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# Design and implementation of remotely monitoring system for pH level in Baghdad drinking water networks

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**ABSTRACT**

Many people in the recent days have suffering from number of diseases due to unsafe and impure drinking water, especially in rural areas. As typical laboratory experiments and official water quality tests take considerable amount of time to obtain results and due to non availability of a simple device that can measure such water quality parameters in real time, therefore in this paper a remote pH level monitoring system for Baghdad drinking water system is proposed. A PH level sensing and monitoring nodes are distributed at different location. These nodes are proactively measured pH level of water and send data to the maintenance center to give them overall picture about pH level via global position system (GSM). This proposed system gives a robust, low-cost and effective method for the drinking water maintenance center to measure and monitoring the water quality in real time environment.



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## 1. INTRODUCTION

As known that water is a prime importance resource for the presence of life in the plant, therefore the availability water with high quality characteristics is an important factor for life survival [1]. One of the main quality parameters for water is 'pH', a chemical characteristic used to measure the acidity level of water. It is an indicator of contaminants in water as pH level varies according to the amount of native substances [2]. The pH of any solution can be measured by taking the negative common logarithm of the hydrogen ion as illustrated in (1) [3].

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

If the activity of hydrogen ion is approximately equal to the hydrogen ion concentration, then the solution is neutral [4]. Water with more hydrogen ions is acidity water, whereas water with more hydroxyl ions is alkaline. The range of pH is from 0-14, the water with pH 7 is being neutral; pH of less than 7 indicate acidity water while a water with pH of greater than 7 indicates alkaline water. The water with too high or two low pH value can hurt the aquatic organisms living within it and also not suitable for drinking. Figure 1 show some examples of everyday substances and their pH. PH can be affected by temperature, for any temperature degree above 25 °C a decrease in pH for about 0.45 occurs [5]. The pH of most drinking water lies within range 6.5-8.5 as shown in Figure 2.

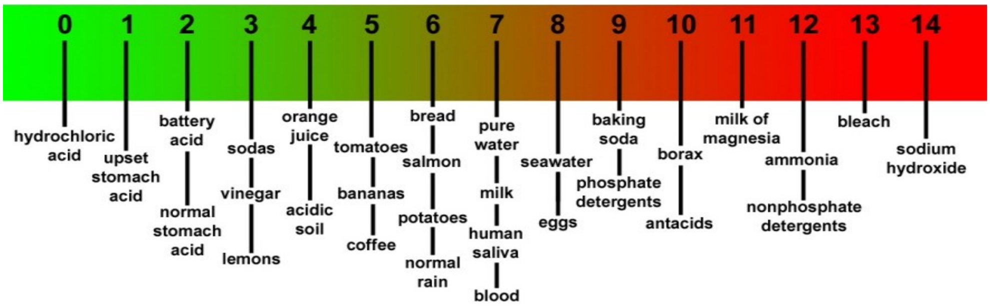


Figure 1. Some Substances and their pH value

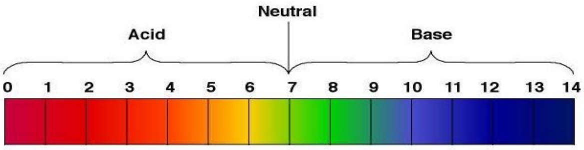


Figure 2. Range of pH

Many standards for water quality are defined by authorized organizations with respect to usage of water [6]. Water quality monitoring is recommended in many situations. Water wells around factories and sites that dump hazardous waste should be regularly monitored [7] as well as water sources in agricultural areas [8, 9]. Moreover, soon after natural disasters such as floods, landslides, and tsunami, water sources in the affected area should be tested whether it is suitable for consumption or not [10, 11]. To assure the quality of water, tests can be performed on actual sites and in laboratories [12]. When few measurements are taken at sites, most of the tests are carried out in laboratories by collecting water samples from a particular site and transporting them into different locations. Taking readings in a different environment other than the native environment of the samples will produce error reports hampering accurate monitoring [13].

