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Evaluate the Efficiency of Drinking Water Treatment Plants in Baghdad City – Iraq

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Abstract The study was conducted to assessment of two drinking water treatment plants in Baghdad City, Iraq from December 2016 to July 2017. Three sites for each plant were selected which represent the sedimentation basin, filtration basin and final stages after chlorination. Seventeen physicochemical parameters of water quality were analyzed in this assessment. These parameters were temperature, turbidity, electrical conductivity, pH, dissolved oxygen, biological demand oxygen, total dissolved solids, total hardness, nitrate, phosphate, calcium, magnesium, residual chlorine and heavy metals (lead, cadmium, Nikel and Chromium). In addition to four bacterial indicators of drinking water pollution (APC, Total Coliform, Fecal Coliform and *Salmonella* spp). The results showed variation in drinking water quality parameter values in both treatment plants. Moreover, the presence of numbers of bacteria greater than permissible limit, indicating a deficiency in the purification process.

Keywords: *drinking water quality, physio-chemical properties, bacterial indicators, havey metals, pollution*

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1. Introduction

The most challenges in most developing countries preserves the water bodies from the impact of pollution, save the drinking water and sacristy of water [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 [2,3].

The water purification establishments are responsible for equipping citizens with clean, colorless water, without a foul taste and bad smell. The use of advanced water purification and sterilization methods have resulted in a decrease in the mortality rate from contaminated drinking water [4,5]. WHO [6] 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 [7,8,9].

The quality of the raw water sources (such as river, lakes, wells.. etc.) is controlled by its physicochemical and biological features, in addition to the pollutants from different sources of pollution [10]. GEMS [8] reported that it's difficult to use a single scale to identify the water quality, and prefer to use a composite indices for this purpose with a number of measurements. Enhancing the quality of water before used by consumer is depend on the efficiency of drinking water treatment processes in the treatment plant which must be safe and within the standard criteria for public health [12,13].

Sorlini, et al. [14] studied the drinking water treatment plant in the North of Italy to assess these plants by checking all treatment processes and measurement of parameters. The study is outlines the problems in the operations systems and allowed to identify the possible solutions to enhance the treatment plant. Collivignareilli [15] reported that the Water Safety plan (WSP) application is the best protocol to save and manage of drinking water treatment plants and to safe the public health. Shanmugasundaram *et al*. [16] evaluated the drinking water quality in India (Coimbatore) by selecting seven parameters. The results showed that the drinking water is not acceptable and needs to purification treatment, and some parameters such as: Alkalinity, TDS, Hardness and turbidity values were exceeded the permissible limit of drinking water quality.

Hassan et al. [17] used fourteen parameters to assess the drinking water treatment plant of Jurf Al-Sakar in Babylon Provence, Iraq. The study revealed that the treatment plant was not efficient to produce drinking water. Barbooti et al. [18] evaluated the drinking water quality in Baghdad city. In this study four parameters, seventeen heavy metals and eleven trihalmathane were selected for the evaluation. The results showed high sulphate and aluminium values in the drinking water.

Tigris river is the ultimate drinking water source for Baghdad City. The city has population of >5 million people. In the last few years, It was noticed an increase of wastewater and direct disposal of Tigris River. Moreover, the detection of the presence of some antibiotics in the drinking water beside of other pollutants [19]. The study was aimed to assess the drinking water quality in two treatment plants before distribution to the consumer in Baghdad city.

2. Materials and Methods

2.1. Description of the Study Treatment Plant

The study was carried out from September 2016 to July 2017, to examine chemical, physical and microbial characteristics of two drinking water treatment plants, in Baghdad city. These plants were AL-Wihda (AW) and AL-Rasheed (AR) water treatment plants (Table 1, Figure 1).

2.2. Water Sampling

Drinking water samples were collected from AL-Wihda and AL-Rasheed plants in the district of AL-Rusafa from three stages within each of the two projects under study and as follows (Sedimentation basin, Filtration process basin, and Final chlorination basin). The following symbols of the selected sites in each treatment plant were used in this study as follows:

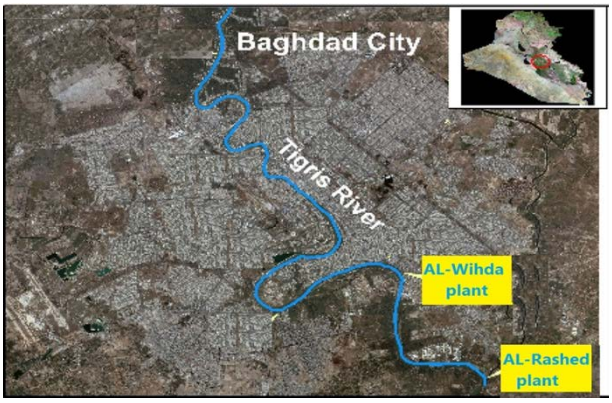

Figure 1. Sampling stations on Tigris River (Map from Google Earth Pro)

