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Research Article

An Android-Based Water Quality Monitoring System and Alerting Through SMS

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Abstract

Drinking water is one of the most important essential element either for human or living organisms. Due to urbanisation, industrialization and increasing population growth may lead to high demand in water supply and also affects the water quality. In few years, there were only a few industries available in a particular region, so the chances of water get polluted is very low. But nowadays there is more number of factories are available in all regions, so the water gets polluted very easily. Drinking water is the main source for the spreading of diseases. Providing pure quality water is a serious concern throughout the globe. To provide pure drinking water, the quality of the water needs to be monitored in real-time. In this paper, we proposed an advanced quality monitoring system using IoT. The microcontroller PIC16F84 is used as the main component for the water level monitoring system and also its guide used to notify the purity level of water in the tank to the cleaning agent using some components and sensors. The pH Sensor is used to check the water quality by using this sensor's parameter. The pH level is measured in real-time by the sensor and the GSM module used to send a notification to the cleaning agent about the purity level periodically using a newly developed android application by including the location of the water tank with the help of a GPS module where the data is stored in SQLite. When the pH level of the water goes below the given purity threshold then an immediate alert message will be sent to the cleaning agent. If the tank is not cleaned by particulars within a certain period then the notification will be forwarded to their's higher officials. If again the proper action is not taken then the water flow will be stopped using solenoid valve and notification gets posted on popular social media such as Twitter, Facebook and Instagram. The uniqueness of the proposed system aid to provide quality drinking water to society with a high efficient water monitoring system.

Keywords: *Microcontroller, pH (potential of Hydrogen) sensor, Solenoid valve, GPS, GSM, Internet of Things (IoT).*

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Introduction

Freshwater is a vital resource for all human or living organism. Over 70% of the earth's surface is covered by water, in that only 2% of the water is freshwater and only 0.036% of water is only accessible for use. It shows that only limited water resource is extremely available in our globe. So, it is important to provide the available water resource purely. The main reason for water contamination is industrialization, agricultural fertilizers, and some time non-uniform distribution of rainfall. Water contamination is increasing every day, and many researchers and scientists are trying to solve the problem by checking and maintaining the quality of water [12]. In the case of urbanization, the water quality monitoring system is most important for a nation like Nepal, the groundwater became worse due to urbanization mainly in the cities like Kathmandu Valley, the groundwater level has been decreasing every year in the Valley due to increasing overexploitation households. Water resource became highly toxic because of sewage discharge, chemicals discharge from factories, urban run-off, oil industries, and run-off from agricultural fields [13]. There are other reasons as well for water pollution such as lack of awareness among people, lack of water quality monitoring system, droughts and floods. According to the World Health Organization (WHO), around the globe, over 3 million people died because of waterborne diseases. In India estimated 580 people die of waterborne illness every day [6]. Pesticides and Fertilizers used by the farmers for raising productivity on less land space and protecting crops from pests. These chemical particles enter the food chain, eventually by killing fish, birds, and mammals. These chemical particles present in pesticides end up in rivers and lakes at the time of rain. Chemical factories also discharge highly toxic waste into the water. Industries use water from the river to run the high power machines. On a personal basis, to prevent waterborne diseases on human, the first step to prevent water pollution is a regular check of stored water from the water tank. Traditionally, the quality of water is estimated manually where water samples are collected and sent to research laboratories for quality check examination which is a time-consuming process, more human resources

required, not cost-effective [7]. The major problem with the traditional technique is that do not provide data in real-time this leads to obtaining an inaccurate result in water quality examination. All the above problems make advanced water quality monitoring most important.

The main aim of the proposed system is to provide a low cost, most efficient and ease use water quality monitoring system using Arduino Uno (microcontroller) along with a GSM module, Wi-Fi module, Solenoid valve to monitor pH sensor parameters. This proposed system includes the special feature of altering the facility of sending messages about deviation in water quality parameters to cleaning agent and officials using an android application.

Related work

Traditional water quality monitoring system has some drawbacks such as complex method, need to for long period to receive the result, need more human resources. The many researchers proposed new methods for monitoring system still the methods need equipment which is high cost and hard to handle. [1] implemented a smart water quality system using a wireless network with IoT where a Wi-Fi module connects the sensors and transducers in a microcontroller. Water quality estimated using four parameters of quality such as pH value, temperature, CO2 and water level. In this method, the information about water quality is sent to a web server periodically, the information can be accessed from a remote place. If the sensors get damaged or do not work then the buzzer will get switched on automatically. [2] quality of the water is unaware when it reaches the end-users to address the issue, the authors proposed a system that uses sensor parameters which been converted to equivalent electrical form this value will be mapped with water purity values using microcontroller and store in the database using IoT. This centralized water quality monitoring system can be accessed from any place to monitor various water resources which been connected to it. This system has the advantage of reducing human resource, lower cost and more efficiency. [3] proposed a low-cost and reusability system, in real-time, this system acquires water parameters such as pH, turbidity and temperature these parameters are compared with a threshold value and necessary information communicated through General Packet Radio Service (GPRS) and stored in the webserver. [4] in this system, the cloud server has been maintained for data analysis and data saving for future development, this system uses three sensors to measure water quality such as ultrasonic, turbidity, and pH sensor controlled by Arduino (microcontroller) and Wi-Fi module ESP8266 used to data communication. [5] measures physical and chemical parameters such as pH,

temperature, turbidity and TDS of the water. Raspberry Pi used as a core processor, the measures sensor data can be viewed by ThingSpeak API through the internet. This system consumes low power and high mobility. [8] uses Raspberry pi, cloud computing using Zigbee protocol to monitor and communicate parameters obtained through water quality parameters such as conductivity, pH, dissolved oxygen, turbidity and temperature estimated using sensors [14]. The parameter values transmitted remotely and can be accessed and viewed on web browsers. The Zigbee technology can be only for short-distance communication hence, it cannot be used for long-distance communication. [9] designed a smart water quality monitoring system using five sensors (Turbidity Sensor, pH Sensor, Conductivity, Temperature sensor, Water flow sensor), Wi-Fi module and Arduino board. Cloud storage is maintained to access, monitor and process the retrieved data. The user can download stored data using the android application from a remote place. This system is capable of continuous estimation of Harmful chemicals, Microbiological parameters and Physical parameters. [10] proposed a deep learning model for water quality monitoring, Wireless Sensor Network (WSN) established using microcontroller, sensors, and inter and intra node communication. Spark MLlib used to visualize the collected data and provides an SMS alert message sent to the cleaning agent when the sensor parameters go beyond a threshold value. [11] this system uses IoT and machine learning technique to collect and manage sensor value obtained from five different sensors and stores in the server further the obtained value compared with standard value to estimate the level contamination of water in tanks. The major disadvantages of existing systems are, no proper end to end communication, Operation and maintenance of the system are too difficult, Supported only to some adequate areas not suitable for all environments, Monitoring of this system is very difficult, Hard to control this system, data communication takes a longer time.

Proposed system

In the proposed system, the water quality and sensor data are monitored and viewed on the Android mobile application. SQLite is used for storing sensor parameter values. Existing water quality monitoring systems are in the need of a personal computer environment and manual calculation method. But the proposed system gives the flexibility of monitoring water tanks on an android phone. The proposed system architecture is shown in fig 1.