Therefore, many real time monitoring systems have been proposed. Zhenan *et al.* [14] presented an intelligent control system for water quality using wireless sensor networks and UAV control algorithm but this method is not efficient for controlling wireless systems. Barabde *et al.* [15] introduced a water quality measurement system based on zigbee and WSN. Rao *et al.* [16] presented an autonomous water quality monitoring system using GSM [16]. A water quality monitoring system based on IEEE 802.15.2.4 and solar energy is proposed by Fredrick *et al.* [17] but this system is expensive and difficult to deploy. Chandrappa [18] proposed a system for monitoring water quality using Raspberry Pi 2. Lai developed an image processing and fuzzy inference system for monitoring the water quality [19]. Thamarai and Anitha [20] introduced a real time monitoring and automated billing system for drinking water. Yu *et al.*, [21] improve the power consumption and packet loss rate by proposing a rural drinking water monitoring system based on wireless sensor network. A robust sensor network that uses the mobile sensor technology and robust sensor placement model (RSPM) is proposed in [22] that can detect pollution events in water supply systems to ensure that the optimal sensor deployment scenario performs well in all achievable pollution scenarios. Jalal and Ezzedine [23] proposed water monitoring system that uses a new generation of wireless sensors to detect the chemical, physical and microbiological water parameters in Tunisian water resources. The proposed system in [24] examine the relationship between pH, total dissolved solids (TDS) and conductivity water quality parameters (WQPs) involved in the detection of hexavalent chromium contamination in the drinking water distribution system. Finally, Zennaro M *et al*. [25] present the design of a water quality measuring system and propose a prototype implementation of a water quality wireless sensor network (WQWSN) as a solution to water quality measurement in Malawi.

The traditional method for measure the quality of water is take samples of water to labs to be analyzed, but this method is not accurate method as well as not economical, reliable and time-consuming method. Therefore, a new accurate, robust and real time monitoring system is required. In this paper an effective, robust, low cost and real time system for measuring the pH level of the drinking water is propose. A distributed pH sensor at different locations in Baghdad are measured and monitored pH level. The output from pH sensors is fed to Arduino microcontroller which reads, processes and send the data to the maintenance center via via GPRS. The remainder of this paper is organized as follows: section 2 describes the proposed system in detail. The simulation results will be analyzed in section 3. And finally, in section 4 conclusions will describe.

## 2. RESEARCH METHOD

The proposed system consists of distributed pH sensors that automatically take water samplesfrom tap water, pH sensor and send the measured information to Arduino microcontroller to be processing and then send periodic message about the status of pH level to the authorize center through GSM module. Finally the maintenance center mobile phone receives information about the level of pH and takes the correct action when the pH level is in the risk level; acidic (below 6.5) or alkaline (above 8.5). The proposed pH level water monitoring system block diagram is show in Figure 3.