The sampling tools were used according to the standard methods (APHA, 2012) as follows: glass bottles of 250 ml with metallic screw caps were used for bacteriological tests which were pre sterilized by oven at 160 °C for 2 hrs. A0.2 ml of sodium thiosulfate solution (10%) was added to offset the effect of residual chlorine, then it was sterilized by autoclaving at 121°C and 1.5 atmospheres pressure for 15 min. The second type of bottles is glass bottles of 1L. These bottles are used for the collection of water samples for physicochemical tests, and light and dark bottles (300ml) were used for DO and BOD_5 tests, respectively. All the glass bottles were washed with soap and washed several times with tap water and distilled water.

2.3. Physicochemical Tests

Field and laboratory measurements were carried out according to the standard methods [20], in the laboratory within 24hrs with three replications per sample.

2.4. Microbial Tests

The membrane filtration methods (MF) were used, after mixing the sample by inverting its container several times, a 100 ml of water samples was passed through the filter cellulose membrane filter (0.45 µ). Then it was transferred into the isolation selective medium and incubated at the proper temperature and time according to APAH [20] (Table 2).

2.5. Statistical Analysis

The Statistical Analysis System (SAS) program was used for the statistical analysis. The least significant difference (LSD test) and T-Test was used to compare between the means of the studied parameters.

3. Results and Discussion

The water temperature is ranged from the lowest value (9.57°C (± 0.37)) in the winter at AW3 to the highest value (36.83°C (± 2.64°)) in the summer at AR1 and AW1 (Figure 2). The water temperature values of drinking water before distribution to consumers (DWBDC) were 9.57°C (± 0.37) in the winter at AW3 and 34.33°C (± 2.35) in the summer at AR3. The raised of temperature in dry seasons than in humid seasons could be due to long and high sunlight intensity [21]. The climate of Iraq is characterized by dry desert type and varying temperatures between day and night, and, among seasons. This difference affects the metabolic processes, and gases solubilities such as oxygen, carbon and chlorine, all these give a clear image of the effect of temperature on all ecosystems [20,23]. The statistical analysis of water temperature showed a significant difference between the season for each site ($P<0.05$) and did not record any significant difference between sites for each season except (LSD=3.09, $P<0.05$).

Table 1. The symbols of the study sites in both drinking water treatment plants

Site	Symbol	Site	Symbol
AL-Wihda- Sedimentation basin	AW1	AL-Rasheed- Sedimentation basin	AR1
AL-Wihda- Filtration process basin	AW2	AL-Rasheed- Filtration process basin	AR2
AL-Wihda- Final chlorination basin	AW3	AL-Rasheed- Final chlorination basin	AR3

Table 2. The culture media of study bacteria and the circumstances of their growth

Bacteria	Media	Circumstances of growth
Aerobic plate count (APC)	Nutrient agar	10 ml of water sample filtered/ incubated at 35 °C for 24- 48 hrs. calculated by colony counters
Total coliform (TC)	M-Endo agar/lactose peptone water.	100 ml of the sample was filtered/ incubated at 35-37°C for 24 hrs. To confirm the results, it wascultured on tubes of lactose peptone water then incubated at 35 or 37 °C for48 hrs.
Feacal coliform (FC)	EC broth, agar and lactose peptone water	100 ml of the sample was filtered/ incubated at, 44-44.5 °C for 24 hrs. To confirm the result, it was cultured on a tube of lactose peptone water, then incubated the tubes at 44 °C for 24hrs.
Feecal Streptococcus (FS)	Azide broth and Pfizer agar	100 ml of the sample was filtered/ incubated at 35 °C for 24 ± 2 hrs. To confirm the results, it was cultured on a Pfizer agar, incubated at 37°C for 24 – 48 hrs.