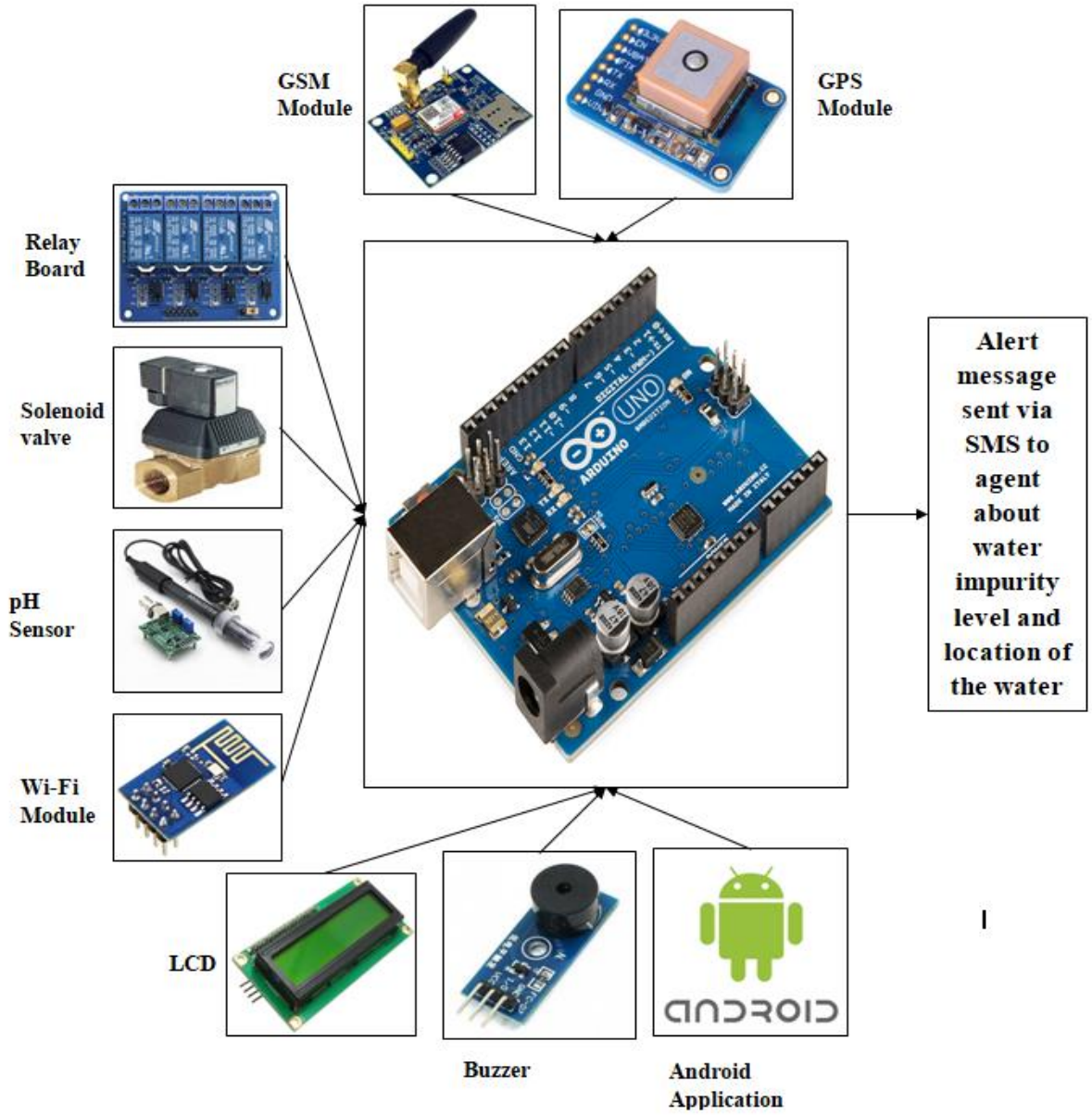

Fig.1. Proposed system architecture

The proposed system subdivided into four modules, i) pH value sensing ii) Alterting through SMS iii) Monitoring through android application iv) Relay Control. it is systematic progress. If that cleaning agent does not complete their work then, the user can able to trace them easily and take necessary actions. In the proposed system, the pH parameter value checks the water purity level. If the tank is not cleaned at the proper time then the water flow will be stopped with the help of an android app. The relay board is connected with the Arduino microcontroller to control the water flow. The proposed system has the advantages of checking the purity level of water, monitor the water quality, control the flow of water.

pH value sensing

pH value is sensed using the pH sensor which is connected with the Arduino microcontroller. pH value varies from 0 to 14. If the pH value below 4.6 then is considered to be acidic water. when the pH value is between 4.6 to 7 it is considered normal water. The pH value above 7 is considered as base water as shown in fig 2. The pH sensor contains two probes that are kept inside the water. It gives the reading which is displayed on the LCD screen. The sensor continuously senses and gives the reading .with the help of the reading user can able to categorize the sensor values whether it is the acid, base or normal water. For example, user can take samples such as lemon, saltwater and detergent powder. The sensor value will change for different solutions user should notice the values with the help of the sensor values user can able to identify the range of the values of unclean water. Then with the help of the values user can find the impurity systematically. The circuit is designed to analyse the pH value. Every time the impurity is found then an alert will be given to the cleaner. pH value is sensed using the pH sensor which is connected with the Arduino microcontroller. Set threshold value for acidic below 5.6, If pH value is greater than the threshold value of acidic. Water considered as acidic. Set threshold value for base above 7, If pH value is less than the threshold value of the base. Water considered as base In between the threshold value 5.6 to 7 Water considered as normal water.

Altering through SMS

When an impurity is found an alert message is sent to the cleaner. The first message will be sent to the cleaner to clean the tank. Within a particular time interval if the tank is not cleaned again a message will be sent to the cleaner. If the proper response is not taken then an alert message will be sent to the higher official. The message will be sent using the GSM kit. The user uses GSM Module – SIM900A to send a message. The GSM module is also connected with the Arduino microcontroller. The first alert message will be sent to the cleaner as shown in fig 3. Within a particular amount of time again the message will be sent to the cleaner. If again the proper response is not taken then the message will be forwarded to the higher authority.

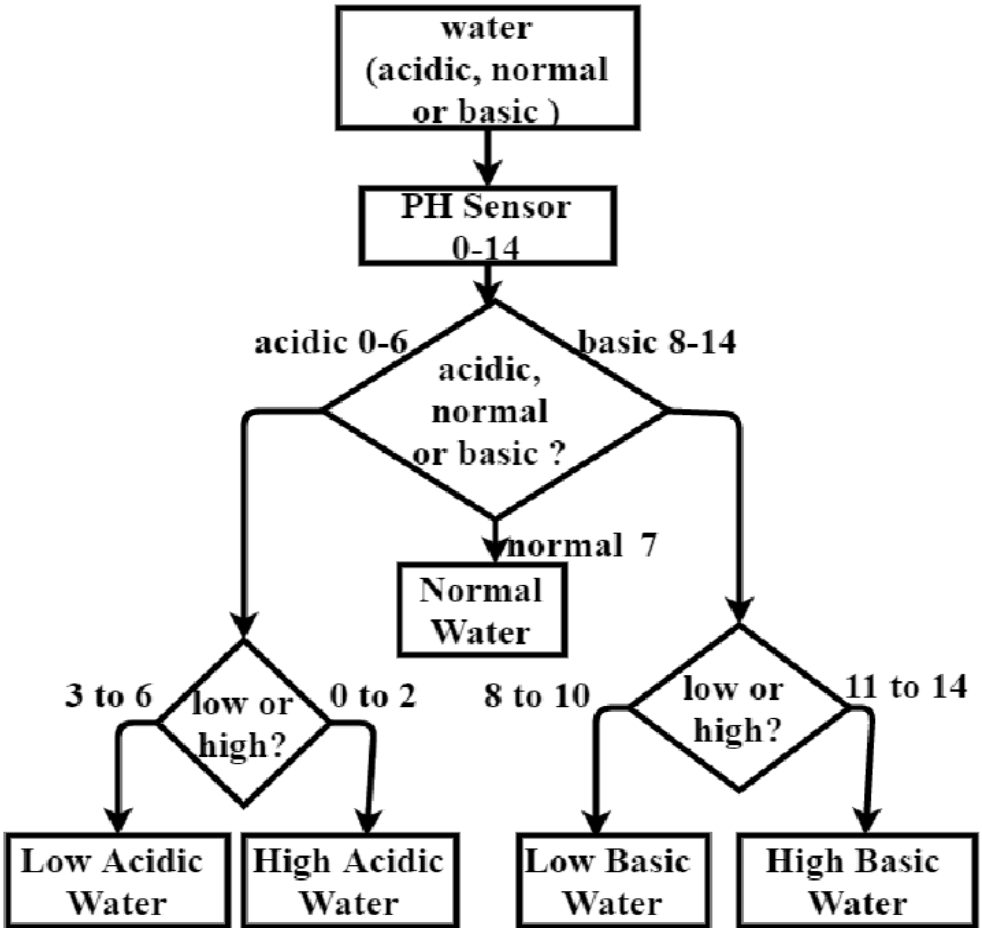

Fig 2. Flow Chart of pH value measurement

Cleaning Agent:

SMS 1: SMS alert on pH purity,

SMS 2: Alert message on cleaning.

