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Assessment of the Quality of Drinking Water for Plants in the Al-Karkh, Baghdad, Iraq

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Abstract

The study aims to assess some physical, chemical, and bacterial characteristics of two of Al- Dora and Al-Qadisiya in the area of Karkh, Baghdad, drinking water treatment plants Iraq. The areas covered by each plants and these sites of areas selected as the nearest and the winter and summer season. Some physicochemical parameters point from plants, for farthest of water quality were taken in this study and these parameters were temperature water, pH, electrical conductivity, total dissolved solids, free residual chlorine, calcium, magnesium, nitrate, nitrite, sulphate and heavy metals (lead). In addition to four bacterial indicators of drinking water pollution (APC, Total Coliform, Fecal Coliform and *Salmonella* spp.). The within the permissible limits for Iraqi criteria and standards for drinking water. results showed

Keyword: water pollution, drinking water, physical and chemical properties, bacterial contamination.

1. Introduction

Water is an essential component of the environment has a major impact on all vital processes occurring within living organisms therefore, its pollution can cause serious damage to living organisms and disruption of environmental balance [1]. Monitoring the physicochemical and biological factors of water bodies and the drinking water plants is important for life of aquatic organisms and public health [2]. WHO [3]. Emphasized the importance to assess the treatment plants from the raw water source to users. Many countries are interested in setting water quality guideline and water quality indices for household, agro-industrial and other use [4,5]. Unfortunately, some sources of drinking water have become exposed to different pollutants such as biological contamination (bacteria , viruses, and fungi) and high level of inorganic elements or heavy metals such as Mg^{+2} ,Ca^{+2} and Na^{+1} ,that are toxic substance at increasing the limit, that makes the water unsuitable for consumption [6]. So drinking water is not valid for drinking when the rates of those pollutants are higher than the acceptable limit or un safety ratio of these contaminants, especially bacteria and some chemical elements [7]. In the Tigris River stretch the pollution increase due to effluent discharges by various uncontrolled sources as domestic, industries, agriculture along the

downstream stretch so, river water quality monitoring is necessary to evaluate the water quality for different uses [8]. Contamination of water has been frequently found associated with transmission of diseases causing bacteria, Vibrio, Salmonella, bacterial and parasitic dysentery, and acute infection diarrhea causing E. coli [9]. It is reported that drinking water is a major source of microbial pathogen and considered to be one of the main reasons for increased mortality rates among children in developing countries [10]. Water quality is determined by comparing the physical and chemical characteristics of a water sample with water quality guidelines or standards. Drinking water quality guidelines and standards are designed to enable the provision of clean and safe water for human consumption, thereby protecting human health. These are usually based on scientifically assessed acceptable levels of toxicity to either humans or aquatic organisms [11-13]. Although there are several contaminants in water that may be harmful to humans, the first priority is to ensure that drinking water is free of pathogens. The greatest risk to public health from microorganisms in water is associated with drinking water that is contaminated with human and animal feces [3].

2. Materials and methods

2.1.Description of study district

This study has examined two water treatment plants in Baghdad city. Iraq included Al-Qadisiyah (AQ) water treatment plant **Figure 1.** and Al-Dora (AD) water treatment plant **Figure 2.**

Figure 1. Al-Qadisiyah water treatment plant from G.I.S.

Figure 2. Al-Dora water treatment plant from G.I.S.

2.2.Samples collection

Water samples were collected from Al-Qadisiyah, **Figure 1.** and Al-Dora **Figure 2.** plants in the district of Al-Karkh from final basin that reaches to the houses directly and another water samples were taken from the tap water of the houses from January 2019 to August 2019. Water samples were taken by using clean glass bottles of 250 ml with tight stoppers, and it has been sterilized by autoclaving at 121°C and 1.5 atmospheres pressure for 15 min. The first group was used for bacteriological tests. A 0.2 ml of sodium thiosulfate solution (10%) was added to offset the effect of residual chlorine. The second group were used for chemical tests (APHA, 2012).