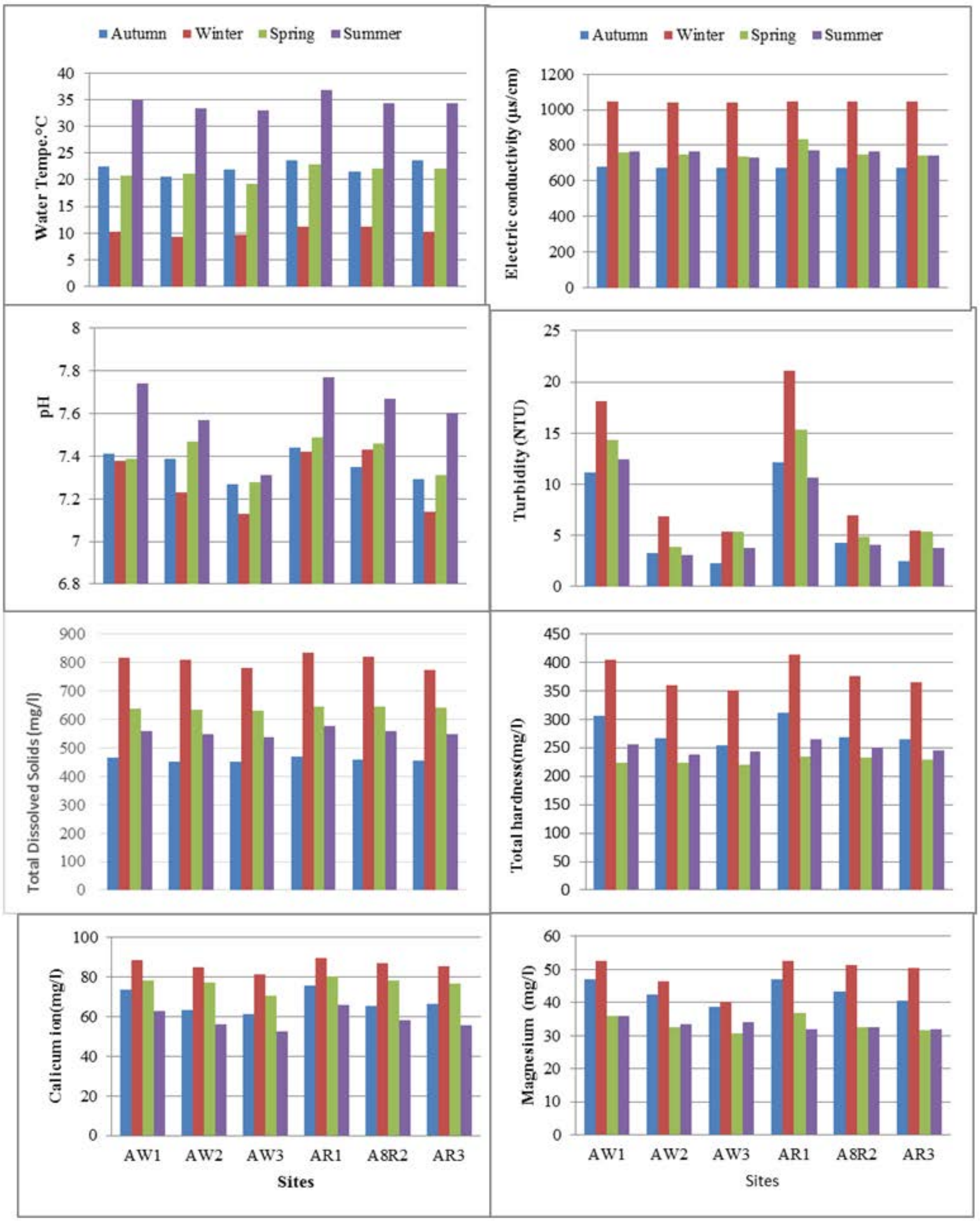

Figure 2. Physicochemical parameters in the study Drinking water treatment plants

The lowest value of pH (7.13 ± 0.42) was recorded at AW3 in winter, while the highest value was 7.77 (± 0.62) at AR1 in the summer (Figure 2). Its values of DWBDC are 7.13 ± (0.42) at AW3 in winter and 7.67 (± 0.51) at AR3 in the summer. The results revealed that higher pH value recorded at both studied plants in the summer, this indicated thatthe decrease of CO_2 concentrations in the water is as a result of high temperature [21]. In addition to the excessive using of $CaCO_3$ in order to control corrosion of pipes [25]. The pH values in these plants were agreed with the high buffer capacity of Iraqi water [1,26], the statistical analysis showed non-significant differences among seasons and sites (P<0.05), The pH values were within the permissible limits (6.5-8.5) of the Iraqi Criteria and Standards for drinking water chemical limits (5.8-8.5) [6,27].

The lowest electrical conductivity (EC) value was 671.56 µs/cm (± 37.38) at AW3 in autumn, and the highest value was 1048.83 µs/cm (± 56.2) at AR3 in winter (Figure 2). EC values of DWBDC are 671.56 µs/cm (±37.38) at AW3 in autumn and 1045.07 µs/cm (± 67.4) at AR3 in winter. 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 [28]. The values of EC of Al- Rasheed plant was higher than AL-Wihda were observed, that may due to ancient age and inefficiency of the basins of sedimentation and filtration [29]. The EC values were within the Iraqi permissible limits (1500 µs/cm) [6,27].