Higher Authority:

SMS 3: pH monitoring with SMS alert system low water level.

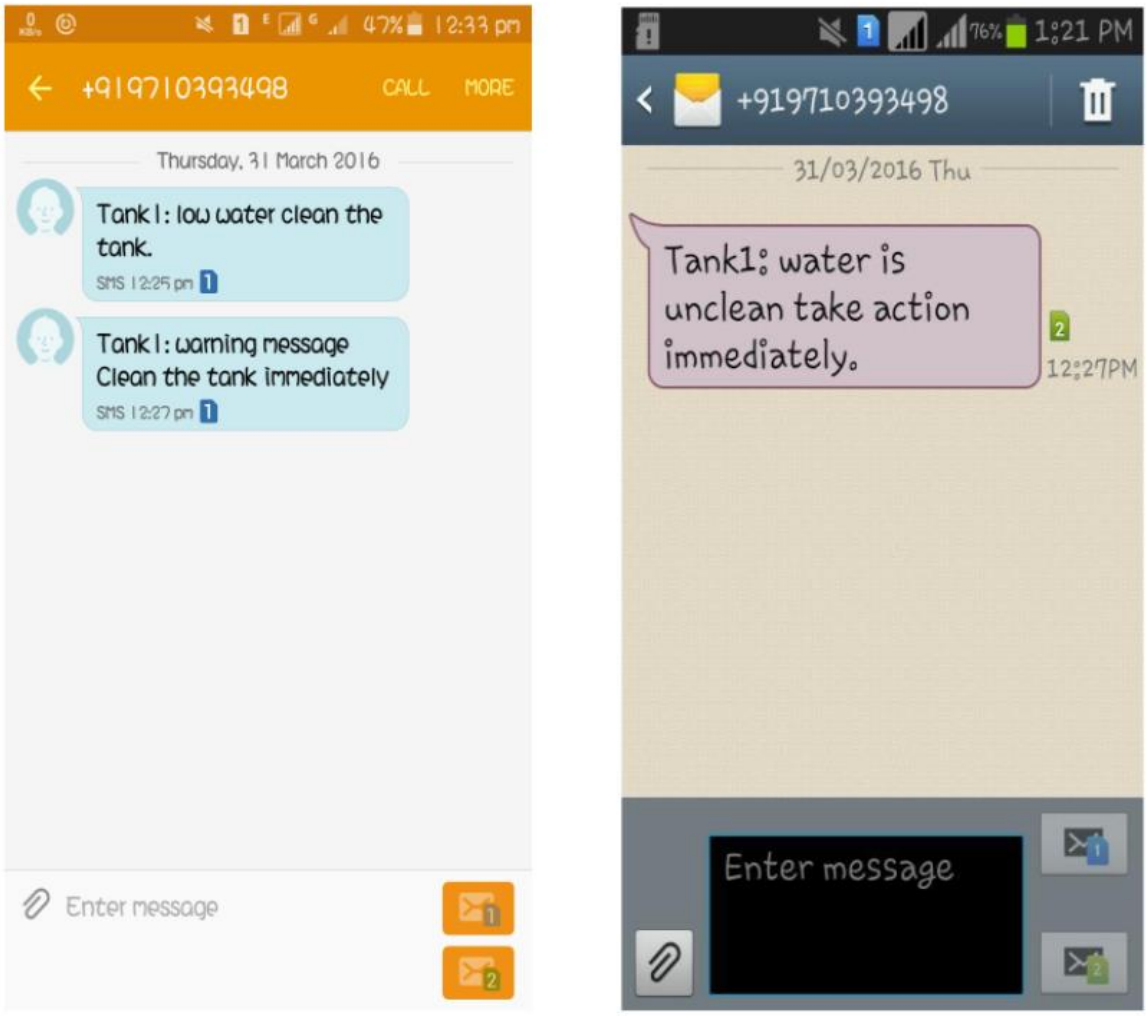

Fig. 3. Alert Message to the cleaning agent and superior officer.

Monitoring through Android Application

The android app is connected with the Arduino microcontroller via Bluetooth. With the help of the android application, user can able to monitor the pH sensor values. The android app is specially designed to control the one channel relay board as shown in fig 4. User can able to ON or OFF the relay board with the android application. After alerting with the message an alarm will be raised. This is just to notify when a message is not sent to a particular person. If the cleaner or the higher authority did not take the proper response to intimate an impurity to the people an alarm will be raised.

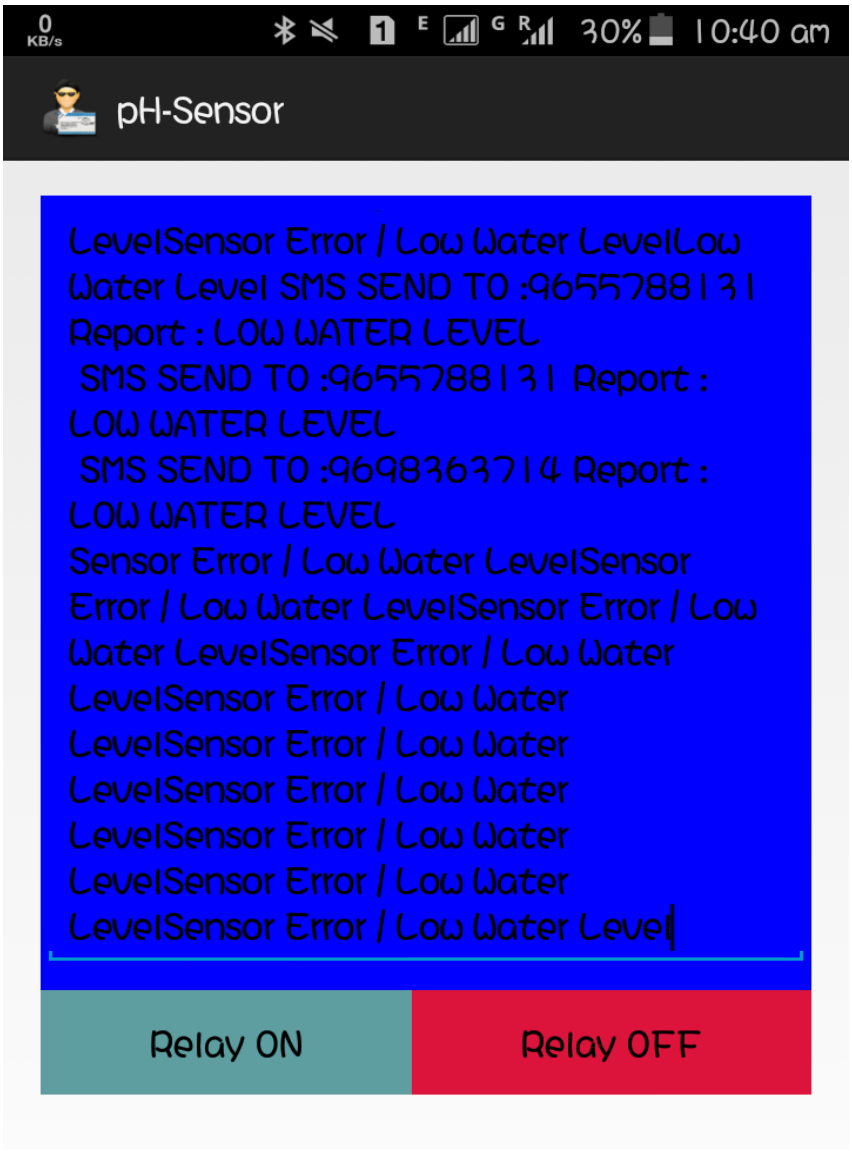

Fig. 4. Android application to monitor water level and purity.

