Microbiological Quality Assessment of Drinking Water at Al-Hayy City, Southern Iraq.

Wisam Th. Al-Mayah[1], Ali O. Shawardi[1] and Rasha M. Salman[2]

[1:]Department of Basic Science, College of Dentistry, University of Wasit

[2:]Department of Biology, College of Science, University of Wasit

تقييم النوعية الميكروبيولوجية لمياه الشرب في مدينة الحي، جنوب العراق

وسام ثامر جبار[1], علي عوده شاوردي[2] و رشا موحان سلمان[3]

[1:]قسم التربة والموارد المائية- كلية الزراعة- جامعة واسط

[2:]فرع العلوم الأساسية- كلية طب الاسنان - جامعة واسط

[3:]قسم علوم الحياة - كلية العلوم- جامعة واسط

المستخلص

تمت دراسة النوعية الميكروبية لمياه الشرب الموزعة من محطة الحي وعدد من المناطق التي تغذيها, شهرياً للمدة من تشرين الأول 2016 إلى نيسان 2017, عبر مراحل التصفيه وصولا للمنازل التي تقع على مسافات مختلفة عن مصدر التجهيز وبواقع نموذجين لكل شهر .تستمد هذه المحطة مياهها من نهر الغراف الذي يقع في الجزء الجنوبي الشرقي من العراق حيث تغذي كل مناطق المدينة بمياه الشرب.تضمنت هذه الدراسة الكشف عن بكتريا ادلة التلوث للمياه (بكتريا القولون ,القولون البرازيه ,بكتريا E.coli ,بكتريا المسبحات البرازية والعدد الكلي للبكتريا), وكذلك بعض العوامل الفيزياويه والكيمياويه (درجة الحرارة, ألكدره, الكلور الحر المتبقي والأس الهيدروجيني).أظهرت الفحوصات البكتريولوجية ارتفاع قيم كل من العد الطبقي للبكتريا الهوائية، البكتريا القولونية الكلية، البكتريا القولونية البرازية، الاشريشية القولونية والمسبحيات البرازية في أشهر (كانون الاول و كانون الثاني) في كل مواقع الدراسة مقارنة بالاشهر الاخرى من السنة لكل من المياه الخام ومياه الشرب.أما قيم المسبحيات البرازية فكانت أقل من الأنواع البكتيرية الأخرى المفحوصة من المحطة. إن نتائج العد الطبقي للبكتريا الهوائية لمياه الشرب تجاوزت الـ (100 خلية\مل) وهو الحد الأقصى المسموح به لمياه الشرب في المحطة، من جانب آخر فقد تعدّت قيم البكتريا القولونية الكلية والقولونية البرازية والإشريشية القولونية الحد المسموح به وهو (صفر خلية\ 100 مل) في عدد من عينات مياه الشرب المحطة مع انخفاض درجات الحرارة شتاءاً. أما الاختبارات الفيزيائية والكيميائية فقد كانت درجات حرارة الهواء وقت جمع العينات مابين 34- 17°م، اما درجات حرارة الماء فتراوحت مابين 29- 11.5 °م وقت النمذجة أيضاً، اما قيم معدلات الاس الهيدروجيني فقد كانت ضمن الحد المسموح به وتراوحت مابين 7.2 - 7.9 كان اعلى معدل للعكارة سجل للمياه الخام في شهركانون الاول, وكانت 89 وحدة عكورة واقل معدل كان في شهر نيسان وكانت 30 وحدة عكورة، بينما كانت اعلى معدل لمياه الشرب 20 وحدة عكورة في شهر كانون الاول واقل معدل كان 1 وحدة عكورة في نيسان. كما أظهرت

الدراسة بأن أعلى معدل للكلور الحر المتبقي سجل في شهر اذار 3.8 ملغم\لتر، وأقل معدل فقد كان 0 ملغم\لتر في بعض النقاط الأبعد عن المحطة.

Abstract:

The microbial quality of drinking water which distributed form Al-Hayy water treatment plant and number of residential areas fed by these water treatment plant was studied each month over six month during a period extended from the October 2016 to April 2017,through the purification stages up to residential sites at different areas situated with various distances from the supplying source, two samples were taken monthly. This station derived their water from AL-Gharraf River in the southeastern part of Iraq, where the feed areas of the city with drinking water. This study included detection of bacteria, evidence of contamination of water (coliform, faecal coliform, Escherichia coli, faecal streptococcus bacteria and total bacteria count), also some physical and chemical variables ware like (temperature, turbidity, free residual chlorine and pH) . Results of Bacteriological tests showed increasing in TPC, TC, FC, *E.coli* and FS bacteria in December and January in all study locations as compared to those of the other months for water plant raw and drinking water and the FS values were less than other bacterial types for water plant. The TPC results of drinking water exceed 100 cell/ml, the allowable limit for drinking water, for all samples of water plant. On the other hand the TC, FC and *E.coli* exceeded zero cell/100ml, the allowable limit for drinking water, in many drinking water samples for water plant with increasing of temperature in summer months. Physiochemical tests showed that air temperature at sampling time was varied between17 and 34°C and between11.5 and 29°C, for water temperature at sampling time also. The results of pH means were within the allowable limit, ranging from 7.2 in October to 7.9 in April.The highest mean value of turbidity recorded for raw water was in December with 89 NTU and the lowest value was in April with 30 NTU, while the highest mean value recorded for Drinking water was 20 NTU again in December and the lowest value was 1 NTU in April. The highest mean value of residual chlorine was recorded in March with 3.8 mg/L, the lowest value was 0 mg/L in some of the farthest points of the plant.