The lowest turbidity value was 2.31 NTU (± 0.18) at AW3 in autumn, while the highest value was 5.44 NTU (± 0.17) in winter at AR3 (Figure 2). Its values of DWBDC are 2.31 NTU (± 0.18) at AW3 in autumn and 5.44 NTU (± 0.17) in winter at AR3. Higher values of turbidity in the winter may be due to the increase of rainfall proportion and rising water levels with the drifting of these rains which are ended in the river water. Also, domestic wastes were contributed to increasing the turbidity [30,31]. The higher turbidity values at Al-Rasheed plant maybe caused by the impact of the south Baghdad electrical power station and AL-Rasheed electrical power station, which lead to the rise in the means of turbidity in the river due to the rise of cooling and cleaning water. A significant differences were noticed between seasons at AW1, AW2 and AR1 and among all sites ($P < 0.05$). The maximum turbidity values recorded in this study were not exceeding the permissible limits (0-5NTU) [6,27].

The lowest value of total dissolved solids (TDS) was 450.17 mg/l (± 26.72) in autumn at AW3, while the highest value was 828.07 mg/l (± 31.69) in winter at AR3 (Figure 2). TDS values of DWBDC are 450.17mg/l (± 26.72) in autumn at AW3 and 828.07mg/l (± 36.13) in winter at AR3. 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 [32]. The increase in TDS values in the AL-Rasheed plant in most cases, as the station is affected by the activities nearby, such as the cooling water disposal of power plants being located south of Baghdad. LSD values showed significant differences among seasons and non- significant differences among the sites. The TDS values recorded in this study were within the permissible limits (1000 mg/l) of Iraqi standards for drinking water [27] and [6] (1500mg/l).

The lowest total Hardness value was 220.50 mg/l (± 14.02) in spring at AW3 while the highest value was 375.10 mg/l (± 15.62) in winter at AR3 (Figure 2). Its values of DWBDC are 220.50 mg/l (± 14.02) in spring at AW3 and 375.10 mg/l (± 15.62) in winter at AR3. The high value of hardness during winter may be due to the erosion of soil across the river as a result of rainfalls and reached these pollutants into the river water, especially calcium salts, also, the agricultural wastes of the nearby lands, lead to the raising of hardness in the water, while the relative increase in autumn because of the increase in salt concentrations especially calcium salts due to the cleaning The lowest biological oxygen demand (BDO_5) value was 1.68 ± 0.02 mg/l in winter at AW, while the highest value was 5.26 ± 0.09 mg/l in summer at AR1 (Figure 3). The highest BOD_5 values (5.44 mg/l (± 0.09) of DWBDC recorded in the summer at AR3. The highest values of BOD_5 showed in the summer, maybe due to the impact of high temperature on metabolic processes and increasing the pollutant activity that effecting the Oxygen requirement [37]. The BOD_5 results from the AL - Rasheed plant were higher than AL-Wihda plant because of the large amounts of sewage discharge [29]. The results indicate that there is a significant difference between seasons for all sites except inAW3, but non-significant differences between sites for all seasons except in spring ($P < 0.05$). The BOD_5 values were exceeding the allowable limits (5mg/l) [6,27].