Relay to water flow control

The relay board is connected with the microcontroller. It is controlled by the android application. User can easily ON or OFF the relay board with the help of an android app. If a user connects the relay board with the solenoid valve user can easily control the flow of water. when the impurity is found on the tank then the user can stop the flow of water with the use of a relay board. The water flow can be blocked with the help of the solenoid valve. The solenoid valve is connected with the one channel relay. With the help of the relay board, the solenoid valve is controlled. The android application helps to ON or OFF the relay board. when the

impurities are found on the water the water flow from the tank is stopped. It helps in avoiding using impure water.

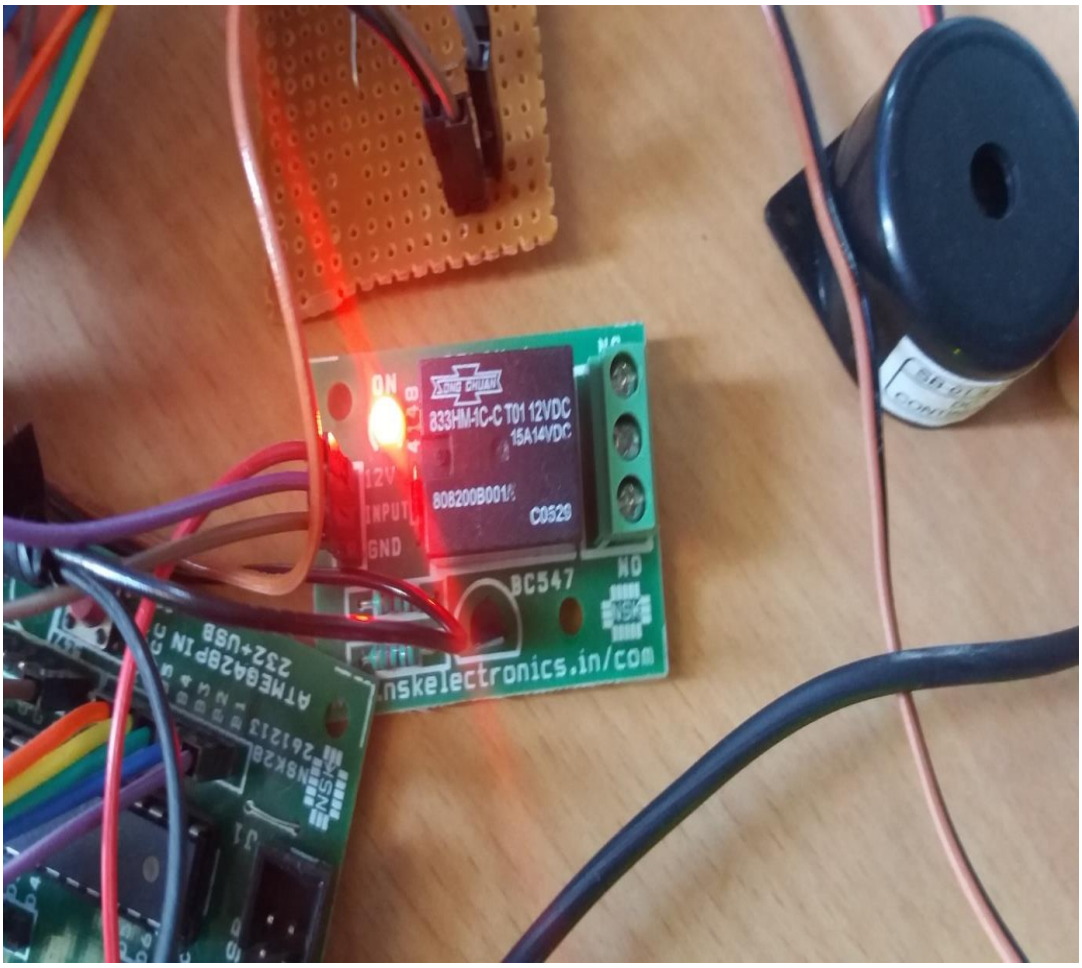

Fig. 5. Water control using a relay board

Hardware setup

The proposed system designed with a pH sensor, Relay board, Wi-Fi module, GPS module, GSM module, LCD screen, buzzer, Solenoid valve and a core microcontroller (Arduino Uno).

Arduino Uno

Arduino Uno ATmega328P is a microcontroller that operates on a 5V power supply, it includes 6 analogue pins, 16 input and output pins, a power jack, a USB-B connection port, a reset button and an ICSP header pin diagram of Arduino Uno is shown in fig 5.

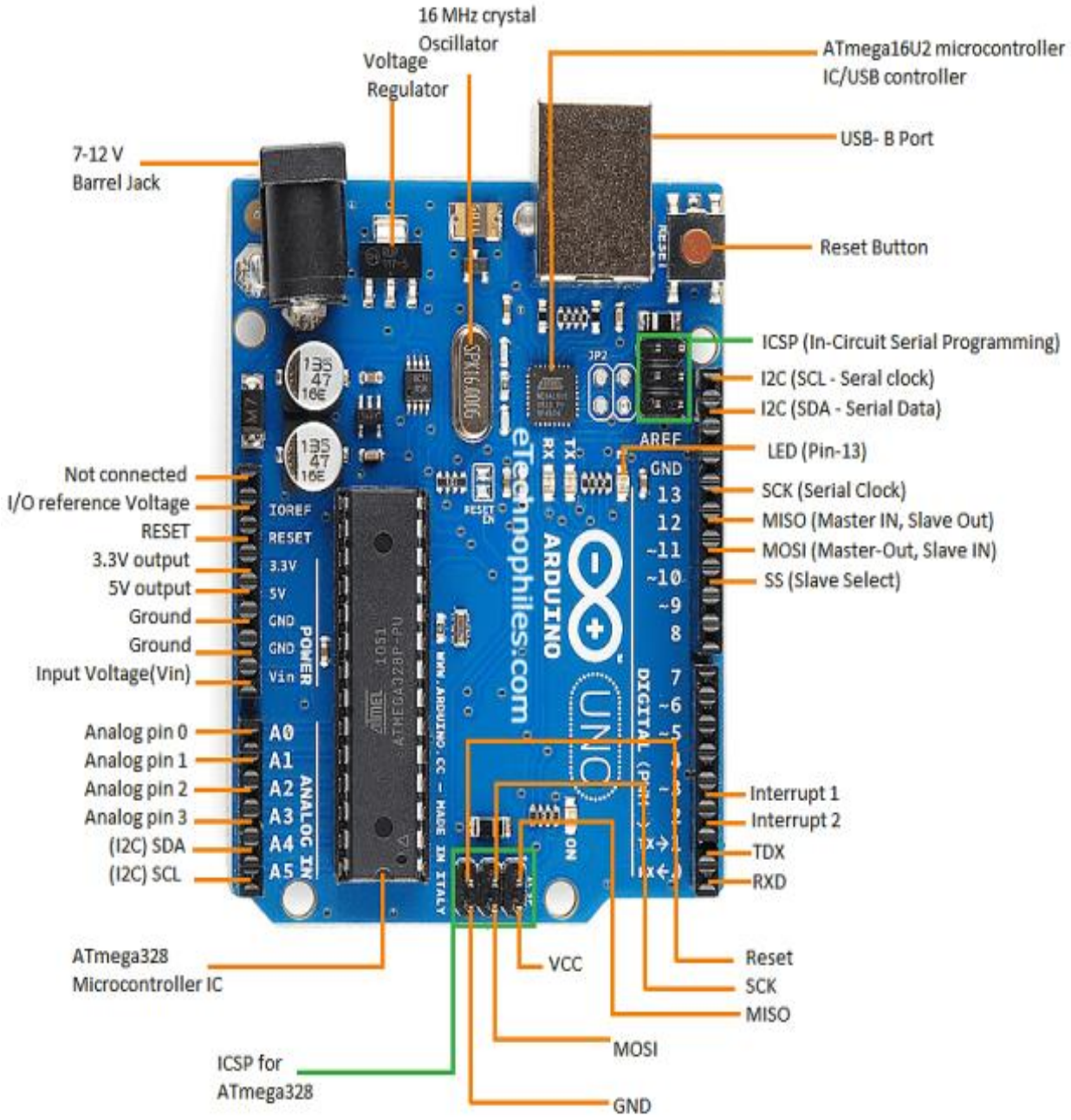

Fig. 6. Arduino Uno ATmega328P pin diagram.