2.3.Physicochemical Tests

The physical tests of water samples were conducted in a field. Temperature, pH, Electrical Conductivity (EC) and Total Dissolved Salts (T.D.S) were measured by using (Milwaukee) device and the free residual chlorine (Cl) was measured by using the HI 701 Free chlorine (HANNA) device and was calibrated in the laboratory with standard solutions for the device. The chemical tests of water samples were conducted in the laboratory. Calcium Ca^{+2}, Mg^{+2} and Lead Pb^{+2} were measured by Atomic Absorption Spectrophotometer Magnesium and Sulfate SO_4 , Nitrate NO_3 and Nitrite NO_2 were measured by UV-Vis Spectrophoto Meter.

2.4.Biological Tests

The bacteriological analysis was done using MPN method with MacConky broth multiple tube method for determining the most probable number of coliforms according to APHA, 2012 [14].

3. Results and Discussion

Bacteriological tests the presence of total coliform in drinking water indicates the possibility of water contamination by pathogens or disease causing bacteria or viruses that exist in fecal matter [15]. In this study is showed that total coliform (TC) and the fecal coliform (FC) for the two water treatment plants Al-Qadisiyah and Al-Dora and also the tap waters of houses were negative in winter and summer season (0 CFU / 100ml), no significant biological contamination was found, these microorganisms are removed or died from water due to the high concentration of chlorine action, the WHO and Iraqi drinking water standard is set at zero because bacterium may cause adverse health effects. So the TC and the FC values were not exceeded the allowable limit (Zero CFU /100 ml) [16]. Total count of aerobic bacteria (APC) are showed the highest value was 4 in the tap waters of houses that away from the plants and the houses near plants are recorded 2 while plants are recorded zero (Nil). The APC values were not exceeded the allowable limit (10 CFU/ml) [16].

Physiochemical tests the water temperature, the highest mean value (27.13±1.27ºC) was recorded during the summer season in water sampling of Al-Dora plant while the lowest mean value was (14.03±1.03 ºC) in the winter season see **Figure 3.** The highest mean value was (27.1±2.22ºC) during the summer season for the nearby areas from Al-Dora plant while the lowest mean value was recorded (14.43±2.09 ºC) in the winter season and for the areas away from Al-Dora plant, the highest mean value was (27.66±2.91ºC) in the summer season while the lowest mean value was (15.90±2.22 ºC) in the humid season. In Al-Qadisiyah plant the water temperature was recorded the highest mean value (27.93±1.44ºC) in summer season while the lowest mean value was (14.33±1.03 ºC) in winter season. The highest mean value was (29.36±1.44ºC) in the summer season for the nearby areas from Al-Qadisiyah plant while the lowest mean value was recorded (14.16±1.69 ºC) in the winter season and for the areas

