Evaluation of Water Quality Passing through Distribution Networks of four Regions in the Basrah Province Center

Abstract The tap water samples transferred from the water distribution networks were collected from four regions located in the Basrah governorate center, during autumn, winter and summer seasons, the regions are: Hay - Alhussain, Al - shamshomeya, Dur - Aldobat, Al - Qebla, the regions were supplied with water from three water purifications plants. Some physical and chemical properties have been measured at the consumer's tap in the water distribution networks for the four regions, as well as the produced water in the three purifications plants. The results showed that the summer season recorded the highest pollution rate, followed by autumn, then winter season. Studies also showed that the water delivered to the consumer is not suitable for drinking, where it recorded a violation of the specifications approved by some parameters. The study showed pollution in all networks of the four regions, and the Hay - Alhussain region recorded the highest pollution, while the lowest pollution was recorded in Dur – Aldobat region, and that there are indications of pollution of water reaching the consumer at the four areas with wastewater due to damage in the water conveying network.

Keywords water distribution networks, water purifications plants, pollution, specification limits.

INTRODUCTION

Variations in the chemical composition of river water are very important in the field of water purification and distribution for different uses. The qualitative evaluation of water through studying the chemical and physical properties gives important indicators about the quality of water before it reaches the consumer. Water is considered safe to drink when it is within the qualitative specifications of water, which are determined by governments and the World Health Organization (WHO).

Projects for supplying citizens with pure water are very sensitive and important projects since they relate to the most important human being needs for the life as well as his health. Therefore, if people supplied with a healthy and continues water, their life would be safer and happier. On the contrast, if the water supply was unsafe and unhealthy, it could cause diseases and spread epidemics in cities and communities as water is considered a major source of infection. Statistics show that %80 of diseases in the world is transmitted by water (Haseena, *et.al*, 2017). In Basrah, the deterioration of water sources has become a major crisis in the summer of 2018 where at least 118,000 people were hospitalized due to symptoms that identified by doctors as related to water quality (Human Rights Watch, 2019). Water means money. Rather, it is more valuable and important than that. It is the life itself for all creatures on the surface of the earth. Before searching for new water resources, what is available should be preserved. leaks in the water distribution network are the most important causes of threat and attrition facing water resources in any country, especially countries have lack in the water resources, especially non-polluting ones. The leakage is the biggest problem facing the water

distribution networks, because most water distribution systems lose 20 to 30% of the water produced in the purifications plants, but in the old networks, the leakage may reach 50% or more (Cheong, 1991).In Europe, the leakage rate is 23%, in the United States and Canada is 13%, in Asia is 22% and 35% in Latin America, while in Africa the leakage rate is 30% (Fang, 2015, Moore, 2009). There are many factors that cause leakage, including erosion due to the properties of soil or high salinity in the water, the excessive pressure of water, the movement of the earth due to drought or freezing, excessive loads and vibration resulting from road traffic, the age of the network and the materials used in the manufacture of pipes and network accessories and temperature and geological changes. (Cheong, 1991, Wu, 2012, Martini, 2015, Puust, 2010). Regarding locations where the leaks occur in the network, they are often at the transmission or distribution pipes, valves, fire hydrants, connectors and accessories (NRC, 2000, Cheong 1991). Fortunately, there are many old and new ways to detect leakage, including audio methods using audio devices and vibration resulting from leakage or using devices of leakage noise links, including non-audio methods such as tracking gas method, infrared imaging method, ground penetration radar, thermal method, and wireless sensor networks method (Hunaidi, 2000, Mashford, 2008, Thompson, 2001, Yang, 2008, Goulet, 2013, Cabrera, 2013, Almazyad, 2014, Zhang, 2019).

The risk of leakage lies in that it wastes both money and precious natural resources. While the main economic loss is the cost of raw water, treatment and transportation, the additional economic loss is the damage to the water network itself and the corrosion of the foundation of pipes, valves and piping accessories, in addition to the damage to road and building foundations nearby (AWWA, 1990). The countries most affected by water loss are low-income countries that cannot afford to lose any valuable water, as it was found that low and middle income countries lose an estimated 60 million cubic meters of water daily due to leakage (Farley, 2003) As indicated by a study conducted by the World Bank that the leakage in the water pipeline exceeds 48.6 billion cubic meters of water annually, and the corresponding annual economic losses amounted to approximately 14.6 billion US dollars (Cataldo, 2012). In the event that it is not possible to obtain the necessary equipment to conduct a survey of water distribution networks and detect leakage, either because of a lack of financial capabilities or carelessness, there are indirect and alternative means for researchers to know the quality of the water distribution network by studying the changes taking place in the water quality reaching the consumer and comparing it with that produced water in the purifications plants. Thus, the safety of the distribution network is evaluated by this comparison. Hence the importance and aims of this work comes in order to study the change in the water quality produced from the purifications plants after passing through the water distribution networks for the study areas in Basra Governorate Center, and to know whether there is deterioration and pollution to water due to its transfer in the water networks. Water purification projects cost the country budget billions of dollars annually from operating equipment and pumps, workers and engineers, preparing chemical materials, maintaining and installing new units periodically. However, all this effort and huge amount of money may go to waste as a result of the deterioration and aging of water distribution networks. Therefore, securing the process of transporting water is no less important than the process of water purification, and thus, the role of one is complementary to the role of the other.

AIMS OF STUDY

1-Knowing the change extent in the quality of water reaching the consumer and coming from the purification plant through the distribution network.

2 knowing the quality of the network that Transporting purified water to the consumer.

3-Evaluation of the quality of water reaching the consumer in terms of its conformity with the specifications of the Iraqi drinking water and the World Health Organization WHO.