Keyword: Assesment, Drinking Water, Pollution,Treatment.

1. Introduction

Water is essential to sustain life, and without it, life becomes impossible.Drinking water is defined as having acceptable quality in terms of physical, chemical, and biological parameters so that it can be in safety used for drinking, cooking and other domestic applications [1].

Drinking water is the main source of microbial pathogens in developing regions, although poor sanitation and food sources are integral to enteric pathogen exposure [2] [3]. The lack of safe drinking water and adequate sanitation measures lead to a number of diseases such as cholera, dysentery, salmonellosis and typhoid and every year millions of lives are claimed in the developing countries [4]. Comprehensive evaluations of microbial quality of water require survey of all the pathogens that have potential for human infections [5].

Drinking water is necessary for ensuring the health and well-being of populations and plays an important role in the development process. All drinking water and sewerage systems are subject, to a greater or lesser degree, to natural disasters such as earthquakes, floods and droughts. The impacts of a natural disaster can cause contamination

of water, break in pipelines, damage to structures, water shortages, and a collapse of the entire system. In this situation, the main public health priority is usually to provide a basic water supply to the affected population [6] [7].

The aim of this search is studying the biological and some physiochemical properties for drinking and raw water for Al-Hayy city and evaluate drinking water quality to decide if drinking water is safe for drinking.

2.Material and Methods

2.1.Sampling

Samples for physical, chemical and biological variables were performed from AL-Gharraf river also water treatment Plant of AL-Hayy and number of residential areas fed by these water treatment plant as show Fig.1, during a period extended from the October 2013 to April 2014. Water samples were collected for physiochemical analysis using pre-washed polyethylene bottle by water sample twice before filling [8].

Water sample for biological analysis were collected in closed glass bottles, washed with distilled water and sterile by placing them in the oven for 4hr at 200^{o}c [8]. kept in Cool box till carrying to a laboratory for examination [9] .

Figure (1): Sampling stations at Al-Hayy water treatment plant.

2.2. Material and Methods.

Water sample for physio-chemical parameters include water temperature (by using precise mercury thermometer, hydrogen ion concentration by using pH-meter, turbidity level by using turbidity-meter and residual chlorine by using addition methods, were measured according to APHA(American Public Health Association) [8]. Water sample for bacteriological analysis were carried out to determine the following parameters:

-Heterophic bacteria developing at 22 °C and parastic bacteria at 37 °C on plate count agar medium using spread plate method (APHA,1998).

-Feacal indicators; total coliform (TC), faecal coliform (FC) and feacal streptococci (FS) were determined by the most probable

number (MPN) method (APHA, 1998) MacConky broth medium was used to

estimate MPN of TC and FC at 37 °C and 44.5 °C for 48 and 24 hrs.,

respectively. On the other hand, azid dextrose broth medium was used to determine FS at 37 °C for 48 hrs.

3. Results and Discussion.

3.1. physical-chemical properties.

The distribution and monthly variation of the physical-chemical qualities in the water of Al-Hayy plant are shown in Table 1 and Figure 2,3,4,5&6 respectively.

Air and water temperature are an important factor in any aquatic environments affecting on biological processes, in this study the highest air temperature values recorded in April (34°C) and the lowest value recorded in January (17°C), while the water temperature values at sampling time varied between 11.5°C and 29°C (Fig.3&4; Table 1). This cause was similar to previous studies done by [10] [11].

The pH value of Al- Hayy plant are presented in Figure (5) and Table (1). The results of the study showed that each of raw and drinking water in Al-Hayy plant, characterized by being relatively base through the pH values for all areas that did not fall below 7, and this result agreed with [12], they reported that Iraqi inland water is regarded to be on the alkaline side of neutrality, reflecting geological formations of the area and the results are agree with the finding that recorded by [13] [14].