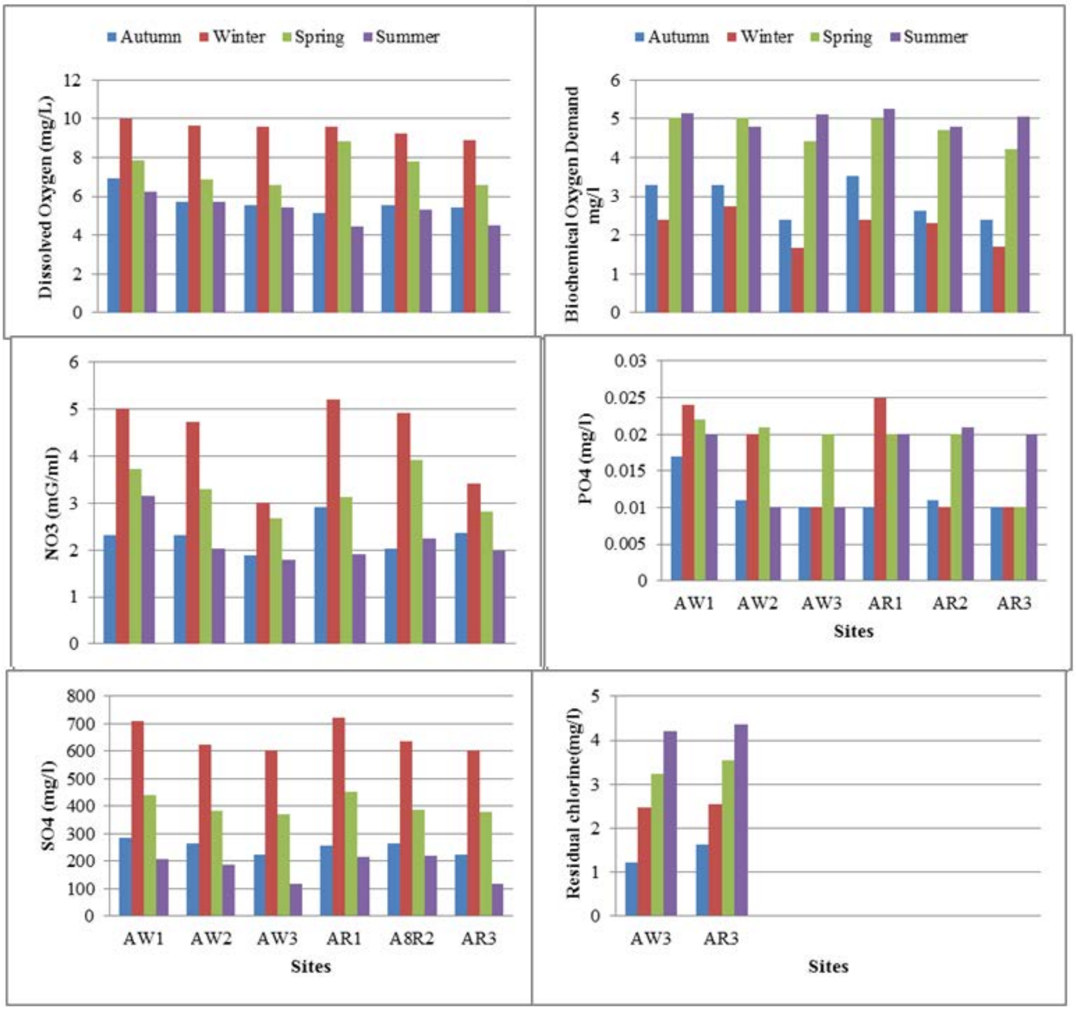

Figure 3. Environmental parameters in the study Drinking water treatment plants

Nitrate (NO_3) concentration is ranged from the lowest values (1.80 ± 0.01 mg/l) in summer at AW3 to the highest value (5.22 ± 0.16 mg/l) in winter at AR1 (Figure 3). NO_3 values of DWBDC are 1.80 mg/l (± 0.01) in summer at AW3 and 3.42mg/l (± 0.08) in winter at AR3. The study showed that the NO_3 concentration is increased in winter and autumn due to the precipitation and erosion of certain salts rich deposits i, which contains nitrate [38], and the increase of comes from the predominant non-organic form of nitrogen because of the abundance of dissolved oxygen in the surface water that acts on the oxidation of nitrite to nitrate [39]. The statistical analysis showed a significant difference ($P<0.05$) in NO_3 among seasons, but no any significant differences among sites was observed in all seasons except in winter and autumn The nitrate value within the allowable limits (less than 50 mg/l) [6,27].

The minimum concentration of phosphate (PO_4) was 0.01 mg/l (± 0.002) during the most seasons in many sites, while the maximum concentration was 0.025 mg/l (± 0.005) in the winter at AR1 (Figure 3). The highest PO_4 values (0.01mg/l (± 0.02) of DWBDC recorded in the winter at AR3.The increase of PO_4 concentration noticed in winter is as a result of washing of the river banks into the river water after the rainfall, in addition to the washing phosphate fertilizers from the agricultural land [39]. Also, population density and type of rock layers are the reasons for high PO_4 concentration, while the low concentration in the summer, due to the consumption of phosphate by algae and aquatic plants because phosphates is an essential nutrient for the growth of organisms [40]. A significant differences ($P<0.05$) in PO_4 values between seasons for all sites were observed except at AW1 and AR1) but non- significant differences among sites were observed in all seasons except in autumn. The values of PO_4 exceeded the permissible limits (0.01 mg/l) [6,27].

The lowest sulfate (SO_4) concentration is recorded (117.58 ± 6.46 mg/l) in summer at AW3 and its highest concentration was 720.00±37.62 in winter at AR1 While its highest values of DWBDC are 392.40mg/l (± 29.67) in the winter at AR3 (Figure 3). The increase of sulphate concentrations in winter may be due to the increase of rains drifting chemical fertilizers, agricultural runoff, and pesticides that contain sulphate [41]. In addition to the increase of sulphate values in the drinking water due to the traditional removing methods or due to adding alum with irregular doses [42]. A significant differences ($P<0.05$) is noticed in the seasons, and non- significant differences among sites for all seasons is detecyed except in summer The sulphate values recorded in the present study exceed the limits (400mg/l) according to ICSDWCL [27] and WHO [6].

The values of residual chlorine are ranged from 1.22mg/l (± 0.06) at AW3 in autumn to 4.35 mg/l (± 0.17) in summer at AR3 (Figure 3). The results show high percentages of residual chlorine in drinking water in the summer, despite the high temperatures which directly affectthe concentration of chlorine and its evaporation, thus the largest doses of chlorinewere added to the water in most of the water purification stations in summer because of the low water levels and increase of pollution [43,44]. A significant differences among sites for both Al-Wihda and Al-Rasheed plants were observed, and non-significant differences among seasons ($P<0.05$). Its values within the Iraqi limits (5mg/l) [6,27].