MATERIALS AND METHODS

Water samples were collected from four water distribution networks (Fig. 1) in the center of Basra Governorate, which are supplied with water from three purifications plants, the Al-Abas purification plant, the Sports City purification plant, and the Al-Jubayla purification plant. The water source for these plants was the Al-Badaa Canal, which is supplied with water directly from the Tigris River. The regions were distributed as follows:

1-Hay-Alhussein Region: The area is equipped with drinking water from Al-Abas purification plant and with four samples (four random points) of tap water intended for consumption to different homes in the region.

2- Al-Qebla Region: It is supplied with drinking water from the Sports City purification plant, and with four random samples of tap water intended for consumption to different homes in the region.

3- Al-shamshomeya and Dur-Aldobat regions: Both are supplied with drinking water from Al-Jubayla purification plant, and with four random samples of tap water intended for consumption to different homes in the region.

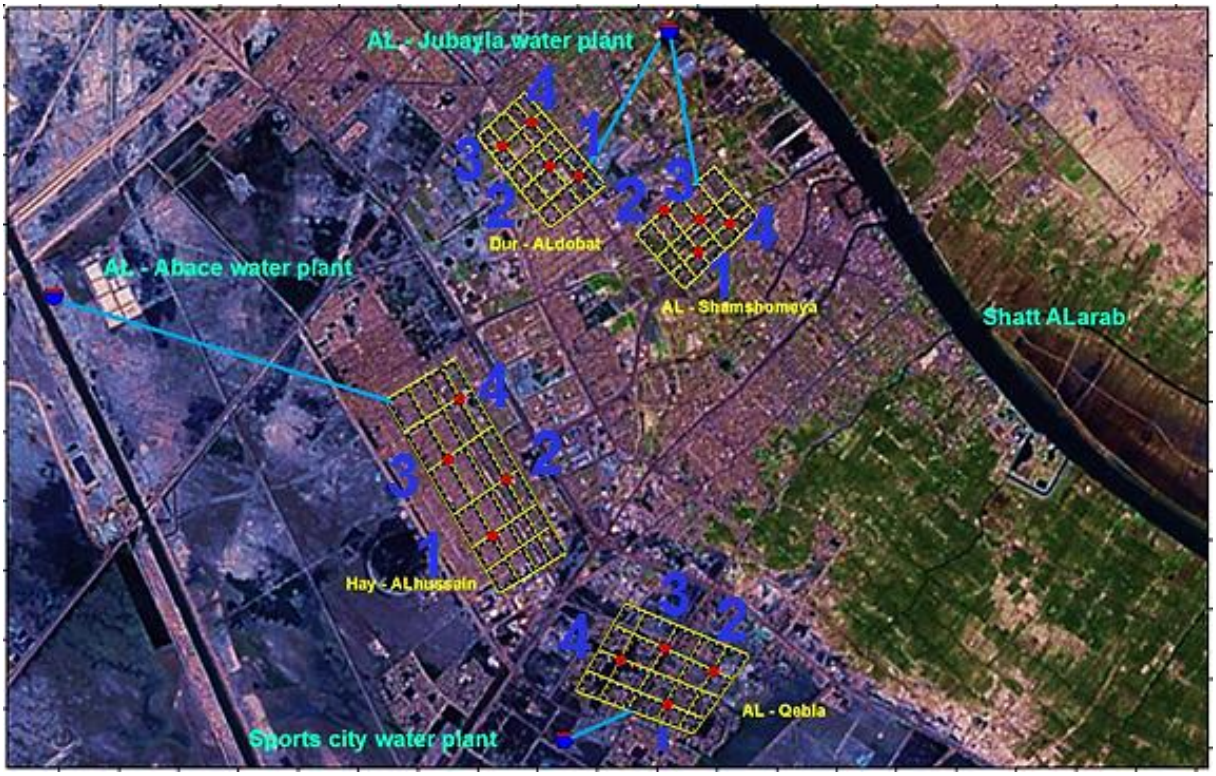

Figure (1) a map of the locations of the four water distribution networks and water purification plants (picture taken from the GIS program).

Water samples were collected after opening the taps for two minutes, followed by opening the bottle cap near the tap and then filling it with water completely and closed tightly to avoid any pollution that might happen in the collecting of samples. Then, the samples were collected in clean and tight plastic containers and three replicates for each sample. The methods described in APHA (2005) were used to estimate the following characteristics: pH, TDS, Ec, Turbidity, TH, Ca, Mg, Na, SO_4,P, and Cl . Tests were taken for three seasons: autumn, winter and summer, in the center of Basra Governorate, in Plains zone, southern Iraq, at longitude 47.815819 $^{\circ}$ E and latitude 30.536242 $^{\circ}$ N, with an area of 194 km^2 and levels above sea level ranging from (5-26) where the extreme weather conditions are accompanied by drought and a very high temperature. Highest temperature occurs in

July and August where the average temperature reaches 49℃, while the coldest months are December, January and mid-February where the average temperature is 13℃, and the average annual rainfall ranges between 125 to 141.8 mm per year (Al-Sayed, 1988, Ministry of Environment, 2013, Al-Qashtaini, 1998, HNJRZ, 2013).

Statistical analysis of the different parameters was performed using analysis of variance Two-Way ANOVA. In order to compare between concentrations of water produced in the plants and the water concentrations in the regions the Paired Sample T- Test method is used. (Amin, 2007, Amin 2008).

RESULTS AND DISCUSSION

Tables (1,2, and 3) showed that the highest recorded value of tap water samples for this parameter was in the Hay-AlHussain region, which average value was 7.99 in the summer, it is fed with drinking water from the Al-Abas purification plant. As for the lowest values, the samples of the Dur-Aldobat region were recorded in the winter with an average values of 7.66, it is fed with water from Al-Jubayla purification plant. The parameter values of the water produced in the plants for the study period ranged between 7.58 to 7.64. From the results. it can be observed that the parameter values of the water coming out of the plants were less than the values of the tap water that reaches the homes in the four chosen regions, but in spite of that, The values of all averages of the four regions during the three seasons were within the permissible limits for the Iraqi standards and the World Health Organization Shown in Table (4).