The highest values of turbidity in Al-Hayy plant was recorded on December 89 NTU for raw water sample and 20 NTU for drinking water sample, while the lowest values recorded in April with 30 NTU for raw water sample and 1 NTU for drinking water sample (Fig.5; Table 1). Water turbidity is caused by increasing of rainfall proportion and rising water levels with all the drifting of these rains that are ended in river water as well as discharge water which leads to increase the level of organic materials and other materials that increase turbidity [15][16]. However, The synchronisation of turbidity increase and decrease depends on what the river water includes from turbidity, and the amount of additive alum, maintenance operational quantity, and the age of project which all have an effect on the turbidity rates in the drinking water [17].This result was similar to previous studies done by [17] [18].

The obtained results showed that free residual chlorine of Al- Hayy plant

drinking water, the highest value (3.8 mg/L) was recorded in a site being immediately chlorinated sample during March while the lowest mean value (0 mg/L) in some of the farthest points of the plant (Fig.6; Table 1). The results showed high percentages of free residual chlorine in drinking water in March despite the high temperatures, which directly affect the concentration of chlorine causing its volatilization and the reason is that most of the water purification plants add largest doses of chlorine to the water in March than in December because of increased pollution due to low water levels in March [19],[20]. These results agreed with [21], [22].

Table (1): Mean of monthly variation for physical-chemical properties through studied period 2016 – 2017

Time	Sites	Air Temper.C °	Water Temper.C °	PH	Turbidity NTU	Cl⁻residual mg/l
October 2016	Site1 R.W	32	28	7.6	66	-
	Site2	32	26	7.2	4	3
	Site3	32	26	7.3	4	1.7
	Site4	32	27	7.6	3	0.5
	Site5	31	26	7.5	5	1
	Site6	30	26	7.6	5	1
	Site7	30	26	7.5	17	1.5
	Site8	31	27	7.5	11	1
November 2016	Site1 R.W	27	22	7.7	58	-
	Site2	26	20	7.4	6	3.3
	Site3	26	20	7.3	2	1.5
	Site4	25	19.5	7.5	1	1
	Site5	25	20	7.4	7	1
	Site6	24	19	7.5	4	1
	Site7	25	19	7.5	7	0.5
	Site8	25	19	7.4	4	2
December 2016	Site1 R.W	21	15	7.9	89	-
	Site2	20	14	7.6	20	3
	Site3	19.5	13.5	7.5	2	1.5
	Site4	19	13.5	7.7	1	1
	Site5	20	14	7.6	17	1.2
	Site6	19	14	7.7	4	0
	Site7	19	13.5	7.7	4	0
	Site8	19	15	7.8	1	0.5
January 2017	Site1 R.W	17	14	7.7	68	-
	Site2	18	13	7.6	16	3.1
	Site3	17	11.5	7.5	5	2.2
	Site4	17	12	7.6	3	1
	Site5	18	13	7.5	4	1.5
	Site6	16	12	7.6	2	0.5
	Site7	17	12	7.5	12	1.5
	Site8	17.5	11.5	7.5	4	0.5
March 2017	Site1 R.W	32	27.5	7.2	39	-
	Site2	29.5	24	7.3	5	3.8
	Site3	29	25.5	7.2	3	2.3
	Site4	29	25	7.4	1	1.2
	Site5	28	23	7.4	3	1
	Site6	29	25	7.3	3	1
	Site7	30	26	7.3	2	1
	Site8	31	28	7.5	5	0
April 2017	Site1 R.W	34	29	7.9	30	-
	Site2	31	26	7.8	4	3.2
	Site3	32	26	7.8	1	2.3
	Site4	32	27	7.6	1	1.5
	Site5	33	26	7.7	2	1.2
	Site6	33	27	7.6	1	0.5
	Site7	33	25	7.6	4	1
	Site8	33	26	7.7	3	0

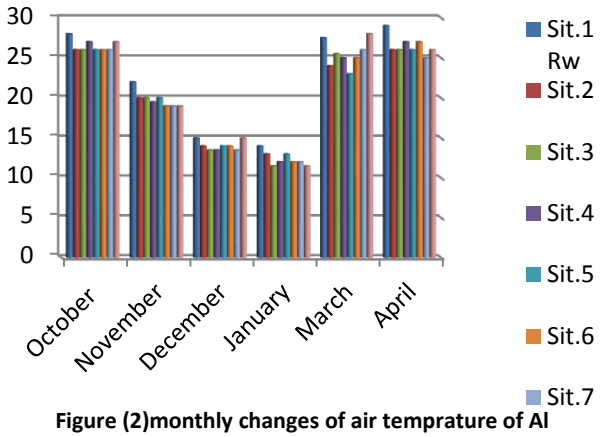

Figure (2)monthly changes of air temprature of Al -Hayy plant during study period