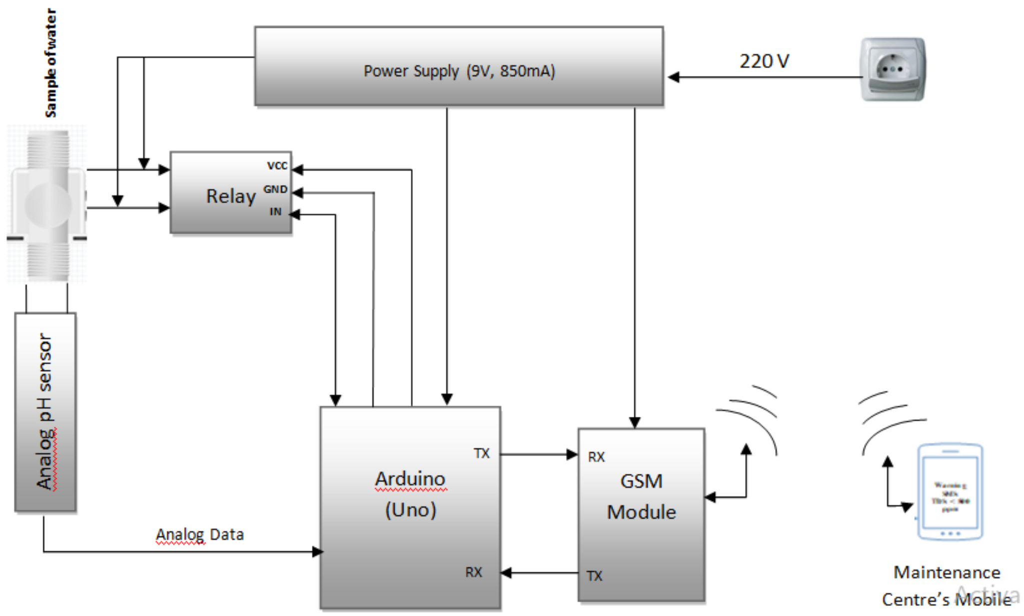


Figure 3. Overall proposed drinking water quality monitoring system

### 2.1. HARDWARE DESIGN

The proposed system consists of three parts; the first is controlling, sensing and processing part. The second part is responsible for transmitter operation. And the last part is the receving part in the maintenance center.

#### 2.1.1. Controlling, sensing and processing tap water sample

Firstly, based on programming procedure a signal is sent from Arduino to relay. Then a relay makesasolenoid valve opening and a sample from tap water will sense by analog pH sensor. The sensing pH level is then processed by the microcontroller to take the correct action. The components; relay, solenoid valve, pH sensor and Arduino are illustrated in Figure 4.

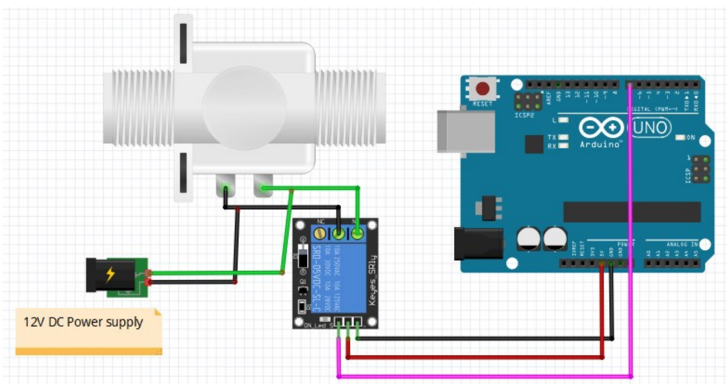


Figure 4. First part components

a. Arduino uno module

This module is the brain of the proposed system. This is a microcontroller board based on the ATmega328P that are used to controlling, processing and analyzing the pH of tap water. This microcontroller is suitable to the proposed system. The specifications of Arduino uno that used in this paper are describe in Table l. Also, in this a paper we need Arduino shield to extend the fectures of Arduino. The Arduino shield that used here is shown in Figure 5. Every Arduino shield must have the same form-factor as the standard Arduino. They are circuit boards that mounted above Arduino module to instill it with extra functionality.

Table 1. Specifications of Arduino Uno

| Microcontroller | ATmega328 |
|---|---|
| Flash Memory | 32 KB (0.5 KB from it used by bootloader) |
| EEPROM | 1 KB |
| SRAM | 2 KB |
| Operating Voltage | 5V |
| Input Voltage | 7-12V |
| Input Voltage | 6-20V |
| Analog Input Pins | 6 |
| Digital I/O Pins | 14 |
| DC Current per I/O Pin | 40 mA |
| DC Current for 3.3V Pin | 50 mA |
| Clock Speed | 16 MHz |

b. Arduino relay

The second part in the propsed system is the relay that connected to Arduino board. It is actually an electrically switch operated by an electromagnet which activated with 5 volts from Arduino and it pulls a contact to make or break a high voltage circuit. It is controlled the valve of the water pipe. Figure 6 shows the circuit schematic of the relay module that represented as communication node between solenoid valve and Arduino.