The results presented in Tables (1,2, and 3) showed that the highest recorded mean for the parameter concentrations was 825 mg/L in Hay Al-Hussain region at summer, and the lowest mean was recorded in Dur-Aldobat region during winter by 537.3 mg/L. While the parameter concentrations of the water produced in the plants during the study period ranged between 512 mg/L to 545 mg/L. The study showed that there were significant differences between the average concentrations of regions with each other at this parameter except for the regions of Al-Shamshomeya and Al-Qiblah, as well as the Al-Qebla and Dur-Aldobat regions. Also, the results recorded significant differences between seasons except for autumn and winter at this parameter. The results also showed that there were statistical differences between the concentrations of water produced in the plants with the averages concentrations of water samples in the four regions, where the average concentrations of regions tend to increase compared to the existing concentrations of the produced water in the plants. This means an increase in the total dissolved salts when they reach the consumer in the Residential neighborhood compared to the main plants, and this indicates that there is a defect in the pipes carrying this water. The Human Rights Watch (2019) indicates in its report that the water distribution network has got the lowest level of investment and maintenance in the past five decades despite the high levels of dissolved solids found in water which results in poor conditions water. As a results, the leakage rate in most of the Basrah networks is about 50%. Furthermore, and what makes matters worse is the frequent power cuts that lead to stopping the flow of water in the pipes and thus changing the pressure, which in turn leads to the leakage of groundwater into the pipes bringing with it mud, sewage and other waste. In spite of this, the average concentrations of salts in all regions for all seasons were within the limits of the specifications of Iraqi standards of drinking water and the World Health Organization. Tables (1), (2) and (3) show the study parameters for the four regions and the water produced in the plants in the study seasons.

Statistical analysis showed that the highest average for the parameter concentrations was in the Hay-Alhussain 1650 ds/m in the summer, and the lowest average was in Dur-Aldubat in winter by 1073 ds/m. While the parameter concentrations of the water produced in the plants for the study period ranged between 1024 ds/m to 1108 ds/m. The results showed that there are significant differences between the regions except between the regions of Al-Shamshomeya and Al-Qebla, as well as Al-Qebla and Dur-Aldubat regions. Statistical differences were recorded for the seasons except between

the autumn and winter seasons at this parameter, and when comparing produced purified water samples with the samples of the regions, the results showed that there were significant differences at the significance level of 0.05. The concentrations average of regions has took a step towards an increase at this parameter compared to the concentrations of water produced in the plants and therefore an increase in the concentration of this parameter when it reaches the consumer in Residential neighborhood compared to the main plants, which indicates that there is a defect in the pipes carrying this water.

The results shown in tables (1,2, and 3) showed that the turbidity values for all plants and regions that receive water from the purifications plants were high and exceeded the highest limits allowed in the Iraqi standards and the World Health Organization. Hay-Alhussain recorded the highest average concentration for this parameter at 14.4 NTU in the summer, Dur-Aldubat in the winter season recorded the lowest average concentration of 8.3 NTU, While parameter concentrations of water produced at plants for study period ranged from 7.5 to 8.8 NTU. The study also showed the presence of significant differences between the seasons except between the autumn and winter. The results also recorded statistical differences between the regions, except for Al-Qebla with Al-shamshomeya and Al-Qebla with Dur-Aldubat for turbidity. When comparing the concentrations of water produced in the plants with the concentration average of regions, the results of the study showed that there were significant differences between them, where the concentrations average of regions took a step towards an increase compared to the values of the concentrations of water produced in the plants, thus increasing the turbidity in the tap water that reaches the homes compared to the purifications plants that supply these regions with water. Turbidity arises in the water as a result of the entry of soil particles and suspended matter such as sand, soil, and silt particles that contain silica compounds and others such as iron oxides, aluminum and carbonates, As well as, the result of the presence of large quantities of microorganisms such as algae and iron bacteria in the water, in addition to water pollution due to drainage of Industrial and wastewaters (Al-Serawi, 2010). This enhances the possibility of leaks with large proportions in the distribution network, through which pollution is entry through leakage openings when the pressure in the distribution system has drops, which poses a threat to both health and the surrounding environment.(AWWA,1990,Mutikanga,2012). Statistical analysis showed that the highest average concentration recorded was in Hay-Alhussain in the summer season with a value of 171.61 mg/L and that the lowest recorded concentration was at the value of 100.2 mg/L in Dur-Aldobat in the winter season. The concentrations of water produced in the plants for this parameter ranged between 89.3 mg/L to 123.45 mg/L. The results of the study recorded the presence of significant differences between the regions except between Al-Shamshomeya with Al-Qebla and Al-Qebla with Dur-Aldobat. The results also showed the presence of significant differences between the seasons except for the autumn and winter seasons. The results also have been showed that there were significant differences between the concentrations of water produced in the plants and the average concentrations for the study regions, and the average concentrations of regions has recorded a trend towards the increase over the values of the concentrations of water produced in the plants. However, the concentration of this parameter in all regions has been within the limits of the approved specifications.

Hay- AlHussain at the summer season recorded the highest average concentration of 994 mg/L, Dur-Aldubat recorded the lowest concentration in the winter season by 547 mg/L for this parameter, While the concentrations of water produced in the plants for the parameter ranged between 521 mg/L to 598 mg/L. The results showed that there were significant differences among the regions, except for the Al-Qebla and Dur-Aldobat regions. Significant differences were also recorded between summer and winter and between summer and autumn. While statistical differences at the significance level 0.05 were recorded between the concentrations of water produced in the plants with the average concentrations of the regions, and the average concentrations of the regions took an increase trend compared to the concentrations values of water produced in the plants. The parameter concentrations in all regions have been above the limits of the approved specifications.