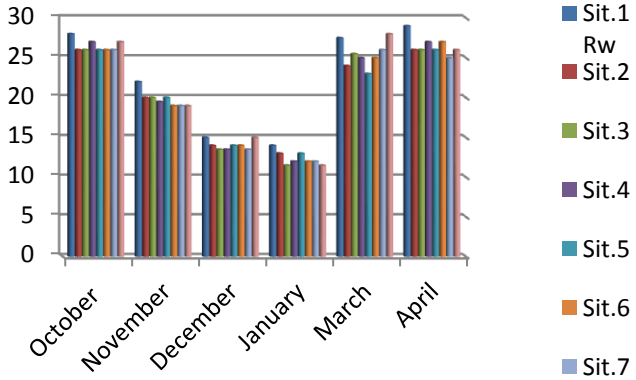

Figure (3) monthly changes of water temperature of Al-Hayy plant during study peroid

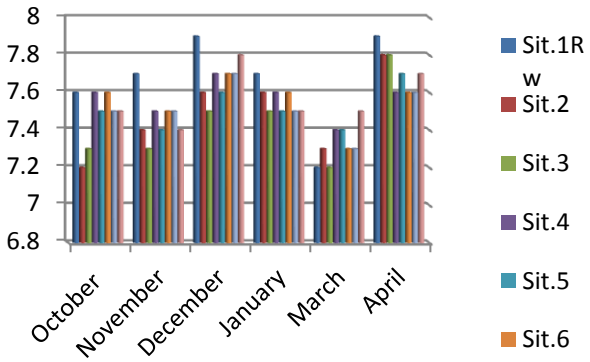

Figure (4): Monthly changes of Hydrogen concentrated of Al-Hayy plant during study period.

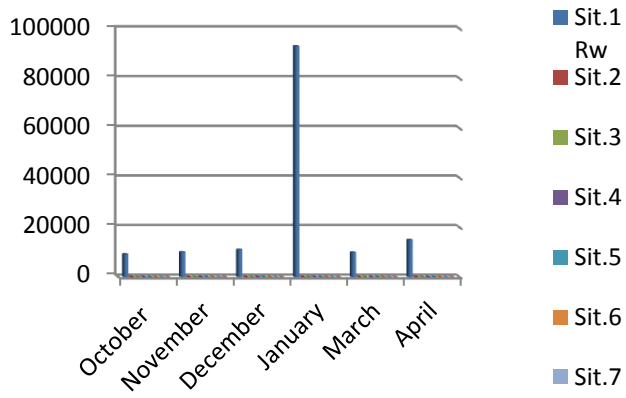

Figure (5): Monthly changes in Turbidity values in Al-Hayy plant during study period.

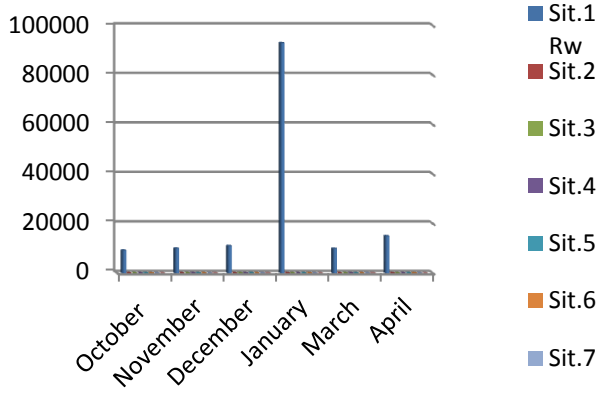

Figure (6): Monthly changes in Residual chlorine values in Al-Hayy plant during study period.

3.2. biological properties.

Table 2 and Figure 7,8,9,10&11, showed distribution and monthly variation for numbers of the Bacteria in Al- Hayy plant. The distribution and monthly variation of the Aerobic bacterial count in Al- Hayy plant are shown in the Figure (7) and Table (2). The highest number of Aerobic bacterial count was recorded in December 9500 Colony Forming Unit/1ml for raw water sample and 190 CFU/1ml for drinking water sample, while the lowest values recorded in April with 420 CFU/1ml for raw water sample and 0 CFU/1ml for drinking water sample. The rise in APC means whenever we moved far away from the distribution point at the plant may return to repeat fractures and defects afflicting distribution network pipeline, which increased the amount of exudes and leaked water from the environment surrounding the pipe leading to the contamination especially in the case of scarcity and use pumps to draw water directly from the network and then increase the likelihood of pollution as a result of the low pressure and enter the sewage or contaminated groundwater to it [23]. APC values recorded in the present work is coincided with findings of [21].