away from Al-Qadisiyah plant, the highest mean value was (30.70±2.37ºC) in the summer season while the lowest mean value was (15.33±2.12 ºC) in the winter season. The overall range in water temperature was a minimum mean value in the winter season and a maximum mean in the summer season seemingly these values followed almost identical seasonal cycles. The raised of temperature in dry seasons than in humid seasons could be due to long and high sunlight intensity [17]. The PH was recorded the highest mean value (6.57±0.18) during the summer season in water sampling of Al-Dora plant while the lowest mean value was (6.11±0.1) in the winter season. The highest mean value was (6.47±0.19) in the summer season for the nearby areas from Al-Dora plant while the lowest mean value was recorded (6.16±0.03) in the winter season and for the areas away from Al-Dora plant see **Figure 4.** the highest mean value was (6.47±0.09) in the summer season while the lowest mean value was (6.08±0.07) in the winter season. In Al-Qadisiyah plant the PH was recorded the highest mean value (6.7±0.0) in summer season while the lowest mean value was (6.37±0.05) in winter season. The highest mean value was (6.57±0.03) in the summer season for the nearby areas from Al-Qadisiyah plant while the lowest mean value was recorded (6.32±0.04) in the winter season and for the areas away from Al-Qadisiyah plant, the lowest mean value was (6.23±0.09) in the summer season while the highest mean value was (6.3±0.07) in the winter season. LSD shows no significant differences between water plants and water sites (P≤0.05). The minimum and maximum mean value of pH recorded in present study was within the permissible limits for Iraqi criteria and standards for drinking water [16]. which was range between 6.5- 8.5. The lowest electrical conductivity (EC) mean value was 734.33 µs/cm (± 121.88) at Al-Dora plant during winter season and the highest mean value was 899.33 µs/cm (± 26.42) in the summer season see **Figure 5.** EC values of nearby areas from Al-Dora the lowest mean were 708.00 µs/cm (±81.99) in the summer season and the highest mean were 872.67 µs/cm (± 22.56) in the winter season and for areas away from Al-Dora plant the lowest electrical conductivity mean were 693.67 µs/cm (± 82.08) in the summer season while the highest mean were 777.00 µs/cm (± 51.42) in the winter season. The lowest electrical conductivity mean value was 696.00 µs/cm (± 76.73) at Al- Qadisiyah plant during summer season and the highest mean value was 875.67 µs/cm (± 56.36) in the winter season. EC values of nearby areas from Al- Qadisiyah plant, the lowest mean were 680.67 µs/cm (±89.40) in the summer season and the highest mean were 875.00 µs/cm (± 42.52) in the winter season and for areas away from Al- Qadisiyah plant, the lowest electrical conductivity mean were 636.67 µs/cm (± 74.22) in the summer season while the highest mean were 823.33 µs/cm (± 15.30) in the winter season. LSD shows no significant differences between water plants and water sites (P≤0.05). The results showed a higher concentration of conductivity in winter than in summer and thus may due to rainfall and soil erosion of the river or due to river loads of tons of sand deposits and various elements loaded with salts [18].These values obtained are not exceeding the permissible limits for Iraqi criteria and standards for drinking water [16]. Which was 1500 µs/cm. In case of water T.D.S, the highest mean value (464±17.21mg/l) was found during the winter in Al-Dora plant while the lowest mean value (395.66±65.36 mg/l) during summer , the nearby areas of Al-Dora plant are recorded the highest mean were (451.00±16.50 mg/l) during winter, while the lowest mean were (367.66±40.88 mg/l) in the summer and for the areas away from Al-Dora plant, the highest mean were(397.67±26.01 mg/l) during winter and the lowest mean(351.67±42.78 mg/l) in the summer, the T.D.S water for Al-Qadisiyah water plant, the highest mean value