The results showed that the highest average concentration was in Hay-Alhussain in the summer season with a value of 192 mg/L and that the lowest recorded concentration was with a value of 121.6 mg/L in Dur-Aldobat in the winter season, While the Ca concentrations of water produced in the plants ranged between 103 mg/L to 127 mg/L. The results of the study showed that there were significant differences between the regions except for Al-Qebla and Dur-Aldobat regions, The results also recorded the presence of significant differences between summer and winter as well as summer and autumn. As for the average concentrations of regions, the trend was towards increasing, compared to the concentrations of water produced in the plants, with significant differences recorded. The Ca average concentration of all regions was within the limits of the World Health Organization specifications, while the four regions were recorded in the summer season, in addition to Hay-Alhussain and Al-Shamshomeya, only during the autumn season, they exceeded the limits of the Iraqi specifications.

The study showed that the highest average concentration recorded was in Hay-Alhussain in the summer season with a value of 199 mg/L and that the lowest recorded concentration was with a value of 103.8 mg/L in Dur-Aldabat in the winter season, While the Mg concentrations of water produced in the plants ranged between 92.34 mg/L to 117 mg/L. The study recorded significant differences in the average concentrations between the regions, except for the two regions of Al-Qebla with Dur-Aldobat. Significant differences were also recorded between summer with autumn and summer with winter, While results showed that there were significant differences between concentrations of water produced in the plants and the average concentrations for the regions, Where an increase in the average concentrations of Mg for the regions were recorded compared to the concentrations of water produced at the plants. Also, the average concentrations of this parameter in all regions exceeded the specifications approved in this study.

During the summer season, Hay-Alhussain recorded the highest average concentration of 0.5 mg/L and Dur-Aldobat recorded the lowest concentration in the winter season by 0.33 mg/L at the parameter, while the concentrations of water produced in the plants for the parameter ranged between 0.23 mg/L to 0.24 mg/L. The results of the study showed the presence of significant differences between the regions at the average concentrations for the parameter, except between the Hay-Alhussain with Al-Shamshomeya regions. The results also showed the presence of significant differences between the seasons and specifically between the summer and autumn seasons and between the summer and winter seasons. The results of the statistical analysis showed that there were significant differences between the concentrations of the produced water and the average concentrations of regions, where an increase in the average concentrations for the regions was recorded at the phosphorous parameter over the concentrations of water produced in the plants. The source of phosphorus in water in agricultural areas is the result of the uses of fertilizers in agriculture, pastures and cultivated land, but inside cities, the source of phosphorus in water is the result of leakage from domestic or industrial wastewater and detergents, which are in the public sewage network. Based on this, and on the results of the phosphorus parameter, it is clear that the presence of concentrations, even in a small percentage of it, in the water produced in the plants indicates that there is a possibility of drainage of puncture water towards the Bedaa channel that feeds the plants. As for the increasing concentrations of the parameter in the regions and in greater proportions than what is found in the produced water, this is evidence of pollution and leakage of the distribution network with domestic and industrial wastewater. (MPCA, 2007, Adesuyi, et.al, 2015). This confirms the suspicions that exist about the possibility of a sewage water leak in some networks of the Basrah Governorate Center, which there is about 50% of the leakage at the networks of those areas (Human Rights Watch, 2019). Moreover, the average concentrations for the regions at this parameter exceeded the allowable limits for the approved standards for drinking water.

Statistical analysis showed that the highest average concentration was in Hay-Alhussain in the summer season with a value of 158 mg/L and that the lowest recorded concentration was at the value of 111 mg/L in Dur-Aldobat in the winter season, while the concentrations of water produced in the plants

ranged between 98.98 mg/L to 112.4 mg/L for this parameter. The results showed that there were significant differences between the average concentrations of Al-Qebla and Hay-Alhussain, and between the two regions of Al-Hussain and Dur-Aldobat, and between the regions of Al-shamshomeya and Dur-Aldobat, The results also showed that there were significant differences between summer and autumn and summer and winter. As for the average concentrations of regions, the trend was towards increasing, compared to the concentrations of water produced in the plants, recording significant differences. The source of sulfates is due to the presence of factories that produce fertilizers and chemicals, the manufacture of dyes, glass, paper, soap, medicine, textile industries, fungicides, pesticides, and leather tanning (SWA, 2007, WHO, 1996, Delisle, et.al, 1977). All or some of sulfate is usually comes from domestic and industrial wastewater. Despite that, all average concentrations of sulfate were within the limits of the Iraqi standards and the World Health Organization.

In the summer season, Hay-Alhussain recorded the highest average concentration of 261 mg/L, Dur-Aldobat recorded the lowest concentration in the winter season by 164.4 mg/L at the parameter, while the concentrations of this parameter at the water produced in the plants ranged between 133.2 mg/L to 156 mg/L. The results indicated that there were significant differences between the regions, except for Hay-AlHussain and Al-Shamshomeya, as well as Al-Qebla and Dur-Aldobat. The study also showed that there were significant differences between summer and autumn as well as summer and winter. As for the average concentrations of regions, the trend was towards increasing, compared to the concentrations of water produced in the plants, with significant differences recorded. However, no region exceeded the limits of the approved standards for drinking water for chloride, except Hay-AlHussain in the summer season.