The heavy metals results showed variation in their concentrations among the seasons and sites. The Lead (Pb) and Nickel (Ni) concentrations are found in lowest concentration in the summer (0.0102 mg/l (± 0.001) and 0.0251mg/l (±0.003) at AR1 and AW3, while for Cadmium (Cd) and Chromium (Cr) were 0.0060 mg/l (± 0.0004) at AW2 and 0.0172 mg/l at AW2 in the spring, respectively (Figure 4). The highest concentrations of Pb, Ni and Cr (0.0277 mg/l (± 0.003), 0.0251mg/l (± 0.003) at AR1 and 0.0298mg/l (± 0.005) at AR2, respectively) were recorded in the winter. Their (Pb, Ni, Cd and Cr) lowest values of DWBDC are 0.0124 mg/l (± 0.004), 0.0152 mg/l (± 0.001), 0.0062 mg/l (± 0.0004) and 0.0176 mg/l (± 0.004) at AW3 in summer for Pb and Ni and for Cd and Cr in autumn at AW3, respectively. Whereas, the highest concentrations of Pb and Ni are 0.0263mg/l (± 0.002) and 0.0229 mg/l (± 0.002) in winter at AR3, and for the CD is 0.0077mg/l (± 0.0004) in autumn at AR3 and for Cr is 0.0281mg/l (± 0.005) at AR3 in the winter.

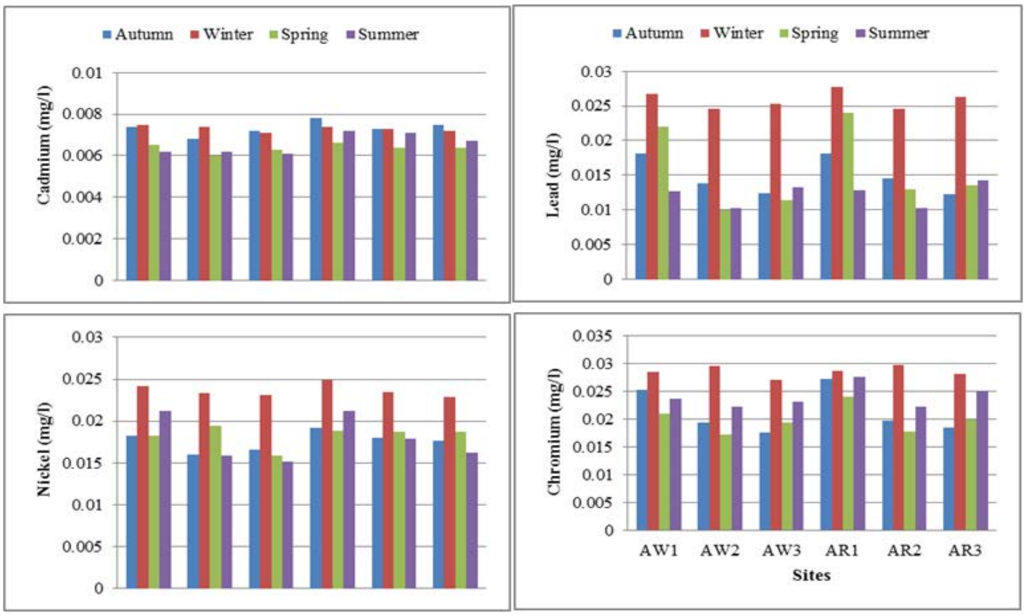

Figure 4. Heavy metals parameters in the study Drinking water treatment plants

The wastewater contains a number of toxic heavy metals such as copper, lead, cadmium, and nickel that accumulate in the soil and reach to the river and affects the aquatic life as they aggregate in the bodies of aquatic organisms [45]. The increasing of lead concentration is caused by the drift of Tetra ethyl lead and Tetramethyl into the rivers by the rainfall, in addition to the car exhausts and its fuel [46]). Also, the treatment processes in the plants were not effective in removing the lead from water. The statistical analysis of the data showed a significant difference (P< 0.05) among seasons for all sites except (AW1) and non- significant differences among sites for all seasons except in spring. The lead concentration was higher than the Iraqi standards for drinking water (0.01mg/l.) [27]. The Cd concentration has no significant differences at the level of the treatment plants, this caused by deficiency of treatment methods in removing the cadmium from water, the statistical analysis of the data showed no significant differences among seasons and sites at (P<0. 05). Ni concentrations recorded non-significant differences in this study, because of the weak ability of nickel to form stable complexes with the organic materials in water which may help to reduce the nickel concentrations in the water. The results indicate that the means of treatment used in these two projects are not able to reduce nickel concentrations and they are incapable to purify water from these elements non-significant differences of Ni concentration are noticed among seasons except at AW3 d AR3, and among sites. Seasonal changes in Cr concentrations showed an increase in the present study in all seasons. Chromium is found in wastewater and industrial processes that include tanning, electroplating and discharge of cooling towers, the AL-Rasheed plant located nearby the Al-Dorra power plants which for this reason cause increasing of Cr concentration in this plant [47]. The statistical analysis of Cr concentrations revealed a significant difference (P<0.05) among seasons except for AW1 and AR1 and non-significant differences among sites. The Pb, Cd, and Ni concentrations were higher than the Iraqi standards for drinking water (0.01mg/l, 0.005mg/l and 0.02 mg/l, respectively) [27]. The Cr concentrations were within the permissible limits (0.05 mg / l) [6,27].