(499.00±35.17mg/l) was found during the winter while the lowest mean value was (384.00±58.97 mg/l) during the summer , the nearby areas of Al-Qadisiyah water plant are recorded the highest mean were (460.33±31.48 mg/l) during winter, while the lowest mean were (346.33±45.26 mg/l) in the summer and for the areas away from Al-Qadisiyah water plant, the highest mean were (383.66±11.79 mg/l) during winter and the lowest mean were (323.00 ±38.00 mg/l) in the summer. LSD shows no significant differences between water plants and water sites ($P \leq 0.05$). Higher concentrations of TDS in winter are attributed to precipitation, especially in densely populated cities and industrial areas where they carry pollutants in the atmosphere [19]. These values obtained are not exceeding the permissible limits for Iraqi criteria and standards for drinking water [16]. Which was less than 1000 mg/l. The values of residual chlorine (Cl) are ranged from 2.3mg/l (± 0.12) at Al-Dora plant in the winter to 2.7 mg/l (± 0.17) in the summer and the sampling water of nearby areas are ranged from 1.9 mg/l (± 0.42) in the winter to 1.7 mg/l (± 0.21) in the summer and the areas away from Al-Dora plant are ranged from 0.8 mg/l (± 0.19) in the winter to 1.4 mg/l (± 0.22) in the summer. The values of residual chlorine are ranged from 1.8 mg/l (± 0.15) at Al-Qadisiyah plant in the winter to 1.3 mg/l (± 0.12) in the summer and the sampling water of nearby areas are ranged from 1.7 mg/l (± 0.15) in the winter to 0.9 mg/l (± 0.04) in the summer and the areas away from Al-Qadisiyah plant are ranged from 1.3 mg/l (± 0.3) in the winter to 0.6 mg/l (± 0.11) in the summer. LSD shows no significant differences between water plants and water sites ($P \leq 0.05$). The gradual decrease of concentrations of residual chlorine from the addition point to the farthest sampling point due to the decomposition of chlorine when it react with water to Hypochloric acid (HOCl). This acid decomposes rapidly into hydrogen and Hypochlorite ions [20]. The minimum and maximum of free residual chlorine values recorded in present study were within the permissible limits for Iraqi standards for drinking water [16]. Which not less than 0.3. It has been found that highest mean calcium ions value 71.23 mg/l (± 11.71) was found in the water sample of Al-Dora water plant during winter while the lowest mean value 52.86 mg/l (± 4.17) was detected in summer , the sampling water of nearby areas are ranged from 60.40 mg/l (± 1.53) in the winter to 54.84 mg/l (± 2.33)in the summer and the areas away from Al-Dora plant are ranged from 66.53 mg/l (± 6.23) in the winter to 64.37 mg/l (± 12.83) in the summer. In the Al-Qadisiyah plant the highest mean calcium ions value was 64.67 mg/l (± 4.02) in the winter while the lowest mean was 63.15 mg/l (± 5.38) in the summer and the sampling water of nearby areas are ranged from 61.37 mg/l (± 3.33) in the winter to 61.18 mg/l (± 5.19) during summer and the areas away from Al-Qadisiyah plant are ranged from 59.67 mg/l (± 0.98) in the winter to 52.66 mg/l (± 3.14) in the summer. LSD shows no significant differences between water plants and water sites ($P \leq 0.05$).These results showed that there is an increase in calcium values during winter, might be due to the increase in water levels because of the rain falls that bring salts including calcium then increase of it concentration in water, also the Off Cree operations occurred near the project intake exposed new layers of soil led to increase salts in water including calcium, also the decrease of temperature helps in CO_2 increasing in the water and forming carbonic acid that helps in dissolution the salts of calcium [21]. The values of calcium not exceeded the maximum allowable limits according to Iraqi criteria and standard for drinking water [16]. Which was 150mg/L. In case of water magnesium ions, the highest mean value 29.77 mg/l (± 2.48) was found in the water sampling of Al-Dora water plant during winter while the lowest mean value 17.91 mg/l (± 8.43) was detected in the summer, the sampling water of nearby areas are

