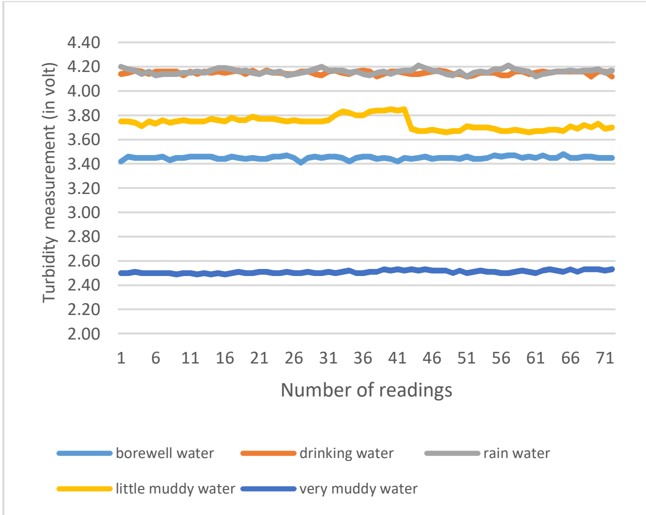

Fig. 10. Turbidity values recorded for different types of water sources

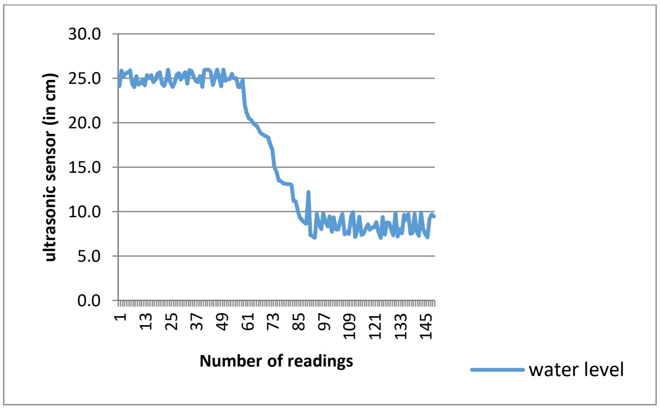

Fig. 11. Water level measurement readings using ultrasonic sensor

In-order to detect, whether the water tanker is full or not, reading of ultrasonic sensor is combined with the output of the float level switch. Some sample readings and it's interpretations are shown in table 5.

TABLE V. Interpretation based on ultrasonic sensor and float switch readings

Sr. No.	Average ultrasonic sensor reading (in cm)	Float switch (high/low)	Interpretation (Empty/Full/Partially filled)
1.	25.3	high	Full
2.	16.1	low	Partially filled
3.	1.2	low	Empty

To detect fraud in the delivery of water to the desired community, the following procedure is followed:

- The source and destination locations of the trip to be covered are stored beforehand in database.

- The initial water level readings and the GPS readings of source location are also recorded.
- Then whenever the same GPS readings are received and the water level is decreasing, it means that the water is being delivered to the community.
- Now the location where the water is delivered is determined and is then compared with the destination location stored in database. If it is not matching, then it is interpreted as "fraud occurred"

V. Conclusion

To conclude, this IoT based system attempts to avoid malpractices in the operations of the water tankers. This system, assures the receiving community, that good quality and proper quantity of water is being delivered to them by the water tanker operators. Further, also for the Government officials, there is a means provided by which they can assure that the water tanker is delivering the water to the desired destination community. As seen from the results, the precision of pH sensor achieved is good and pH value of 6.98 is recorded for drinking water. Also turbidity sensor readings show that the turbidity of rain water is almost same as turbidity of drinking water having value of around 4.16 volts. Further, combination of ultrasonic sensor, float switch and GPS location helped to detect the fraud carried out while delivering water to the desired destination community. This work can be extended further to detect fraud and malpractices followed in transporting other types of liquids such as oil, milk, fuel and so on.

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References

[1] Vishwa Kundapaura, "Tankers supplying water in Kolar adopt GPS", The Hindu, Karnataka, 13 July 2015 (https://www.thehindu.com/news/national/karnataka/tankers-supplying-water-in-kolar-adopt-gps/article7415193.ece)

[2] "PMC links water tankers bills with GPS records", Times of India, Pune, 13 July 2017 (https://timesofindia.indiatimes.com/city/pune/pmc-links-water-tankers-bills-with-gps-records/articleshow/59572367.cms)

[3] Abhay Khairnar,"HT Spotlight: How tanker 'mafia' controlling flow of water in Pune", Hindustan Times, Pune, 19 April 2018 (https://www.hindustantimes.com/pune-news/ht-spotlight-pune-s-water-tanker-mafia-is-sinking-housing-societies/story-JdkoTT00GeSdvQgbX0kkbO.html)

[4] "BMC busts water tanker racket, razes 50,000 litre tank", Times of India, Mumbai, 26 Feb 2018 (https://timesofindia.indiatimes.com/city/mumbai/bmc-busts-water-tanker-racket-razes-50k-litre-tank/articleshow/63072465.cms)

[5] Shakir Mir, "Water tankers on MCG radar but supply gap keeps door open for private players", Times of India, 2 May 2018 (https://timesofindia.indiatimes.com/city/gurgaon/water-tankers-on-mcg-radar-but-supply-gap-keeps-door-open-for-private-players/articleshow/63992853.cms)

[6] K.C. Deepika, "Where do tankers source water from?", The Hindu, Bengaluru, 29 April 2017 (https://www.thehindu.com/news/cities/bangalore/where-do-tankers-source-water-from/article18311097.ece)

[7] Chittaranjan Tembhekar, "Ground rules ready, private water tanker operators to face heat", Times of India, 31 July 2018 https://timesofindia.indiatimes.com/city/mumbai/ground-rules-ready-private-water-tanker-operators-to-face-heat/articleshow/65206292.cms

[8] Christopher Gasson, "A new model for water access", The Global Water Leaders Group Suite C, Kingsmead House Oxpens Road, Oxford, 2017.

[9] Odai, S & A. Andam, K., "Role of Water Tanker Services in the Water Supply Chain in Urban Ghana", Second KNUST School of Engineering Research Retreat Conference, 2002

[10] Abu-Lohom, Naif Mohammed; Konishi, Yasuo; Mumssen, Yogita; Zabara, Bilkis; Moore, Scott Michael, "Water Supply in a War Zone : A Preliminary Analysis of Two Urban Water Tanker Supply Systems in the Republic of Yemen" World Bank, Washington, DC, 2018.

[11] Dibesh Shrestha, Ashutosh, "Globalization of Water Governance in South Asia: Chapter 15 Private Water Tanker operators in Kathmandu: analysis of water services and regulatory provisions", Routledge, Taylor and Francis Group, 2013