In this study, the results of TC for raw water showed that sample of Al-Hayy plant had the highest mean value (11.000CFU/100ml) in December the lowest mean (8320CFU/100ml) was detected in raw water samples in April (Table 2), (Figure 8).While drinking water sampled from different sites showed the highest mean TC (23 CFU/100ml) was recorded in water sample collected from site 5 during December and the lowest mean TC water content (0.0 CFU/100ml) was detected in water samples of several examined sites in all months (Table 2), (Figure 8). This results were agreed with the finding that recorded by [24]. The presence of coliform in these samples may be attributed to inadequate chlorination, insufficient contact time, and poor maintenance of service reservoirs [25], and may be because regrowing of bacteria in the distribution system [26]. Al- Hayy plant raw water exanimated samples showed the highest mean value of FC (17000 CFU/100ml) found in December and the lowest mean value (80 CFU/100ml) found in April (Table 2),(Figure 9).While for drinking water, the highest FC mean value was (26 CFU/100ml) in site 6 in December and the lowest mean value was

(0.0CFU/100ml) detected in several sites in all months (Table 2),(Figure 9).FC values recorded in the present work coincides with findings of [21]. The presence of Faecal coliform in treated water is an evidence of faecal contamination and an indicator that water became contaminated either within the disinfection system or within distribution system and this may refer to defects on the pipelines which could be old, fracture or may be misuse by consumers of water such as the use of water pumps that caused major damage in the distribution network pipes [27], [28].The distribution and monthly variation of the E.coli in Al-Hayy plant are shown in the Figure (10) and Table (2).The highest number of E.coli was recorded in December 5200 CFU/100ml for raw water sample and 23 CFU/100ml for drinking water sample, while the lowest values recorded in April with 2200 CFU/100ml for raw water sample and 0 CFU/1ml for drinking water sample (Table 2),(Figure 9). These high values of E.coli in raw water may be due to plant site near untreated domestic sewage or may be the same reasons

that affect the presence of faecal coliform [27]. The result of this study agrees with [17], who reported the results of his study that the rising of bacterial content in drinking water accompanied by low concentrations of chlorine, especially in the summer, due to the lack of a chlorine stability at high temperatures. The highest mean values of FS in Al- Hayy plant was recorded in December 1250CFU/100ml for raw water sample and 5.1 CFU/100ml for drinking water sample, were lower while the lowest values recorded in March with 96CFU/100ml for raw water sample and 0 CFU/100ml for drinking water sample (Fig.11; Table 2). They were lower than that reported by [29].The appearance of FS bacteria in drinking water of the houses, might be due to the decrease of chlorine effects as a result of the low concentration of chlorine availability in that point of the network due to the long distances that water pass through the pipes, especially at the ends of distribution network, also the cracks in the distribution pipes that lead to contamination as a result of the entry of contaminated water from the sewage or groundwater [30][27], and also might be due to the availability of nutrients, suitable temperature, and other factors [28].

Table (2): Mean of monthly variation for biological properties through through studied period 2016 – 2017

Time	Sites	A.B.C CFU/1ml	T.C CFU/100ml	F.C CFU/100ml	E.Coli CFU/100ml	F.S CFU/100ml
October 2016	Site1 R.W	1480	9200	9200	9200	261
	Site2	Zero	Zero	Zero	Zero	Zero
	Site3	10	Zero	Zero	Zero	Zero
	Site4	Zero	Zero	Zero	Zero	Zero
	Site5	20	1.1	1.1	Zero	Zero
	Site6	Zero	Zero	1.1	1.1	Zero
	Site7	120	1.1	Zero	1.1	Zero
	Site8	111	Zero	Zero	1.1	Zero
November 2016	Site1 R.W	1790	10000	5400	5200	320
	Site2	Zero	Zero	Zero	Zero	Zero
	Site3	12	Zero	Zero	Zero	Zero
	Site4	Zero	1.1	Zero	Zero	Zero
	Site5	Zero	Zero	Zero	Zero	Zero
	Site6	Zero	Zero	Zero	Zero	Zero
	Site7	50	Zero	1.1	Zero	Zero
	Site8	60	1.1	Zero	Zero	Zero
December 2016	Site1	9500	11000	8200	5200	1250
	Site2	81	5.1	Zero	Zero	Zero
	Site3	59	5.1	3.6	1.1	Zero
	Site4	27	9.2	5.1	Zero	3.6
	Site5	161	23	23	23	5.1
	Site6	119	2.2	3.6	2.2	1.1
	Site7	190	1.1	2.2	2.2	1.1
	Site8	20	1.1	Zero	Zero	Zero
January 2017	Site1 R.W	3600	93000	42000	24000	544
	Site2	39	3.6	Zero	Zero	Zero
	Site3	26	3.6	Zero	Zero	Zero
	Site4	12	Zero	Zero	Zero	Zero
	Site5	57	2.2	2.2	Zero	Zero
	Site6	75	2.2	2.2	2.2	Zero
	Site7	82	1.1	2.2	2.2	Zero
	Site8	12	1.1	Zero	Zero	Zero
March 2017	Site1 R.W	500	9900	5400	4400	96
	Site2	30	Zero	Zero	Zero	Zero
	Site3	29	Zero	Zero	Zero	Zero
	Site4	45	Zero	Zero	Zero	Zero
	Site5	Zero	Zero	Zero	Zero	Zero
	Site6	Zero	Zero	Zero	Zero	Zero
	Site7	70	5.1	Zero	Zero	Zero
	Site8	50	Zero	Zero	Zero	Zero
April 2017	Site1 R.W	420	15000	7000	-	114
	Site2	40	9.2	6.9	6.9	Zero
	Site3	71	12	9.2	9.2	Zero
	Site4	50	Zero	Zero	Zero	Zero
	Site5	Zero	Zero	Zero	Zero	Zero
	Site6	Zero	Zero	Zero	Zero	Zero
	Site7	90	6.9	Zero	Zero	Zero
	Site8	70	9.2	9.2	2.2	Zero