The total Coliform (TC) showed high content in summer (5.01 CFU/100 ml, ± 0.12) at AR3 and lowest mean was 1.32 CFU/100 ml (± 0.04) at AW3 in winter (Figure 5). The increased TC during the hot seasons may be the result of favorable temperatures for growth of bacteria which is associated with increasing temperature and human activities may increase the reproduction rate of bacteria. In Al-Wihda plant, the presence of bacteria was less in drinking water relative to Al-Rasheed plant, this may be due to the efficiency of the first plant relative to Al-Rasheed plant, which is characterized by less efficiency of filtration processes, adjusting the quantities the alum and chlorine Also, its location in the south of Baghdad City leads to increasing the entry of pollutants from both river banks [29]. A significant differences of TC (P<0.05) are recorded between seasons for all sites except (AR3) and showed significant difference between sites. The TC values were exceeded the allowable limit (Zero CFU /100 ml) [6,27].

Fecal Coliform (FC) contents in winter and summer are 1. 65 CFU/100 ml (± 0.09) and 6.05 CFU/100 ml (± 0.08) at AW3 and AR3, respectively (Figure 5). The presence of fecal coli in the treated water is an evidence of fecal contamination and an indicator that the water became contaminated. The highest counts of these bacteria in summer can be attributed to suitable environmental conditions for growth in this season, also to the domestic wastewater and random defecation the river banks by both humans and the animals that graze along the river banks [20]. A significant differences of FC (P<0.05) are noticed among seasons for all sites except at AW3 and AR3 and showed significant difference among sites for all seasons The FC values were exceeded the allowable limit (Zero CFU /100 ml) [27].

The Aerobic Plate Count (APC) was recorded 11.9 CFU/ml (± 0.71) and 20.25 CFU/ml (± 1.60) in winter and summer at AW3 and AR3, respectively (Figure 5). The increase of APC during summer season in all locations might be due to the available growth factors and the activity of microorganism. The increase of nutrients of organic and inorganic matter and salts in water sources, also the lack of adequate contact time to ensure the elimination of the bacteria before the pumping, The lack of quality of the filtration process is due to of the filters that are contaminated [48]. A significant differences of APC (P<0.05) are recorded among all sites and seasons for all sites except (AW3, AR3). The APC values were exceeded the allowable limit (1 CFU/ml) [6,27].

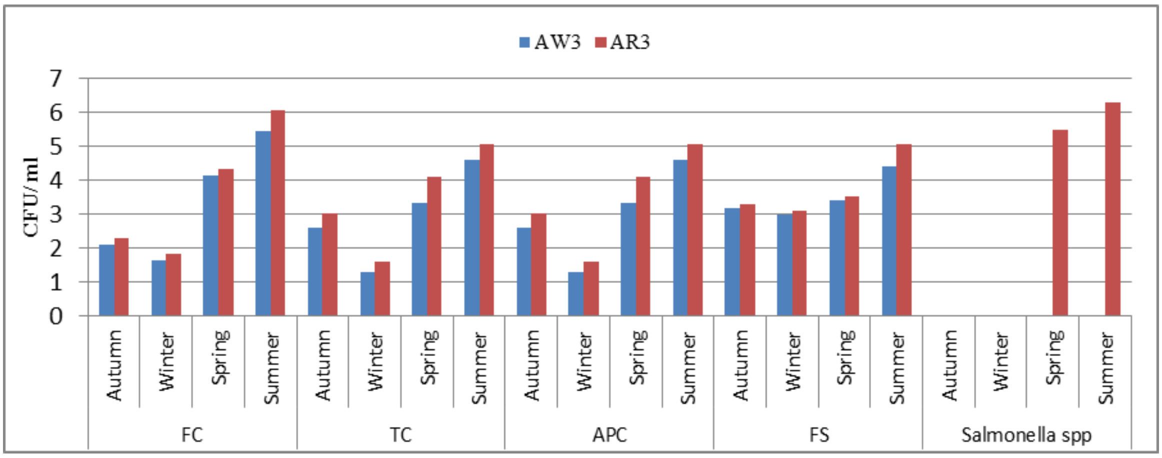

Figure 5. Microbial parameters in the study Drinking water treatment plants. TC= total Coliform, FC= Fecal Coliform, APC= Aerobic Plate Count, FS= Fecal *Streptococcus*