The proposed system chose Arduino Uno as the backbone controller for the following reasons: open-source electronics platform, easy to use, help to design complex system in low cost and high efficiency, supports a wide array of sensors.

Wi-Fi module

The ESP8266 WiFi module is a popular and mostly used SoC chip for IoT embedded applications, pin diagram is shown in fig 6. Which takes the power supply of +3.3V only, 100mA current consumption includes 512KB flash memory, it can also be used as an access point or station or vice versa. Programmed using Arduino IDE or Lua script or AT-commands.

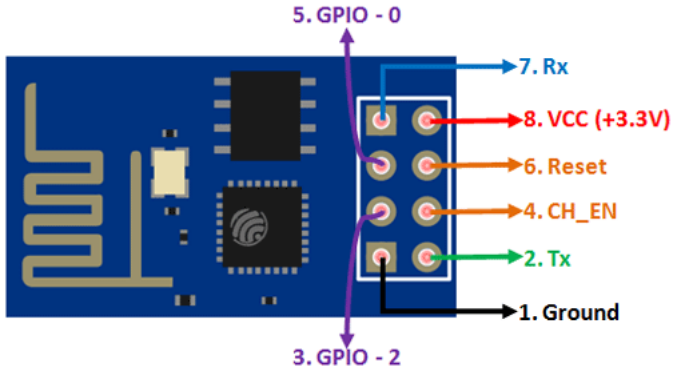

Fig. 7. ESP8266 WiFi module pin diagram.

The proposed system programmed a wi-fi module using Arduino IDE. The Microcontroller also connected through the LCD, which is used to display the result like pH value and SMS details.

pH sensor

pH (potential of Hydrogen) calculated the amount of free hydrogen and hydroxyl ions present in water. Takes the value from a range of 0 to 14, the value less than 7 considers as acidic and the value more than 7 considers alkaline as shown in fig 7. Mathematically, pH is measured using the negative logarithm of the molar concentration of Hydrogen Ions ([H+]) as shown in eqn (1). Consuming acidic or alkaline water is unhealthy. The pH sensor is designed with four elements such as preamplifier, electrode, transmitter or analyzer, and a reference electrode.

$$pH = -\log [H+] \quad (1)$$

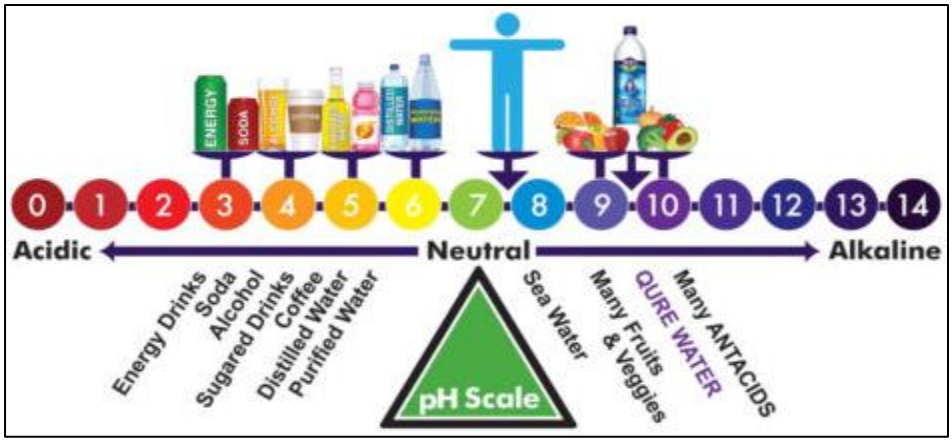

Fig. 8. pH scale of acidic and alkaline water.

Relay board, Solenoid valve, LCD and Buzzer

The proposed system uses 4 Channel Relay Board to control the water flow and solenoid valve. LCD is used to display the current and pH value on the water and also it displays the SMS which been sent to the cleaning agent after the change in the neutral water pH scale. Solenoid value is used to block and unblock the water flow. Once the pH level of the water goes beyond or below the threshold value of 7 then solenoid value comes into the picture to block the water flow into the water tank. A buzzer is used to notify the message been to the agent, After alerting with the message an alarm will be raised. This is just to notify when a message is not sent to a particular person. If the cleaner or the higher authority did not take the proper response to intimate an impurity to the people an alarm will be raised. An android application is used to monitor the water level, water purity level, notification message details etc., from a remote place. Where all the data are stored in the SQLite database. GPS and GSM module is used to sent accurate water tank location and generates text message periodically.

Results and Discussion

The performance of the proposed system is evaluated in real-time in with given set up as shown in the proposed system architecture. This system obtained satisfactory result compared to existing methods as shown in fig 8 and 9. The impurity water value is shown in LCD and android application. This system outperforms existing methods in terms of sending notifications to agents, there may be a possibility of agent to forget the notification this system keep on sending notification until and unless the water tank gets cleaned.