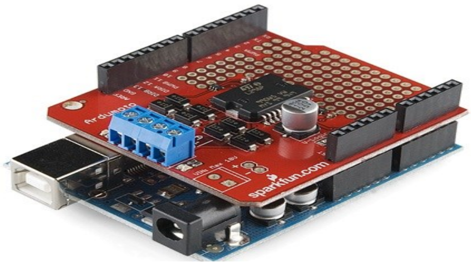

Figure5. Arduino uno with shield

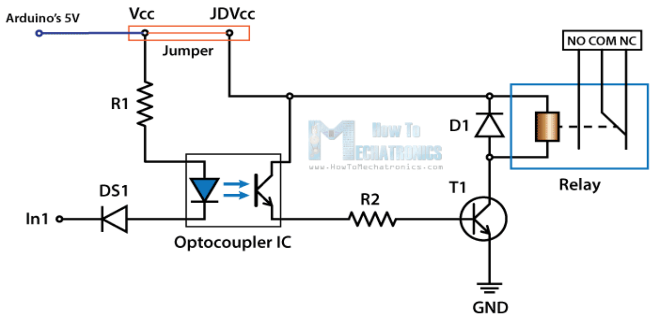


Figure 6. Circuit schematic of the relay module

c. Solenoid valve

The solenoid valve used for controlling water flow based on the signal came from Arduino through relay. The flow of water is received by pH sensor to read the level of the PH. Based on the sensed PH value, Arduino make the correct action. The valve should connect to tap water pipe at homes as shown in Figure 7.

d. Analog pH Meter (SKU: SEN0161) module

This meter has build-in, simple and convenient connection and particularly designed for Arduino microcontrollers. It must be noted that before the meter can be used and to obtain more accurate results, it must calibrate by the standard solution as shown below in the following steps:

- Firstly, equipment required for calibration is connected as shown in Figure 8.
- Under 25 ℃ environment temperature the pH electrode will put into a solution with pH value 7.0. And the result started to appear in the serial monitor of the Arduino IDE will record as shown in Table 2. If the reading on the serial monitor is close to the standard's solution conductivity, then the calibration process was successful.

Figure 7. Solenoid valve connecting to tap water pipe

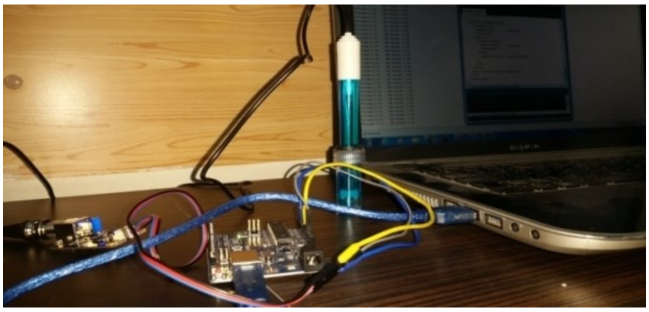

Figure 8. Analog EC meter calibration

Table 2. Calibration with 7.0 pH solution

| Standard solution with pH value 7.0 |
|---|
| Voltage: 2.10 ph value:7.34 |
| Voltage: 2.10 ph value:7.34 |
| Voltage: 2.10 ph value:7.34 |
| Voltage: 2.10 ph value:7.35 |
| Voltage: 2.10 ph value:7.34 |
| Voltage: 2.10 ph value:7.34 |
| Voltage: 2.10 ph value:7.35 |

#### 2.1.2. The transmitting part

In the transmitting part, GSM SIM900A module is used. This module is used for transmit notification about the level of pH that sensed from the home water pipe to the maintenance center to take the correct action. A picture for the connection of the GSM SIM900A module to the Arduino microcontroller is shown in Figure 9.