The value of Fecal *Streptococcus* (FS) in winter and Summer are 3.01 CFU/100ml (± 0.02) at AW3 and 5.06 CFU/100ml (± 0.07) at AR3, respectively (Figure 5). The high concentration of FS in summer may be due to the suitable temperature, the high domestic activities near the river, drifting the soil and the availability of the nutrients, meanwhile the less efficiency of disinfection processes in the treatment plant. F is characterized by the ability to resist the effect of chlorine and withstand high temperatures reach 44.5. A specific seasons do not determine the increasing ofbacterial numbers, but related to the state of the habitat in which they live and the availability of nutrients [49]. The contamination of FS in AL-Rasheed plant is higher than AL-Wihda plant due to the old age of the plant and some operational problems also, disrupt the chlorine pumps, the irregular addition of doses, and inadequate contact time with chlorine to ensure that pathogenic bacteria are eliminated before pumping to the distribution network and so the consumer receives unsafe drinking water [29]. Significant differences in ($P<0.05$) in FS between seasons for all sites except at AW3 and AR3 and showed significant difference between sites for all seasons. The FS values were exceeding the allowable limit (Zero CFU /100 ml) [6,27].

The results revealed that the drinking water was absent of *Salmonella ships* in both plants during the study period, except in AL-Rasheed plant in spring and summer at AW3 and AR3 (5.5 CFU/100 ml and 6.3 CFU /100 ml, respectively). *Salmonella* spp is a dangerous human pathogen and its presence in the drinking water is danger to public health [50]. Therefore, it is very important to detect of this microorganism in order to prevent the infection from the water. These might be due to the impact of competitive action between bacteria and short life period with a high sensitivity for the disinfection, which helped to remove it from the water [51]. Furthermore, the intermittent detection of *Salmonella* in aquatic environments may be due to the period of the irregular adding of chlorine due to the malfunction of the chlorination pumps especially in AL - Rasheed plants. The results of this study agree with [52], while disagreeing with the studies of [53]. The *Salmonella* spp values were exceeded the allowable limit (Zero CFU /100 ml) [6,27].

Table 3. Comparison of the studied puppeteers' values (not permissible limits of the drinking water criteria) in the AL-Wihda (AW) and AL-Rasheed (AR) drinking water treatment plants

Parameters	Mean ± SE		T-Test
	AW	AR	
TUR. (NTU)	4.218 ± 0.17	4.598 ± 0.22	0.831 NS
BOD_5 (mg/l)	3.525 ± 0.09	4.173 ± 0.15	0.469 *
SO4 (mg/l)	310.808 ± 27.92	352.558 ± 31.75	29.633 *
Pb (mg/l)	0.011 ± 0.002	0.020 ± 0.004	0.013 NS
Cd (mg/l)	0.0071 ± 0.0003	0.0078 ± 0.0002	0.002 NS
Ni (mg/l)	0.016 ± 0.004	0.021 ± 0.003	0.006 NS
APC (CFU/ml)	14.608 ± 0.81	18.188 ± 1.05	2.783 *
TC (CFU/ml)	2.323 ± 0.03	5.450 ± 0.32	1.961 *
FC (CFU/ml)	3.903 ± 0.07	4.400 ± 0.16	0.357 *
FS (CFU/ml)	3.485 ± 0.11	4.760 ± 0.25	0.803 *
Salmonella spp CFU/ml.	0.00 ± 0.00	2.950 ± 0.06	1.025 *
* ($P<0.05$), NS: Non-Significant.			

The results of eleven parameters values were exceeded the permissible limits of drinking water in both plants (Table 3). Only BOD_5, SO_4 and all bacteriological tests at AL-Rasheed (AR) showed a significantly different from The AL-Wihda (AW).

4. Conclusions

1. Five parameter values (Turbitity, BOD_5, Pb, Cd and Ni) were exceeded the permissible limits, in addition to the microbial test (APC, TC, FC, FS and *Salmonella* spp)
2. The drinking water produced from the AL - Rasheed plant have contained more contaminants than AL-Wihda plant in which the stages of water treatment were characterized by the old condition compared to the first project AL-Wihda.
3. Increase the concentration of some physicochemical parameters (turbidity, BOD, and SO_4) in certain sites that were not removed completely during the treatment stages and it is exceeding the permissible limits of Iraqi criteria and standards for drinking water (IQS 417, 2001).
4. The values of microbial pathogens (APC, TC, and fecal coliform) exceeded the allowable limit for drinking water in summer in all Sites of both plants.
5. The results of heavy metals show that the Lead, Cadmium and Ni were exceeded the allowed limits in all sites of the study, where they were not removed completely during the treatment stages for both plants.

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