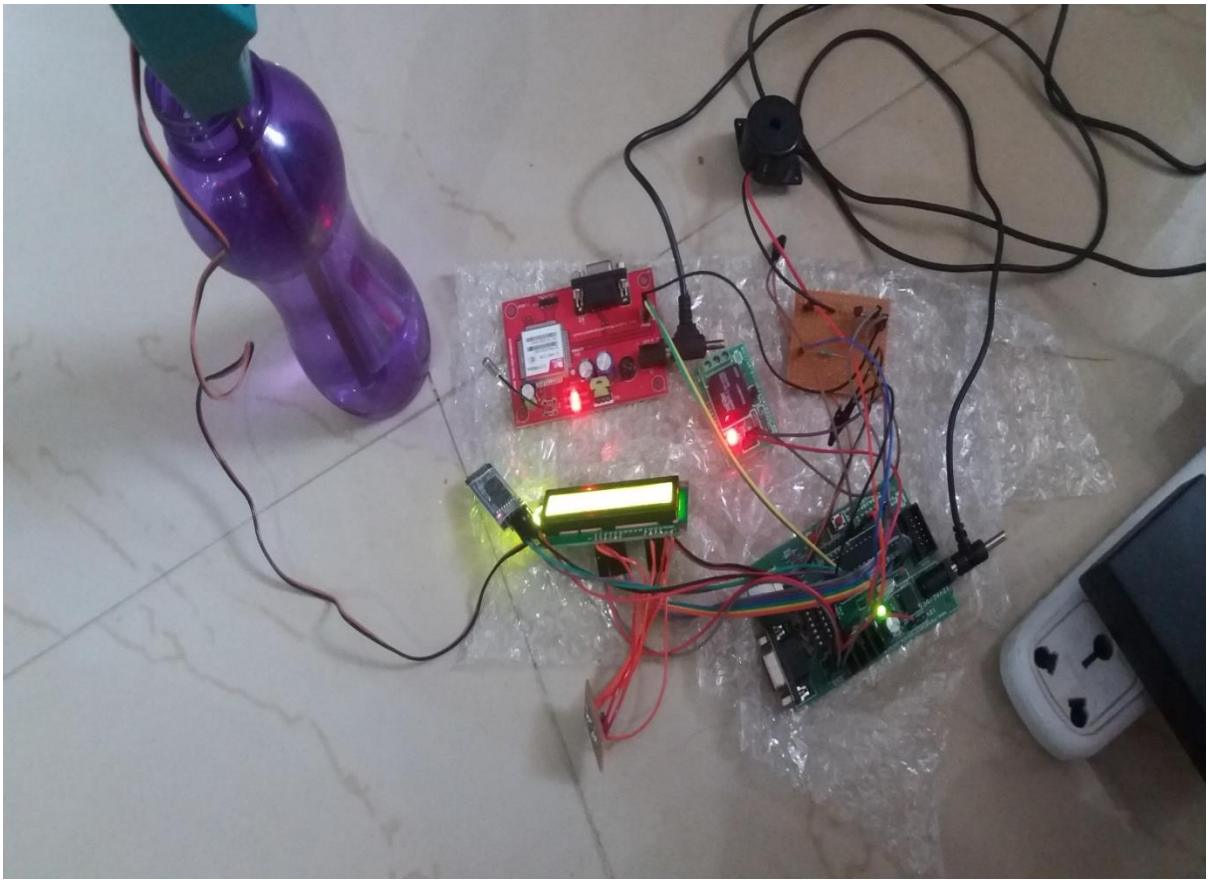

Fig. 9. Experimental setup

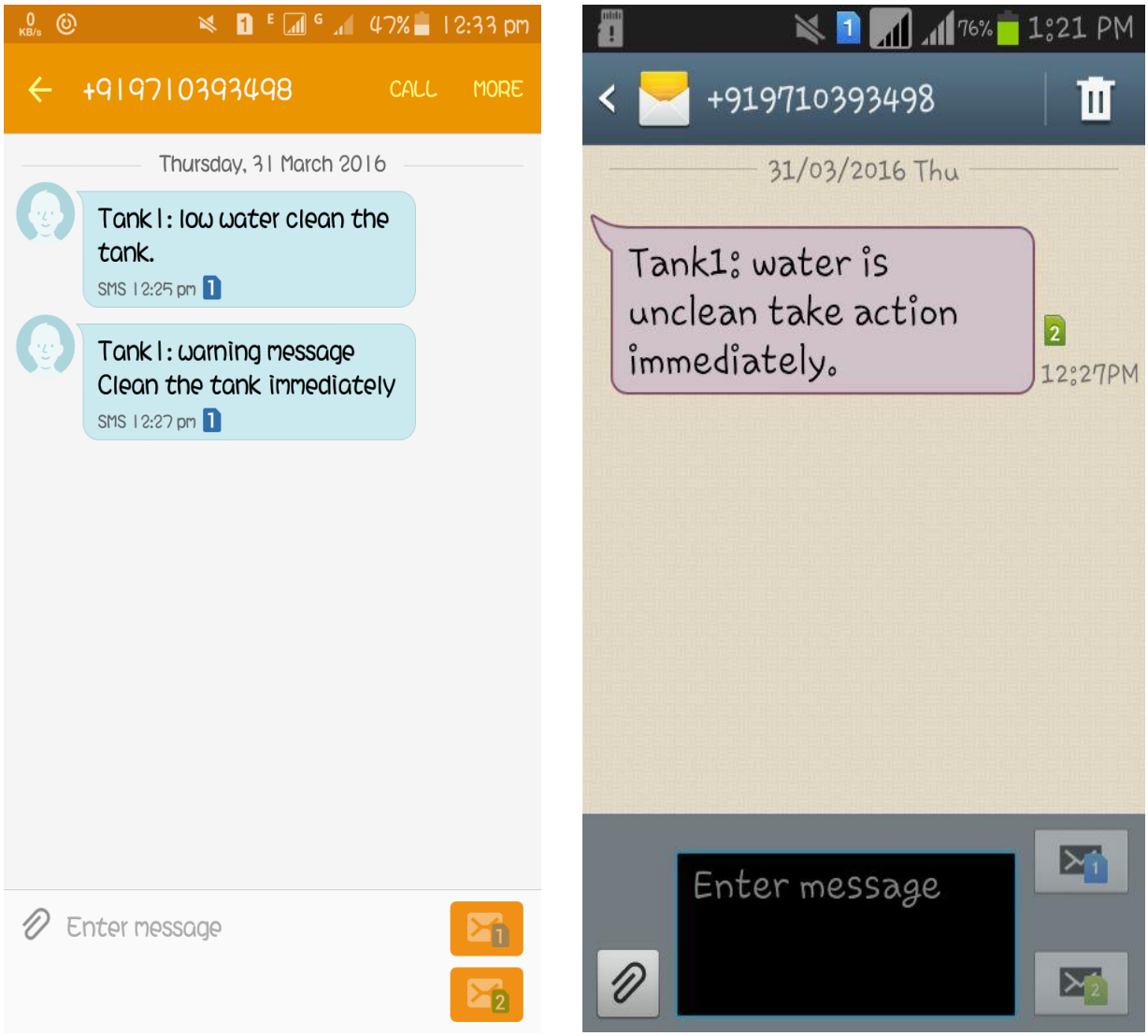

Fig. 10 (a) & (b). Notification sent to cleaning agent and superior officer.

The results, performance, error rate, and accuracy are shown in fig 10-15. The proposed system obtained an accuracy of 92.16% and periodically produces low error compared to the existing system.

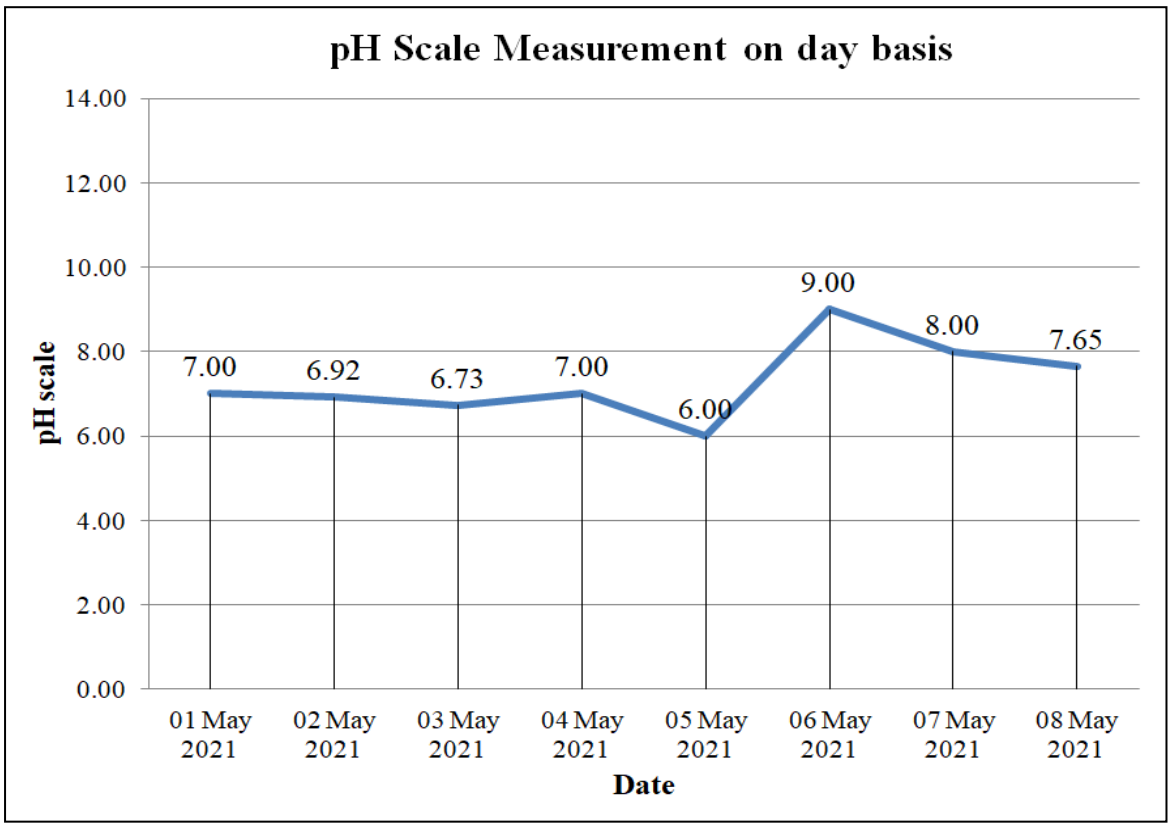

Fig. 11. Report of pH scale value generated by the proposed system on water tank 4.