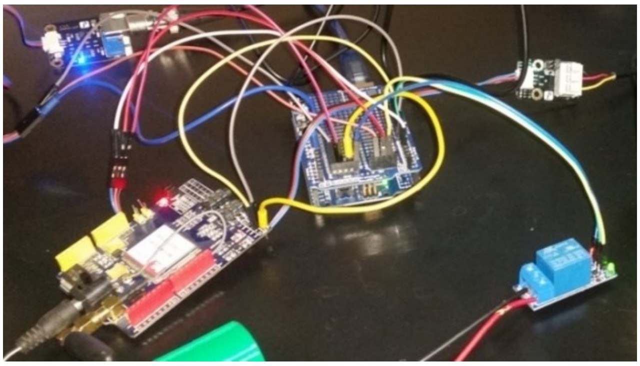

Figure 9. GSM SIM900A connected to Arduino

#### 2.1.3. The receiving part

The mobile phone of maintenance control stationwill receive a periodically notification message about the pH level. The transmitted value is sensed by PH sensor and send by GSM module. The authorized persons in the maintenance station will record pH value corresponding to the location of the water pipe. The record the location corresponding to the phone number that implanted in GSM module in transmitting part.

### 2.2. Software design

The Software approach for the monitoring system of drinking water pH level is based on programming the Arduino Uno to communicating withGSM SIM900A module and analog pH meter. The Arduino Uno is programmed with the Arduino software. After measuring the level of PH, GSM SIM900A module send the PH value to the mobile phone of the maintenance center to take the correct action based on the sensed value. Figure 10 show a detailed flowchart about the proposed water pH level monitoring system.