To find out most and least polluted region, Figure (2) shows a comparison of the general difference between the sum of the averages of the concentrations of the study parameters in each region, and the sum of the averages of the concentrations of the study parameters at the water produced in the plant corresponding to the region it serves, at each season separately. They were as follows, Hay-Alhussain, Al-Qebla, Al-shamshomeya, and Dur-Aldobat, respectively (144.78, 82.94, 99.29, and 61.95) in the summer, and they were in the autumn respectively (89.63, 37.78, 64.42, and 22.55), while in the winter season they were for the regions as follows (83.54, 33.78, 58.44, and 16.24) respectively. To know most and least polluted season, Figure (3) shows a comparison of the general difference between the sum of the averages of the concentrations of the study parameters in each region, and the sum of the averages of the concentrations of the study parameters at the water produced in the plant corresponding to the region it serves, at each region separately, and they were at Hay-Alhussain for the seasons of summer, autumn and winter, respectively (144.78, 89.63 and 83.54), and at Al-Qebla region they were respectively (82.94, 37.78, and 33.78), and at Al-Shamshomeya they were respectively (99.29, 64.42, and 58.44), while Dur-Aldobat was (61.95, 22.55, and 16.24), respectively

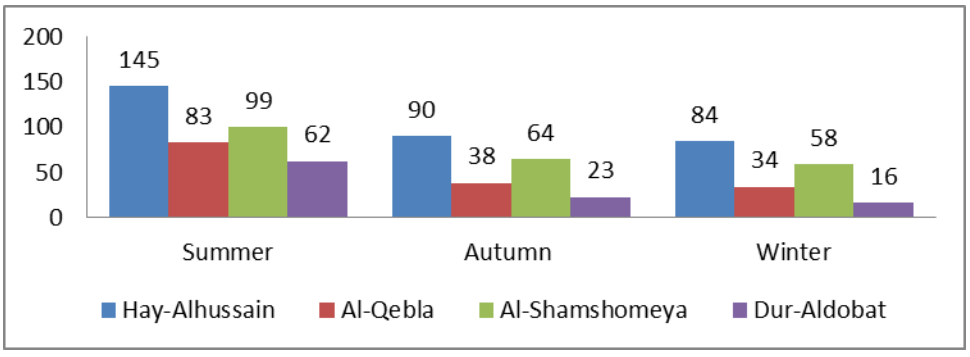

Figure (2) a comparison of the general differences at each season separately.

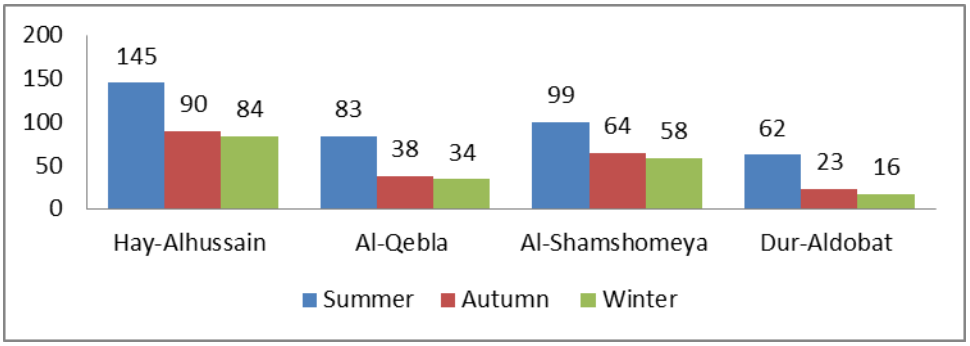

Figure (3) a comparison of the general differences at each region separately.

CONCLUSION

1-The results of the study showed that there were pollution occurring in all networks of the four regions, and the arrangement of the regions have been as follows: Hay-Alhussain, then Al-Shamshomeya, then Al-Qebla, and finally Dur-Aldobat.

2-The study showed that the summer season has recorded the highest rate of pollution, followed by autumn, while the winter season was the least pollution.

3- The study showed an increase in the concentrations of sulfate and phosphorous over the existing concentrations of water produced in the plants, as well as the rest of the other parameters, which is evidence of tangible partial pollution and leakage of sewage and ground water into the water distribution network for the study regions, as a result of damage in these networks.

4- The water delivered to the consumer and transported through the water distribution network was not suitable for drinking, as it exceeded the limits of the specifications approved by the parameters TH, Mg, Ca, Turbidity, and P.

Recommendations:

1-It is recommended to conduct a field survey with leak detection devices for the study regions and to address the causes of pollution from cracks and leaks in the networks of the study regions, and then laboratory analyzes of water parameters should be performed again to ensure that the pollution that occurs in the water conveying networks has reduced and faded.
2-It is recommended to review the water distribution networks, especially in Hay-Alhussain and Al-Shamshomeya regions, in the event that laboratory analyzes prove that water pollution remains through the water conveying networks, Because the network is then considered useless and becomes a major source of pollution

Table (1) The study Parameters for the four regions and the water produced in the plants in the summer season