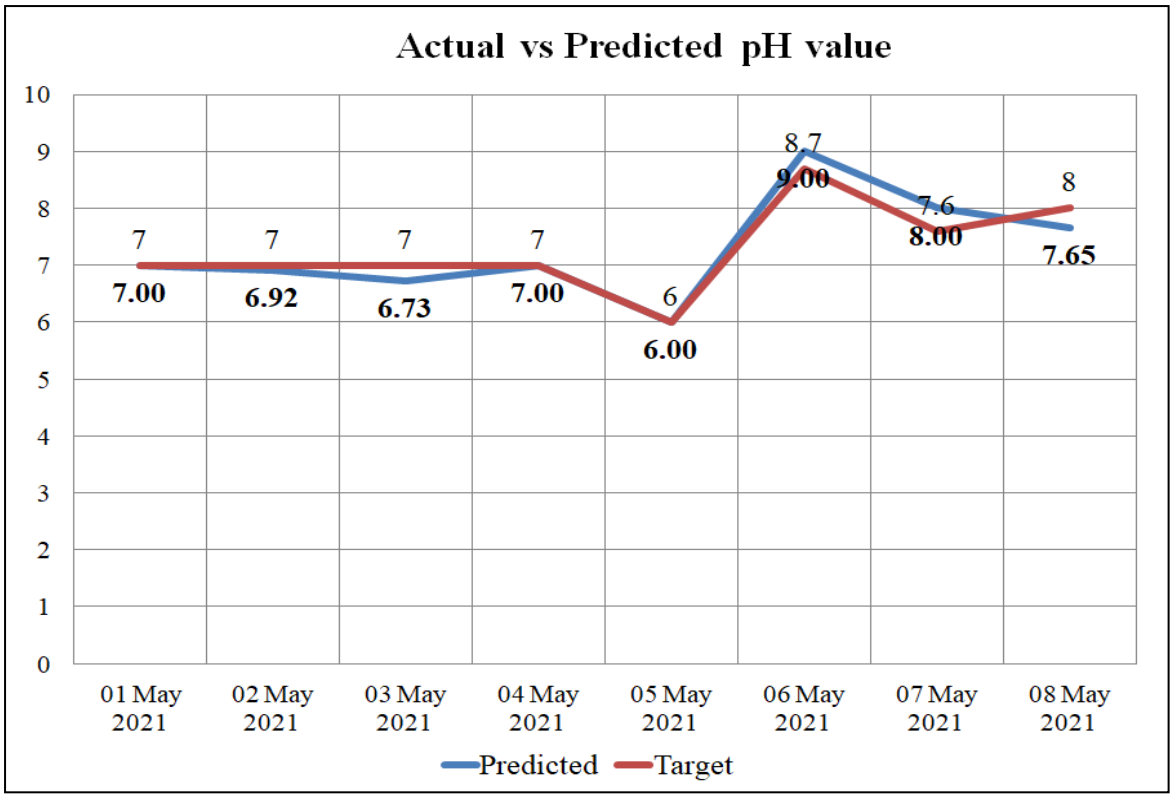

Fig. 12. Actual vs Predicted pH scale measurement of the proposed system on water tank 4.

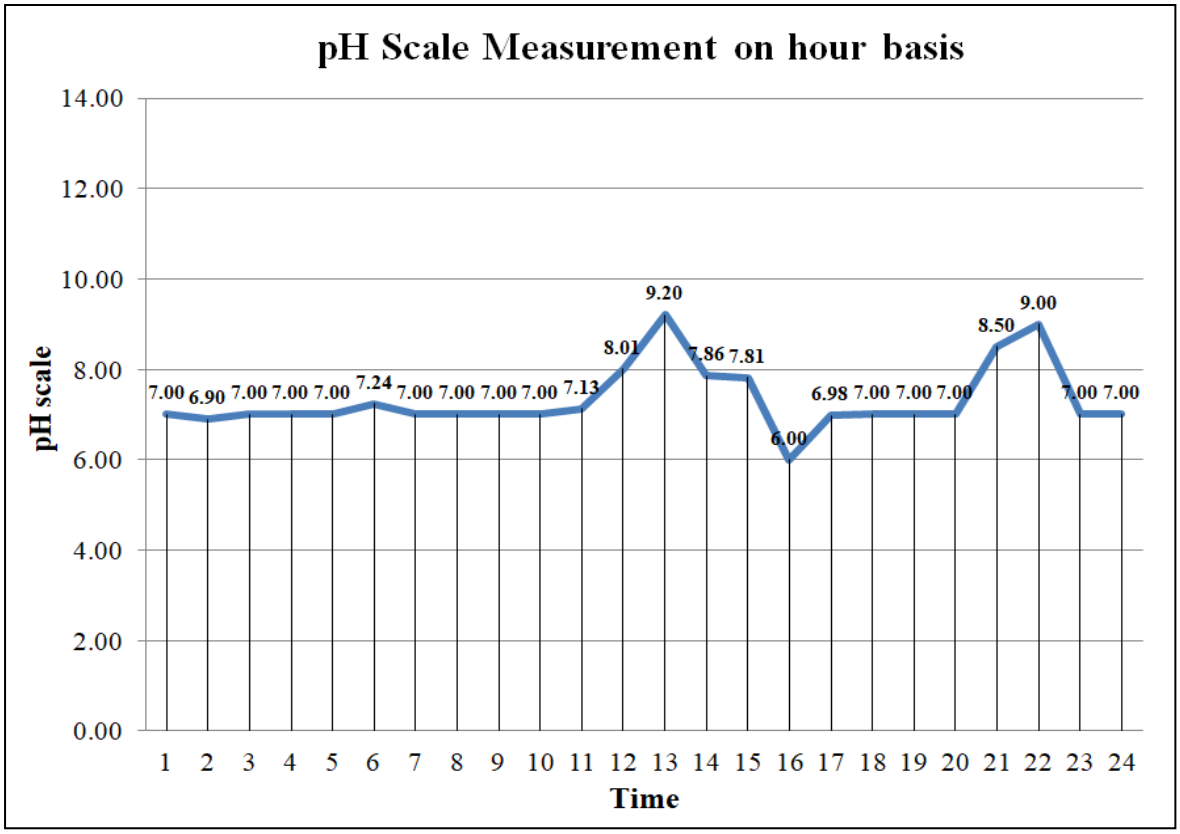

Fig. 13. Report of pH scale value generated by the proposed system on an hourly basis.