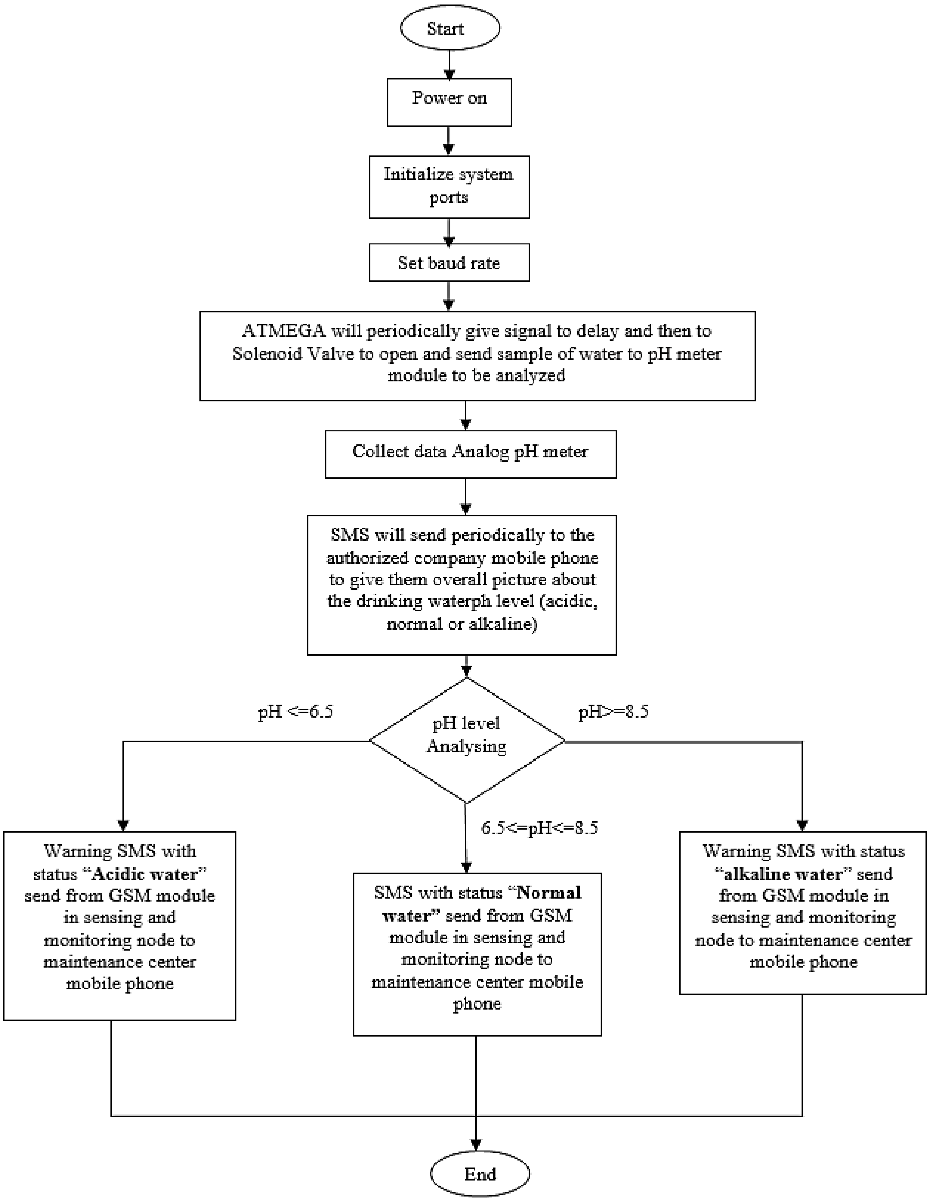


Figure 10. Flowchart for proposed system

## 3. RESULTS AND ANALYSIS

The prototype ofthe proposed pH level monitoring system is shown in Figure 11. We measured pH level of tap water at center and side locations in Baghdad as shown in Figure 12. Also, pH level of tap water in locations near the filtering and generating drinking water stations at different locations are measured as shown in Figure 13. This measuring information through pH meter is periodically sent to maintenance center through GSM module as SMS shown in Figure 14. The measured ph level will save based on phone number putting on GSM module for the monitored place, if the recoded ph value is lower than 6.5 (acidic water) or higher than 8.5 (alkaline water) the maintenance center should take necessary action to return the water to normal level (about 7.0).

It noticed from the measured results that range of pH in most locations is about 9. In spite of some studies said that drinking alkaline water may have benefits for people who suffer from high cholesterol, diabetes, and high blood pressure but it has some negative side effects such as decreasing the natural acidity level of stomach and the decreasing of free calcium in the body, which can affect bone health. Additionally, a high level of alkalinity in the body may cause skin irritations and gastrointestinal issues. Therefore, the monitoring center in Baghdad drinking water should treat of high alkalinity in drinking water and conversion to neutral water.