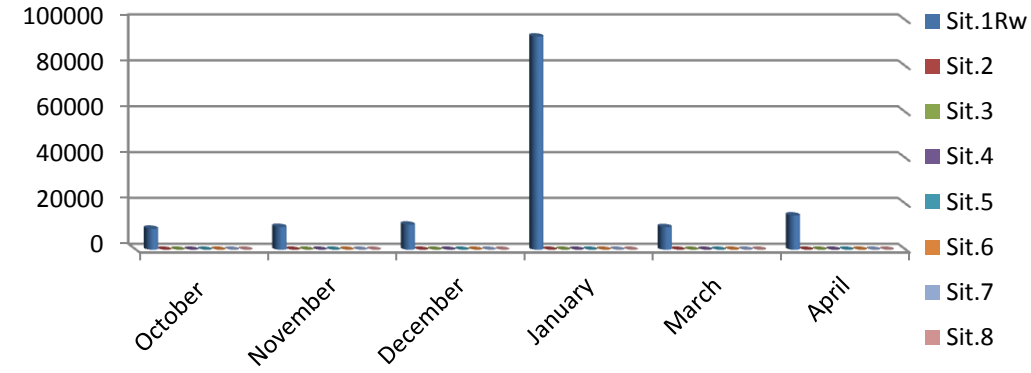

Figure (7): Monthly changes of Aerobic bacterial count in Al-Hayy plant during study period.

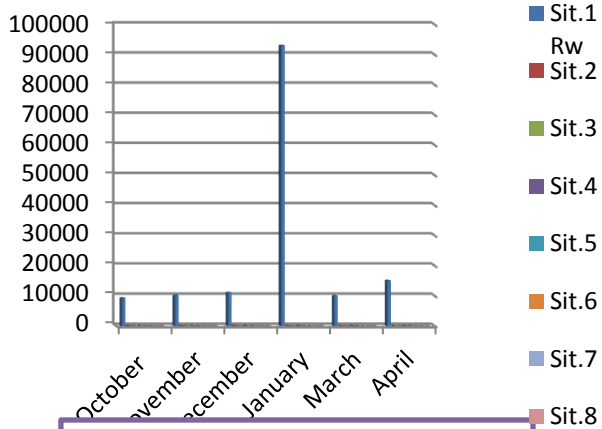

Figure (8): Monthly changes of Total coliform number in Al-Hayy plant during study period.

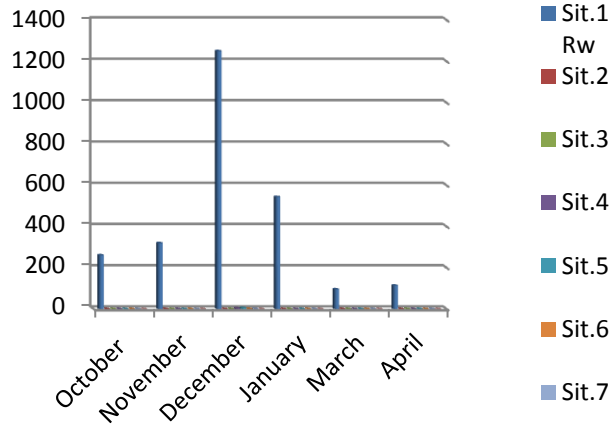

Figure (9): Monthly changes of Faecal coliform number in Al-Hayy plant during study period.

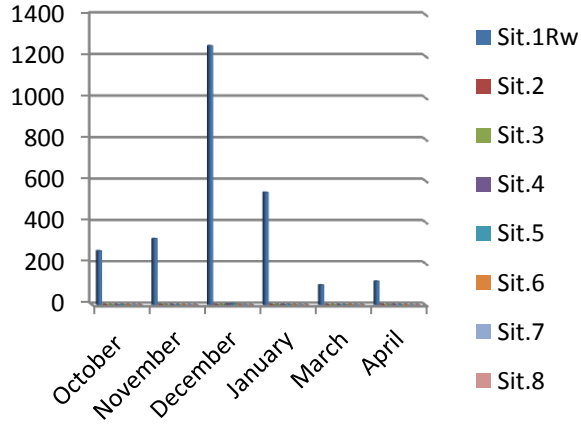

Figure (9): Monthly changes of E.Coli number in Al-Hayy plant during study period.