Standard / sample	pH	TDS mg/l	EC ds/m	Turb NTU	Na mg/l	TH mg/l	Ca mg/l	Mg mg/l	SO4 mg/l	P mg/l	Cl mg/l	Average
Hay-Alhusain1	7.92	772	1543	15.5	158.65	994	191	198	149.86	0.51	235	-
Hay-Alhusain2	7.83	706	1412	13.5	143.20	976	174	196	134.47	0.46	214	-
Hay-Alhusain3	7.85	718	1435	13.8	151.54	990	181	197	138.95	0.48	221	-
Hay-Alhusain4	8.35	1105	2210	25.7	233.05	1014	221	204	208.80	0.54	375	-
The average	7.99	825	1650	17.1	171.61	994	192	199	158.02	0.50	261	406.90
Al-Abas water purification	7.64	554	1108	8.81	123.45	598	103	117	107.13	0.24	156	262.13
General Average Difference	0.35	271	542	8.32	48.16	396	89	81.8	50.89	0.26	105	144.78
Al-Qebla1	7.85	721	1442	13.9	166.24	938	179	185	163.38	0.47	243	-
Al-Qebla2	7.70	602	1204	10.3	123.17	748	145	147	124.23	0.44	181	-
Al-Qebla3	7.84	709	1418	13.6	157.56	914	177	180	158.42	0.47	237	-
Al-Qebla4	7.71	611	1222	10.6	126.24	769	148	151	127.29	0.44	187	-
The average	7.77	661	1322	12.1	143.3	843	163	166	143.33	0.45	212	333.84
Sport city water purification plant	7.59	517	1034	7.7	119.24	590	125	113	103.55	0.23	141	250.90
General Average Difference	0.19	144	288	4.4	24.06	252	37.3	52.4	39.78	0.22	70.7	82.94
Al-Shamshomeya1	7.79	672	1345	12.4	139.80	886	159	174	141	0.46	235	-
Al-Shamshomeya2	7.93	778	1554	15.7	191.55	910	199	181	169	0.47	283	-
Al-Shamshomeya3	7.80	682	1363	12.7	141.91	889	176	177	146	0.46	244	-
Al-Shamshomeya4	7.79	670	1339	12.4	136.01	880	153	174	137	0.45	234	-
Average	7.83	701	1400	13.3	152.32	891	172	177	148.25	0.46	249	355.59
General Average Difference	0.22	172	342	5.3	29.998	297	45	62.5	41.8	0.23	96.3	99.29
Dur-Aldobat1	7.74	636	1272	11.3	139.21	811	159	159	139.44	0.44	208	-
Dur-Aldobat2	7.74	635	1270	11.3	138.48	811	158	159	139.11	0.44	204	-
Dur-Aldobat3	7.73	624	1248	11.0	134.59	792	151	156	133.51	0.43	193	-
Dur-Aldobat4	7.73	625	1250	11.0	134.87	803	152	159	134.74	0.43	197	-
Average	7.73	630	1260	11.1	136.79	804	155	158	136.7	0.43	200	318.25
Al-Jubayla purification plant	7.60	529	1058	8.0	122.32	594	127	114	106.45	0.23	153	256.30
General Average Difference	0.13	101	202	3.1	14.47	210	28.1	44.4	30.25	0.2	47.8	61.95

Table (2) The study parameters for the four regions and the water produced in the plants in the autumn season

Standard / Sample	pH	TDS mg/l	EC ds/m	Turb NTU	Na mg/l	TH mg/l	Ca mg/l	Mg mg/l	SO4 mg/l	P mg/l	Cl mg/l	Average
Hay-Alhussain1	7.90	755	1509	15.0	2135.	774	173	146	150	0.44	242	-
Hay-Alhussain2	7.78	662	1322	12.1	123.5	703	147	136	129	0.40	203	-
Hay-Alhussain3	7.89	750	1498	14.8	130.6	770	171	146	148	0.44	240	-
Hay-Alhussain4	7.93	784	1568	15.9	160.1	815	185	154	158	0.45	263	-
Average	7.87	738	1474	14.4	4137.	765	169	145	146	0.43	237	348.63
Al-Abas water Purification plant	7.63	549	1098	8.7	94.2	587	125	111	112	0.24	155	259.00
General Average Difference	0.25	189	376	5.8	43.15	178	44.2	34	33.8	0.19	81.6	89.63
Al-Qebla1	7.74	637	1274	11.4	122.6	595	138	112	137	0.39	187	-
Al-Qebla2	7.66	571	1140	9.3	106.4	575	122	111	120	0.35	161	-
Al-Qebla3	7.72	617	1236	10.7	117.1	590	133	112	132	0.37	177	-
Al-Qebla4	7.68	589	1176	9.9	108.7	584	126	112	125	0.35	166	-
Average	7.70	604	1207	10.3	113.7	586	130	111	128	0.36	173	279.09
Sport City water purification plant	7.59	518	1036	7.7	94	545	106	96.4	103	0.23	140	241.31
General Average Difference	0.11	85.5	171	2.6	19.74	40.7	23.9	15	24.9	0.131	32.5	37.78
Al-shamshomeya1	7.72	623	1246	10.9	118.1	663	146	126	129	0.40	208	-
Al-shamshomeya2	7.85	717	1437	13.8	132.8	773	172	147	152	0.48	243	-
Al-shamshomeya3	7.73	630	1258	11.1	121	672	149	128	132	0.41	212	-
Al-shamshomeya4	7.72	618	1236	10.8	116.3	653	143	124	127	0.40	201	-
Average	7.76	647	1294	11.7	122	690	152	131	135	0.42	216	309.85
General Average Difference	0.16	124	248	3.8	29.34	136	39.3	28.1	29.7	0.2	69.9	64.42
Dur-Aldobat1	7.67	577	1154	9.5	108.9	595	131	113	117	0.35	173	-
Dur-Aldobat2	7.66	576	1153	9.5	107.8	594	130	113	116	0.35	173	-
Dur-Aldobat3	7.65	563	1126	9.1	101.3	555	124	105	112	0.33	161	-
Dur-Aldobat4	7.66	575	1151	9.5	105.5	584	128	111	116	0.35	171	-
Average	7.66	573	1146	9.4	105.9	582	128	111	115	0.34	169	267.98
Al-Jubayla purification plant	7.59	523	1046	7.9	92.7	554	113	103	105	0.24	146	245.43
General Average Difference	0.06	49.8	100	1.5	13.19	27.6	15.2	7.56	9.9	0.10	23.1	22.55

Table (3) The study Parameters for the four regions and the water produced in the plants in the winter season