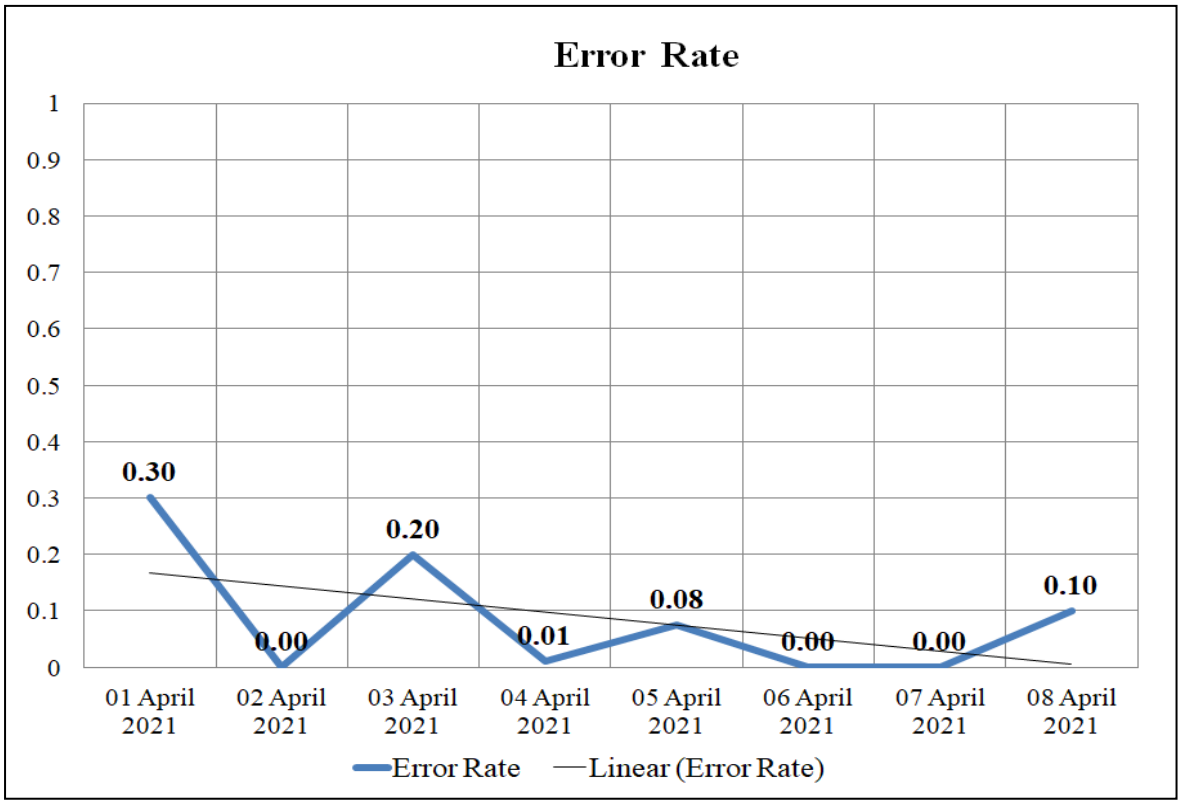

Fig. 14. Error rate obtained by the proposed system in a week.

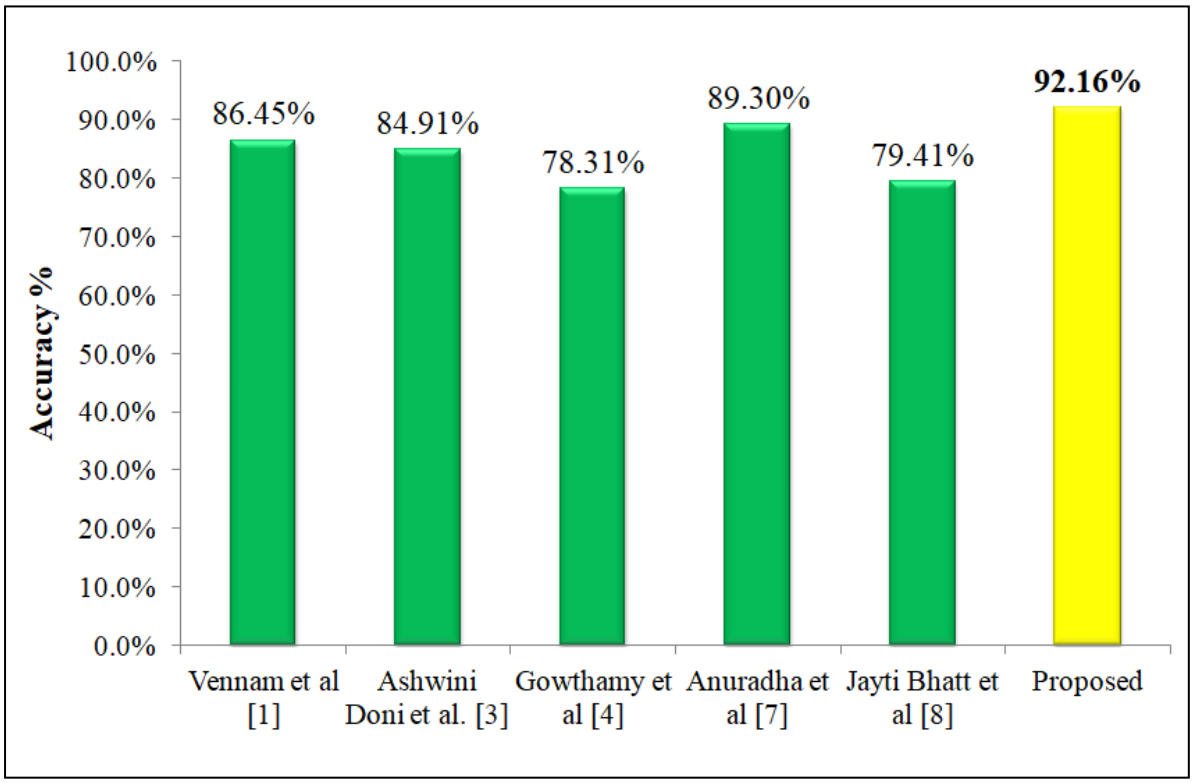

Fig. 15. Proposed System Accuracy.

Algorithm: pH level monitoring
Input: Drinking water **Output:** pH value, Notification message generation.

pHVal=analogRead(A0);
lcd.setCursor(0,0);
lcd.print("TANK1 pH :");
lcd.print(pHVal);
if(pHVal<6) {
lcd.setCursor(0,1);
lcd.print(" SENSOR ERROR !!");
bluetooth.print("Sensor Error / Low Water Level"); }
if(pHVal>=6 && pHVal<=15) {
lcd.setCursor(0,1);
lcd.print("TANK 1 LOW WATER ");
bluetooth.print("Low Water Level");
sendsms("9655788131"," LOW WATER LEVEL "); delay(1000);

```
sendsms("9655788131"," LOW WATER LEVEL "); delay(1000);
sendsms("9698363714"," LOW WATER LEVEL "); beep(); }
if(pHVal<=70 && pHVal>=16) {
lcd.print(" NORMAL WATER "); }
if(pHVal>100) {
lcd.print(" SALT WATER ");
sendsms("9655788131"," SALT IS PRESENT IN WATER "); delay(1000);
sendsms("9655788131"," SALT IS PRESENT IN WATER "); delay(1000);
sendsms("9698363714"," SALT IS PRESENT IN WATER "); beep(); }
void sendsms(char phone_no[],char statuss[])
{
Serial.print("AT+CMGS=\""); Serial.print(phone_no); Serial.println("\"");
Serial.print(" pH Monitoring With SMS Alert System ");
Serial.print("Status:");
Serial.print(statuss);
delay(1000);
Serial.write(0x1A);
Serial.write(0x0D);
Serial.write(0x0A);
bluetooth.print(" SMS SEND TO :");
bluetooth.print(phone_no);
bluetooth.print(" Report :");
bluetooth.print(statuss);
bluetooth.println("");
delay(1000);
}
```

Conclusion

The proposed system proposes a new method to sense the pH scale value of water, controls the water flow and determines the quality of water. This system is more reliable, low cost and flexible to use. The naive users can also install the app and use it easily. The sensors and hardware helped to design a low-cost system used and monitored from a remote place. More water tanks can also be monitored. By using this system the purity of water can be determined

easily in an efficient way. Two different ways to monitoring the water such as water pollution monitoring and blocking the water flow. The two-level information passing enables confidence overconsumption of water from the public water tanks. Finally, the water monitoring system can be installed in homes or offices and can be monitored through an android application. By using the monitoring system user can easily prevent water contamination, avoid consuming impure water and the water will be saved for the next generation. In future work, the user expects to publish information about the quality of water in social networks. This can also be implemented in open areas such as lakes and rivers.

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