ranged from 30.93 mg/l (± 6.00) in the winter to 14.66 mg/l (± 6.75) in the summer and the areas away from Al-Dora plant are ranged from 32.27 mg/l (± 2.74) in the winter to 14.22 mg/l (± 6.81) in the summer. In the Al-Qadisiyah plant the highest mean magnesium ions value was 27.82 mg/l (± 3.07) in the winter while the lowest mean was 15.12 mg/l (± 7.08) in the summer and the sampling water of nearby areas are ranged from 25.36 mg/l (± 2.62) in the winter to 14.94 mg/l (± 7.28) during the summer and the areas away from Al-Qadisiyah plant are ranged from 25.72 mg/l (± 0.51) in the winter to 12.47 mg/l (± 6.16) in the summer. LSD shows no significant differences between water plants and water sites ($P \leq 0.05$). These results showed that the Magnesium ions increased to high level during the winter season that might be due to Mg^{+2} ions in the soil which discharge the water resources by the actions of the rain fall, industrial and domestic discharge, sedimentation by forming non dissolved compounds in water, in addition to absorption of Mg^{+2} ions by plants which depends on water temperature, pH, and dissolved Oxygen concentration that record the highest levels of consumption during summer due to the plant growing [22]. The study results showed that the calcium ion were higher than Mg^{+2} ions, that's because the geological nature of the land, the results were similar to [23]. That found that the Ca^{+2} ions concentration values were higher than Mg^{+2} ion concentration during study period. The values of the Mg^{+2} not exceeded the maximum allowable limits according to Iraqi criteria and standard for drinking water [16]. Which was 100mg/L. Nitrate NO_3, the highest mean value 8.97mg/l (± 0.30) was found in the water sampling of Al-Dora water plant during winter while the lowest mean value 5.03 mg/l (± 0.90) was found in the summer , the sampling water of nearby areas are ranged from 9.58 mg/l (± 0.40) in the winter to 4.95 mg/l (± 0.90) in the summer and the areas away from Al-Dora plant are ranged from 8.68mg /l (± 0.82) in the winter to 4.97 mg/l (± 0.91) in the summer. In the Al-Qadisiyah plant the highest mean NO_3 value was 7.50 mg/l (± 0.31) in the winter while the lowest mean was 3.80 mg/l (± 0.72) in the summer and the sampling water of nearby areas are ranged from 7.58 mg/l (± 0.29) in the winter to 3.89 mg/l (± 0.78) during summer and the areas away from Al-Qadisiyah plant are ranged from 7.87 mg/l (± 0.33) in the winter to 3.71 mg/l (± 0.93) in the summer. LSD shows no significant differences between water plants and water sites ($P \leq 0.05$). The study showed that NO_3 concentration is increased in winter due to the precipitation and erosion of certain salts rich deposits, which contains NO_3 [23]. The results of percent study were agreed with Iraqi standard for drinking water [16]. Which was 50 mg/L see **Figure 6.** In case of water sulphate content, the current study has recorded mean values to vary from minimum mean value of 132.32 ± (36.33) mg/l in water sampling during summer to maximum value of 166.69 ±(8.42) mg/l during winter at Al-Dora water plant and the sampling water of nearby areas are ranged from 178.10 mg/l (± 19.90) in the winter to 140.59 mg/l (± 40.55) in the summer and the areas away from Al-Dora plant are ranged from 165.54mg /l (± 34.35) in the winter to 131.10 mg/l (± 38.23) in the summer. At Al- Qadisiyah plant the minimum mean value of sulfate was 135.42± (39.01) mg/l during summer to maximum value of 181.78 ± (5.47) mg/l during winter and the sampling water of nearby areas are ranged from 170.47 mg/l (± 21.93) in the winter to 171.61 mg/l (± 31.95) in the summer and the areas away from Al- Qadisiyah plant are ranged from 146.77mg /l (± 15.35) in the winter to 149.34 mg/l (± 34.97) in the summer see **Figure 7.** LSD shows no significant differences between water plants and water sites ($P \leq 0.05$). The increase of sulphate values in the drinking water due to the traditional removing methods or due to adding Ammonium alum with irregular doses [21]. The values obtained are not

exceeding the permissible limit for Iraqi criteria and standards for drinking water [16]. Which was 400mg/L for drinking water. Most of results of nitrite showed U.D.L means under detection limits in the bath water plants Al-Dora and Al- Qadisiyah plant and all houses that near and far away from plants during winter and summer season. The nitrite was within the permissible limit of the Iraqi standards for drinking water (3mg/l) [16]. The heavy metals (lead) results showed U.D.L means under detection limits in the bath water plants Al-Dora and Al- Qadisiyah plant and all houses that near and far away from plants during winter and summer season see **Figure 8.** The lead concentration was within the permissible limit of the Iraqi standard for drinking water (0.01mg/l) [16].