Standard / Sample	pH	TDS mg/l	EC ds/m	Turb NTU	Na mg/l	TH mg/l	Ca mg/l	Mg mg/l	SO4 mg/l	P mg/l	Cl mg/l	Average
Hay-Alhussain1	7.86	730	1460	14.2	142	798	176	152	146	0.44	244	-
Hay-Alhussain2	7.72	616	1232	10.7	118	665	146	127	122	0.40	202	-
Hay-Alhussain3	7.72	620	1240	10.8	120	677	148	129	124	0.40	205	-
Hay-Alhussain4	7.91	764	1528	15.3	151	807	185	152	154	0.47	257	-
Average	7.80	683	1365	12.8	133	737	164	140	136	0.43	227	327.79
Al-Abas Purification Plant	7.59	521	1044	7.8	94.5	549	112	105	103	0.23	142	244.24
General Average Difference	0.21	162	321	5.0	38.5	188	51.6	34.5	33.9	0.20	85	83.54
Al-Qebla1	7.80	680	1360	12.7	128	690	148	129	144	0.42	200	-
Al-Qebla2	7.60	527	1054	8.0	98.2	539	111	104	109	0.32	142	-
Al-Qebla3	7.67	583	1162	9.7	108	562	125	106	123	0.36	167	-
Al-Qebla4	7.66	576	1152	9.5	106	543	122	102	120	0.35	162	-
Average	7.68	592	1182	10.0	110	584	127	110	124	0.36	168	274.01
Sport city water purification plant	7.59	516	1032	7.6	92.3	541	110	92.3	106	0.23	137	240.23
General Average Difference	0.10	75.5	150	2.3	17.9	42.2	16.8	18.2	17.8	0.13	30.6	33.78
Al-shamshomeya1	7.69	595	1191	10.1	116	635	142	120	126	0.40	194	-
Al-shamshomeya2	7.75	643	1283	11.5	127	703	156	133	139	0.44	217	-
Al-shamshomeya3	7.72	622	1244	10.9	122	671	151	127	133	0.42	208	-
Al-shamshomeya4	7.68	590	1180	9.9	114	628	138	120	124	0.40	189	-
Average	7.71	613	1225	10.6	119	659	147	125	131	0.41	202	294.43
General Average Difference	0.13	101	201	3.1	30	138	40.6	29.5	31.7	0.19	68.7	58.45
Dur-Aldubat1	7.63	551	1099	8.7	103	567	128	107	115	0.34	173	-
Dur-Aldubat2	7.63	549	1096	8.7	102	564	125	107	114	0.34	168	-
Dur-Aldubat3	7.59	522	1045	7.8	96.9	522	114	99.5	107	0.32	157	-
Dur-Aldubat4	7.60	527	1052	8.0	98.8	534	119	101	108	0.33	159	-
Average	7.61	537	1073	8.3	100	547	122	104	111	0.33	164	252.23
Al-Jubaila Purification Plant	7.58	512	1024	7.5	89.3	521	106	95.6	99	0.23	133	235.99
General Average Difference	0.03	25.3	49	0.8	10.9	25.7	15.5	8.17	12.1	0.11	31.2	16.24

Table (4) The statistical analysis of the parameters of the study regions and the limits of the approved specifications.

Standards / regions			PH	TDS mg/l	EC ds/m	Turb NTU	TH mg/l	Ca mg/l	Mg mg/l	Na mg/l	SO_4 mg/l	P mg/l	CL mg/l
The lease significant difference at 0.05	Significant differences between the regions	regions combined	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Hay-Alhussain - Al-Qebla	-	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.012	0.000	0.000
		Hay-Alhssain – Al-Shamshomeya	-	0.001	0.001	0.000	0.000	0.002	0.000	0.021	0.126	0.057	0.086
		Hay-Alhussain – Dur-Aldobat	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Al-shamshomeya – Dur-Aldobat	-	0.009	0.009	0.000	0.000	0.000	0.000	0.015	0.005	0.000	0.000
		Al-Shamshomeya – Al-Qebla	-	0.204	0.204	0.250	0.000	0.003	0.000	0.195	0.290	0.001	0.001
		Al-Qebla – Dur-Aldobat	-	0.159	0.159	0.162	0.168	0.416	0.162	0.230	0.064	0.031	0.588
	Significant differences between the seasons	Seasons combined	-	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Summer -Autumn	-	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.002
		Summer - Winter	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Autumn - Winter	-	0.149	0.149	0.155	0.143	0.282	0.91	0.487	0.262	0.471	0.378
	Total significant differences between purifications plants samples and regions samples		-	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.000	0.000	0.000
Standard specifications for drinking water approved in the study		WHO specifications	**6.5-8.5**	**1000**	**-**	**5**	**500**	**200**	**50**	**200**	**250**	***0.015-0.025**	**250**
		Iraqi specifications	**6.5-8.5**	**1000**	-	**5**	**500**	**150**	**50**	**200**	**250**	-	**250**

*** :Indicates the US Environmental Protection Agency (EPA) specifications for drinking water (Vouldouris,etc,2012).**

REFERENCES

HNJRZ, General Authority for Weather and Seismic Monitoring, (2013), Annual Rain Rates in Iraq for the period from 1970 to 2011, Ministry of Transport, Iraq, reviewed on January 15, 2020. http://www.meteoseism.gov.iq/index.php?name=Pages&op=page&pid=93

Ministry of Environment, (2013), Forecasts of the state of the environment in Iraq - First Report, Iraq.

Human Rights Watch, (2019), Basra Atashana - Iraq's Failure to Address the Water Crisis, USA, ISBN: 978-1-6231-37519, https://www.hrw.org/ar/report/2019/07/22/332258, see it on 12-1-2020.

Al-Sayed, Majed, and Razzouqi, Abd al-Ilah, (1988), Iraq Climate, College of Arts, University of Basra, Iraq.

Al-Qashtaini, Basil Ihsan, (1998), Spatial and temporal distribution of rain in Iraq, Journal of the Iraqi Geographical Society, No. (37), February, pp. 123-124.