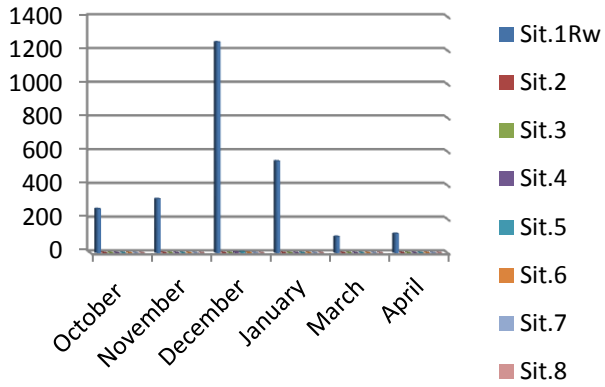

Figure (11): Monthly changes of of Faecal streptococcus number in Al-Hayy plant during study period.

Table (3): Comparison between some water quality parameters of Al- Bashaar water treatment plant with the Iraqi and international standards(31,32).

Parameter	WHO standards for drinking water in 2004	Iraqi standard for drinking water (2270/14at 2001)	Present Study Minimum & Maximum
pH	6.5- 8.5	6.5 - 8.5	7.2- 7.9
Turbidity NTU	0-50	0 - 5	1– 17
Residual Chlorine mg/L	-	0.3 – 2-5	0 – 3.8
Aerobicbacteria count CFU/100ml	100 cell / ml	10 cell / ml	0 - 190
Total Coliform CFU/1ml	Absent	Absent	0 – 23
Fecal Coliform CFU/1ml	Absent	Absent	0– 23
Fecal Streptococci CFU/1ml	Absent	Absent	0 – 5,1
***E. coli* CFU/1ml**	Absent	Absent	0 – 23

4.Conclusion.

Drinking water should be free from pathogenic bacteria and safe for human consumption. From the results of this study, it can be concluded that the drinking water in Al-Hayy supply network is generally undesirable for drinking according to the Iraqi standards (2270/14at 2001), and WHO standards for the drinking water.This due to most of the physical,chemical and biological parameters examined exceeded the maximum level of thresholds, and the total coliforms counts were recorded more than value 10/100ml MPN. However, the present of faecal coliform and other bacterial genera in some samples were reflecting the contamination caused by humans or animals, and recontamination of water with bacteria was occurring due to the sediments of organic and inorganic matter inner the old pipes (Asbestos) which, encourage the growth of the organism.

5. References

1. **Gadgil, A. (1998).** Drinking water in developing countries. Annu. Rev. Energy Environ., Vol.23, p:253–86.
2. **Al–Khatib, I, A. Kamal. S, Taha, B. Al-Hamad. J and Jaber. H. (2003)** water-health the relationship in developing countries: a case study in Tulkarem district in
3. Palestine, Internal Journal of environmental Health Research 13, 199-206**.**
4. **Ashbolt, N. J.(2004**) Microbial contamination of drinking water and disease outcomes in developing regions. Toxicology, No.198, p:229-238.
5. **OmbakaO, Gichumbi, J.M1 and Kibara, D. (2013).** Evaluation of Ground Water and Tap Water Quality in the Villages Surrounding Chuka Town, Kenya. Vol. 3, No. 2,p: 1551-1563.
6. **Miranzadeh, I.B.; Heidari, M.; Mesdaghinia, A.R. and Younesian, M. (2011).** "Survey of microbial quality of drinking water in rural areas of kashan, Iran in second half of 2008". Pakistan Journal of Biological Sciences.Vol.14,No.1,p:59–63.