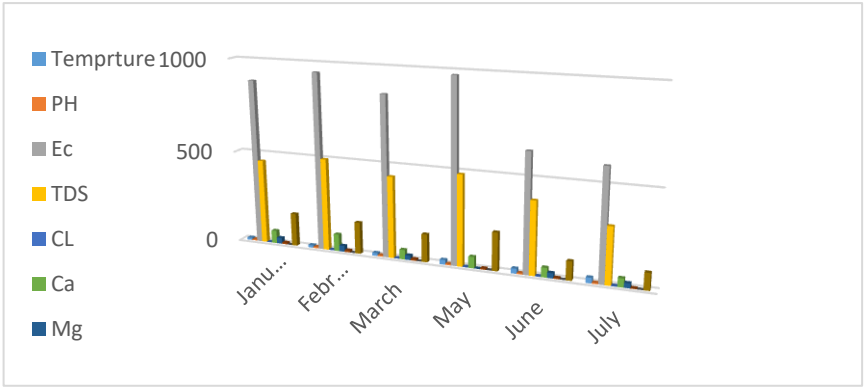

Figure 3. Physicochemical Parameters in AL-Dora Plant.

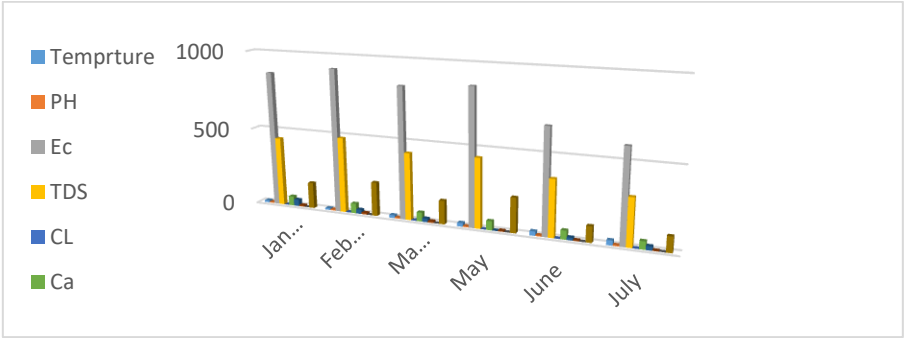

Figure 4. Physiochemical Parameters in areas nearby from AL-Dora Plant.

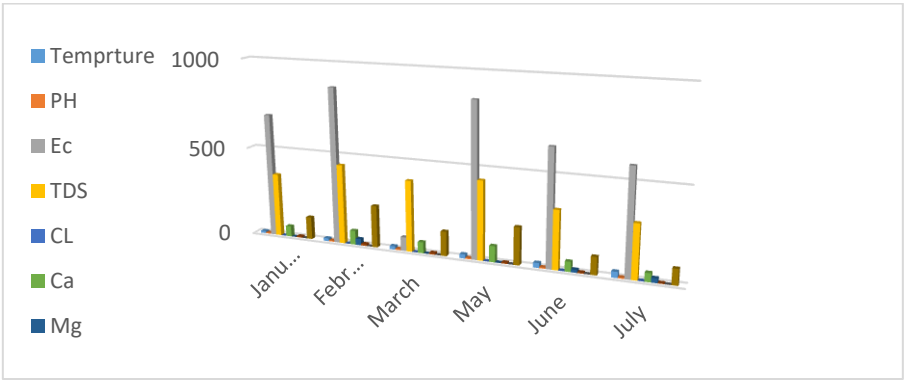

Figure 5. Physiochemical Parameters in areas away from AL-Dora Plant.

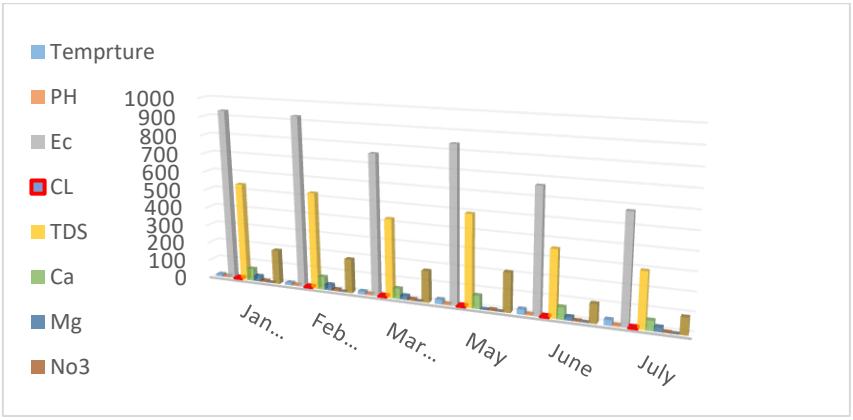

Figure 6. Physicochemical Parameters in AL-Qadisiyah Plant.