Amin, Osama Rabie, (2007), Statistical Analysis Using SPSS Program, Sadat College of Commerce, Menoufia University, Deposit No. 3142/2007, Egypt, p. 199.

Amin, Osama Rabie, (2008), Statistical Analysis of Multiple Variables Using SPSS Program, Department of Statistics and Mathematics, College of Commerce in Sadat, Menoufia University, Cairo, Egypt, p. 199.

Al-Serawi, Ahmed, (2010), Principles of Water Quality Control, Performance Development and Development Center, 2010 \ 9252, Egypt.

Central Organization for Standardization and Quality Control, (2001), Iraqi Standard Specifications for Drinking Water, GTA 417.

Adesuyi, A.A., Nnodu, V. C. , Njoku, K.L., Jolaoso,A., (2015)," Nitrate and Phosphate Pollution in Surface Water of Nwaja Creek, Port Harcourt, Niger Delta, Nigeria", International Journal of Geology, Agriculture and Environmental Sciences Volume – 3 Issue – 5.

Almazyad, A.S.(2014), "A proposed scalable design and simulation of wireless sensor network-based long-distance water pipeline leakage monitoring system". Sensors, 14, 3557–3577.

APHA, AWWA, WPCE, .(2005). "Standard Methods for the Examination of Water and Wastewater". 21. St . ed . New york, pp. 1199.

AWWA. Water audits and leak detection.(1990), "Manual of Water Supply Practices" No. M36, American Water Works Association.

Cabrera, D.A.; Herrera, M.; Izquierdo, J.; Levario, S.J.O.; Garcia, R.P.(2013), "GPR-based water leak models in water distribution systems". Sensors, 13, 15912–15936.

Cataldo, A.; Cannazza, G.; Benedetto, E.D.; Giaquinto, N.(2012), "A new method for detecting leaks in underground water pipelines". IEEE Sens. J., 12, 1660–1667.

Cheong, L.C. (1991), "Unaccounted for water and the economics of leak detection". Proceedings of the 18th International Water Supply Congress and Exhibition, Copenhagen, published in Water Supply, 9:3&4:IR1.1, 1991.

Delisle. CE., Schmidt. JW (1977), "The effects of sulphur on water and aquatic life in Canada. In: Sulphur and its inorganic derivatives in the Canadian environment". Ottawa, Ontario, National Research Council of Canada (NRCC No. 15015).

Fang, D.; Chen, B.(2015), "Ecological network analysis for a virtual water network". Environ. Sci. Technol, 49, 6722–6730.

Farley, M.; Trow, S. (2003), “Losses in Water Distribution Networks”; IWA publishing: London, UK; ISBN 1900222116.

Goulet, J.A.; Coutu, S.; Smith, I.F.C. (2013), “Model falsification diagnosis and sensor placement for leak detection in pressurized pipe networks”. Adv. Eng. Inform., 27, 261–269.

Haseena, M., Faheem, M. M., Javed, A., Arshad, S., Asif, N., Zulfiqar, S., and Hanif, J., (2017) , “Water pollution and human health”, Environmental Risk Assessment and Remediation, Volume 1, Issue 3.

Hunaidi, O., Chu, W., Wang, A., and Guan, W.,(2000), “Detecting leaks in plastic pipes”. Journal AWWA, 92:2:82-94, American Water Works Association.

Martini, A.; Troncossi, M.; Rivola, A. (2015), “Automatic leak detection in buried plastic pipes of water supply networks by means of vibration measurements”. Shock Vibrat, , 1–13.

Mashford, J.Silva et al.(2008), “An approach to leak detection in pipe networks using analysis of monitored pressure values by support vector machine”. the 3rd international conference on network and system security.

MPCA Minnesota pollution control agency,(2007),” Phosphorus: Sources, Forms, Impact on Water Quality - A General Overview”, 520 Lafayette Rd. N., St. Paul, MN 55155-4194,wasley.US.

Moore, N.M. (2009), “The Green City: Sustainable homes, sustainable suburbs. Nicholas Low”, Brendan Gleeson, Ray Green, and Darko Radovi ć. Urban Geogr., 30, 927–928.

Mutikanga, h.e. (2012). “Water loss management”. USA, university of technology.

NRC.National Research Council of Canada, (2000), “Detecting Leaks in Water-Distribution Pipes”, Ottawa, K1A 0R6, ISSN 1206-1220.

Puust, R.; Kapelan, Z.; Savic, D.A.; Koppel, T.(2010), “A review of methods for leakage management in pipe networks”. Urban Water J., 7, 25–45.

SWA,Saskatchewan Watershed Authority, (2007),”Sulphate For Private Water and Health Regulated Public Water Supplies” ,Saskatchewan Ministry of Agriculture,Canada.

Thompson, M.; Chapman, C.J.; Howison, S.D.; Ockendon, J.R.(2001), “Noise generation by water pipe leaks”. In Proceedings of the 40th European Study Group with Industry, Keele, UK, 9–12 April; pp. 1–4.

Voudouris, Kostas., Voutsa, Dimitra.,(2012), “Water Quality Monitoring and Assessment”,Latch:janeza,tridine 9,51000,Rijeka,Croatia.

WHO,(1996),”Guidelines for drinking water quality”,2nd.ed.Vol,21,Geneva,Switzerland.

Wu, Z. Y. (2012), "Roles of Advanced Information Technology in Water Loss Management". IWA Water Loss, Manila, Philippines.

Yang, J.; Wen, Y.; Li, P.(2008), “Leak acoustic detection in water distribution pipelines”. In Proceedings of the 7th ,World Congress on Intelligent Control and Automation, Chongqing, China, 25–27 June; pp. 3057–3061.

Zhang, T.; Fan, H.; Loo, J.; Liu, D.(2019), “User preference aware caching deployment for device-to-device caching networks”. IEEE Syst. J., 13, 226–237.