7. **EPA (Environmental Protection Agency).(2013).** Domestic waste water treatment systems,Ireland.
8. **Malekmohammadi, B. Nazaiha M. and Hesari, N. (2013).** Emergency Response Planning for Providing Drinking Water in Urban Areas after Natural Disasters using Multi Criteria Decision Making Meth.
9. **APHA (American Public Health Association). (1998).** Standard Methods for the Examination of Water and Waste water, 20th Ed. Washington, D.C.
10. **APHA, AWWA and WFF. (2005a).** Standard Methods for the Examination of Water and wastewater, 21th ed., edited by Eaton, A. D. ; L. S. Clesceri; E. W. Rice, and A. E. Greenberg. American Water Work Association and Water Environment Federation, USA.
11. **Al-Helaly, S. H. E. (2010).** An investigation of some heavy metals in water, sediment and some biota of Al-Gharraf River, south of Iraq. M.Sc. Thesis. College of science, University of Baghdad.
12. **Al-Mayah,W. Th. J.(2013)** Effect of domestic sewage on water quality of Al-Gharraf River in Al-Haay city.M.Sc. Thesis. College of science, University of Baghdad.
13. **Maulood, B. K. ; Hinton, G. C. F. and Al-Dosky H S. (1980).** A study on the blue green algal flora of Arbil province, Iraq. Zanco Sci. J. Univ. Sulaimaniyah, Iraq,Vol. 6,No.:6,p:7-90.
14. **Al-Lami, A. A.; Jaweir, H. J. and Nashaat, M. R. (1998).** Benthic invertebrates of the river Euphrates upstream and downstream sectors of Al-Qadisia Dam, Iraq. Reg. Riv.Vol.14, No.4,p:383-390 .
15. **Al-Obaidi, G. S. A. (2006).** A Study of phytoplankton community in Abu Zirig marsh, Southern Iraq. MSc Thesis, University of Baghdad, Iraq.
16. **Al-Shalchi, T. K.(2006).** Evaluation of environmental impact of Tigris river pollution (between Jadirriya and Dora bridges). MSc. Thesis. College of Engineering, University of Baghdad, Iraq.
17. **Al-Jebouri, M. M. and D. R. Trollope. (1984).** Indicator Bacteria in Marine and freshwater marine Molluscs. J. Hydrobiologia,Vol. 111,No.2,p:93 - 102.
18. **Al-Zubaidi, A. N. H.(2011).** A study of Al-Kut and Al-Karama water treatment plants efficiency to

purify the drinking water in Al-Kut city. MSc. Thesis. College of Science, University of Baghdad, Iraq. p :95.

19. **Abed Al-Razzaq, H. T.(2011)** Effect of Domestic Wastewater from Pumping Station of Al-Kadimiya on Ecological Properties of Tigris River. MSc. Thesis Collage of science, Baghdad university.p :87.
20. **Xin, L. I.; G. U. Da-ming; Q. I. Jing-yao; M. Ukita and Z. H. A. O. Hong-bin.(2003)** Modeling of residual chlorine in water distribution system. Journal of Environmental Science, Vol.15,No.1,p:136 - 144.
21. **Al-Sudany, A. A. J. (2012).** Determination of Residual Chlorine after Treatment Drinking Water in Different Sites of Baghdad. MSc. Thesis. College of Science, Al-Mustansyriah University, Iraq. p: 76. (In Arabic).
22. **Barakat, N. T.(2007).** Measuring contaminants of drinking water in some areas of Baghdad. MSc. Thesis. College of Science, University of Baghdad, Iraq .p : 164. (In Arabic).
23. **AL-Hashimi, H. H. H. (2012).** Quality Study for drinking Water in Some Regions of Baqubah City. MSc. Thesis. College of Science, University of Baghdad, Iraq p: 128. (In Arabic).
24. **Al-Jubori, K. J. M. (2007).** Water pollutants and drinking water specifications and plans provided to the city of Baghdad, specialized seminar about healthy drinking water and proper for the Iraqi people. Ministry of Higher Education and Scientific Research, Baghdad University, Center for Market Research and Consumer Protection.
25. **Al-Sammarai, B.A.M.(2009**). Ecological and microbiological study on suplement water in Salah Addin province.M.Sc. Thesis. College of science, University of Baghdad.
26. **Khadse, G. K., M. Kalita, S. N. Pimpalkar, and P. K. Labhsetwar (2010)** Drinking water quality monitoring and surveillance for safe water supply in Gangtok, India. Environ Monit Assess.
27. **(APHA), American Public Health Association, American Water Works Association, Water Pollution Control Federation (2005b)** Standard Methods for the Examination of Water and Wastewater. 21th ed. American

Public Health Association, Washington .p :78.

28. **Sulieman, A. E.; A. M. El-Amin and E. A. El-Khalifa. (2009).** Chemical and microbiological assessment of drinking water quality in central Sudan. Thirteenth International Water Technology Conference (IWTC). Hurghada, Egypt. p : 1109 - 1110.
29. **Al-Aney, I. A. M. (2012).** Evaluation of potable water of both East Tigris and Al-Karama purification plant in Baghdad. MSc. Thesis. College of Science, University of Baghdad, Iraq p: 124.
30. **Al-Azzawi, A. S. N.(2004).** Study some physical, chemical and bacteriological tests of Jurf Al-Sakhar water station in Babylon governorate. PhD. thesis. College of Science, University of Babylon. p :59.
31. **Chan, C. L.; M. L. Zalifah; and A. S. Norrakiah.(2007).** Microbiological and physiochemical quality of drinking water. The Malaysian Journal of Analytical Science, Vol.11,No.2,p:414 - 240.
32. **WHO (World Health Organization). (2004)** Guidelines for drinking-water quality. 3rd ed. first addendum, vol. 1. World Health Organization, Geneva. pp : 515.
33. **Iraqi standard criteria for drinking water (2270/14at 2001**) for chemical and physical limits.