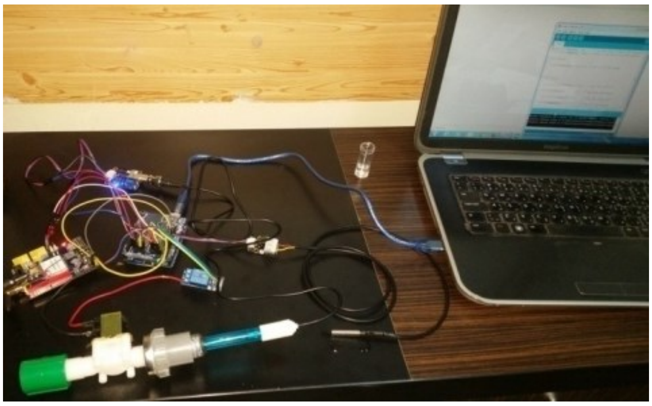

Figure 11. Proposed system overview picture

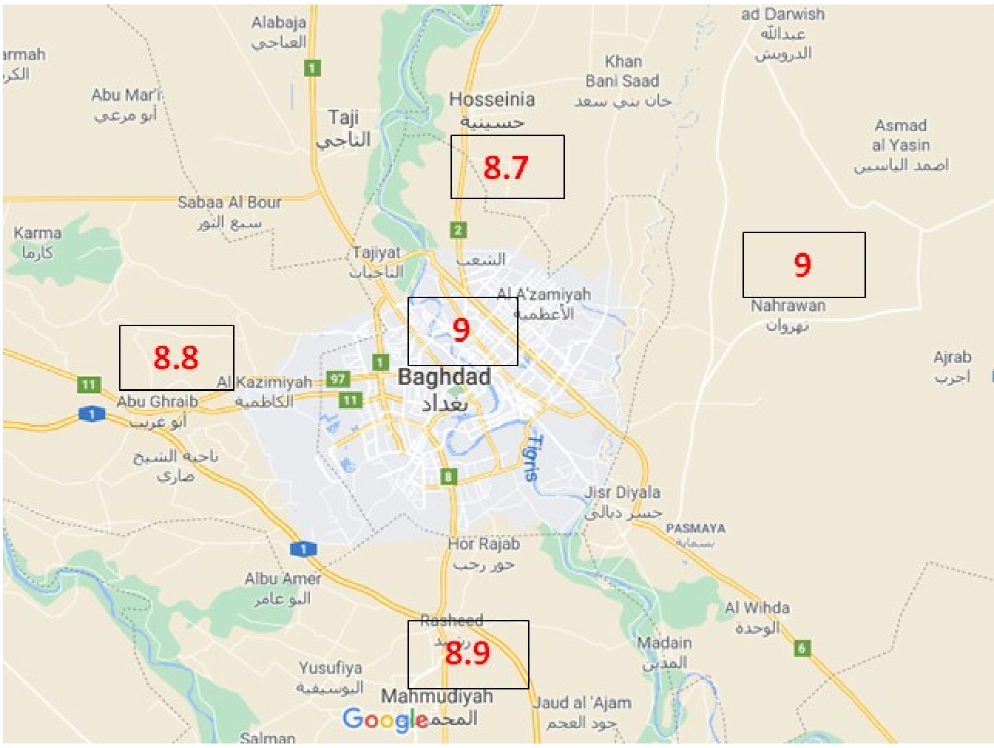


Figure 12. Measuring ph level

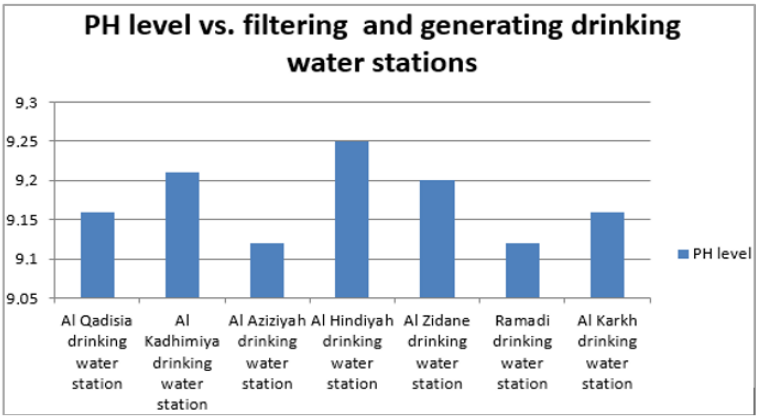


Figure 13. Ph level at filtering and generating drinking water stations

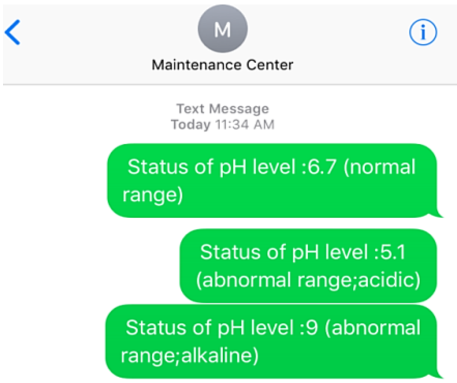


Figure 14. Periodic monitoring message

## 4. CONCLUSION

One of the important things for human health is to consider the water quality. Therefore, in this papera real time pH level monitoring system for drinking water at consumer sites is presented. A number of sensing and controlling nodes are distributed at different locations to measure the pH level. These low cost, low power and lightweight distribute nodes is sense and process the measured data and send periodic message to the maintenance center mobile phone to give them overall picture about the pH level and if the level of pH is lower than 6.5 or higher than 8.5, then a warning message is sent to maintenance center to take an immediate action and return the level of pH to normal range (about 7). It noticed from the calculated results that the level of PH is in the alkaline level (above 8), therefore a water treatment system should apply to return the water to normal range.

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