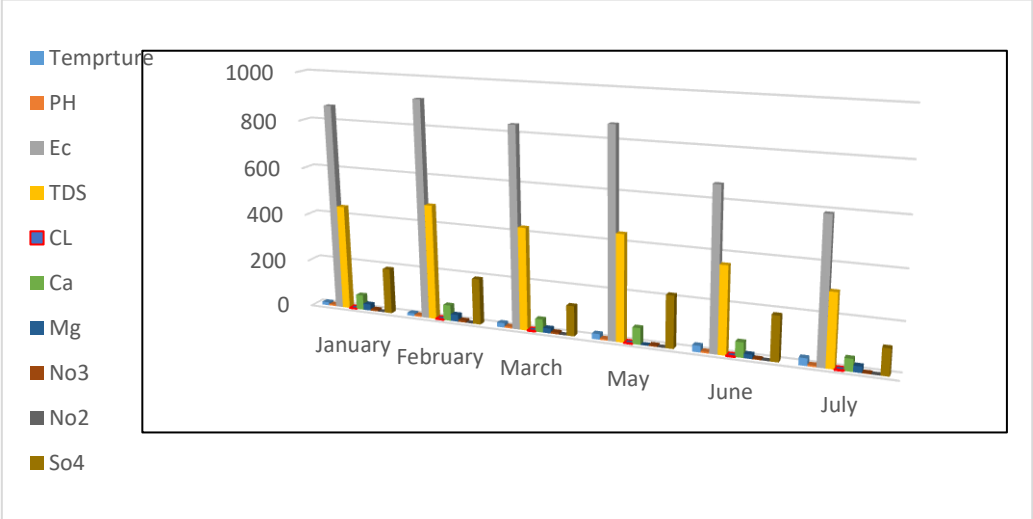

Figure 7. Physiochemical Parameters in areas nearby from AL-Qadisiyah Plant.

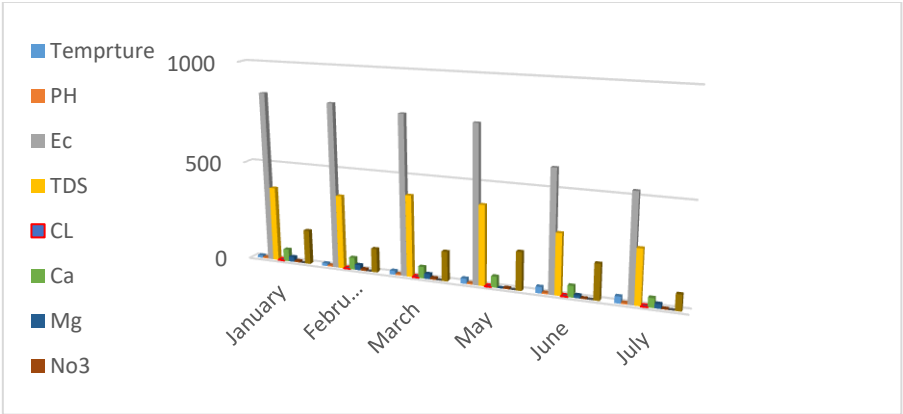

Figure 8. Physiochemical Parameters in areas away from AL-Qadisiyah Plant.

4. Conclusions

1- The values of microbial pathogens (APC, TC, and fecal coliform) were not exceeded the allowable limit for drinking water in both of plants and all sites that near and far from plants
2- The results of heavy metals (Lead) were not exceeded the allowed limits in all sites of the study
3- The physiochemical parameters were not exceeded the allowed limits in both of plants and all sites that near and far from plants

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