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Water Microbial Contamination in Tikrit City

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Abstract. *In the world consequently, pollution of water has become a great concern, and with emphasis on the quality of water especially on those which originate from natural sources, with regard to water borne diseases and their causing pathogens. Some of the more familiar water borne pathogens include: aquatic or enteric bacteria such as Salmonella typhi, Shigella, Coliform bacteria; viruses; and Protozoa. Also relevant to diarrhea are rotavirus, astrovirus, adenovirus, norovirus, picobirnavirus, and enterovirus. This research work was done on a cross-sectional study basis over a period of four months, from April to October of the year 2022 at various water supply stations in Tikrit City, Salah Al-Deen province. Grab samples were taken from both the wells and the Tigris River to carry out microbiological processing and quality check in the laboratory. The samples used in this study included river and well water sources taken at the water treatment centers. Samples were collected at three points in the Tigris River and at three points from wells, although the points varied across the different sites. The findings were mainly secular for E. coli followed by P. aeruginosa and parasite such as Giardia cysts, and amoebic cysts.*

Keywords*: water-borne, contamination, water, pollution.*

1. INTRODUCTION

Infection of non-portable water bodies by waterborne pathogens and consequently diseases associated with them are emerging major global concerns of water quality. This problem is distributed all types of water objects and therefore emphasis to indicate this fact and understand pathogen contamination (U. S. EPA 2012). An area given special attention by the United Nations as one of the MDG is the quality of water; there is a call to, by the year 2015, reduce by half total number of people without access to safe water (WHO, 2011). Since there is undoubtedly compelling evidence of climate change (IPCC, 2007), one must analyse how changes in weather may influence the content of pathogens in water sources. The storage of water is also going to be vital for the future population requirements concerning food, energy, and ecosystems and therefore there is going to be a need for long-term planning for development of dams among other water storage infrastructure (World Bank, 2010). Still, they can bring new constructions that may worsen possibilities to control public health threats and water quality.

Some of the most common organisms that may be found in water are the aquatic and enteric bacteria, virus and protozoa. Some of the enteric viruses that have been indicated to cause diarrhea are: rotavirus, astrovirus, adenovirus, norovirus, picobirnavirus and enterovirus (Liste et al. , 2000). Studies conducted by Boughattas et al in 2017 show that water which is directly exposed to effluence from human and animals is a key route of transmission of

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Cryptosporidium spp. Among protozoa the major ones include Giardia lamblia, Blastocystis hominis, Dientamoeba fragilis, Giardia duodenalis, Entamoeba histolytica. Two early discovered waterborne disease causing pathogens in the 19th century are the Vibrio cholera and Salmonella enterica serovar Typhi which have affected human population across the world. Furthermore, domesticated as well as wild animals accused of holding Salmonella spp. and Campylobacter in their digestive tracts that make them a risk to human health contaminate water sources (CDCP, 1996). In the United States, in a drinking water outbreak, the bacteria which included; Shigella Sp. This is well illustrated by following bacterial pathogens: Voboria, Campylobacter, and Pseudomonas that continue to point to the existing dangers (Cotruvo et al. , 2004). Some of the particular serotypes of Escherichia coli also cause diseases in human and animals also (Honda, 1992).

The World Health Organization (WHO) reports that illnesses associated to water claim the lives of 3.4 million people annually, the most of them are children (WHO 2014). A 2014 evaluation by the United Nations Children's Fund (UNICEF) estimated that 4000 children perish from drinking contaminated water every day. According to WHO (2010), there are over 2.6 billion people who do not have access to clean water, and this causes over 2.2 million deaths each year, of which 1.4 million are in children. Global illness burden can be lowered by about 4% with improved water quality (WHO 2010). The purpose of this study is to identify the kinds of bacteria present in Tikrit City's drinking water as well as the degree of contamination.

2. MATERIALS AND METHODS

Location and Duration of Study

The research was conducted over a period of four months, from April 2022 to October 2022, across various water supply sites in Tikrit City, located in Salah Al-Deen province, as illustrated in Figure 1. Samples of well water and Tigris River water were collected and subsequently analyzed in the laboratory for microbial processing and quality control.

Figure 1: Tikrit City map showing Tigris river

Tested variables, sample, and population

The rivers and wells in Tikrit City served as the study's population. River water and well water collected from the water treatment facilities served as the study's samples. Three samples from each site were collected from the Tigris River and three samples from the well, each from a distinct sampling point: the river's surface (S1), middle (S2), and riverbank (S3), and the well's surface (S1), middle (S2), and bottom (S3) portions. As a result, there are a total of 18 samples total, including details on 9 river water samples and 9 well water samples.

Equipment, supplies, and methodology of the study The equipment used in the study includes a petri dish, measuring pipette, test tube, Durham tube, inoculation loop, bunsen/methylated spirit burner, gloves, antiseptic, matches, crucible tongs, cool box, GPS (Global Position System), DSLR camera, calculator, meter, and methylated cotton sample bottles with cotton caps. The following materials were utilized in this study: label stickers, tissue, rubber bands, EC Broth (Escherichia coli Broth), BGLB (Brilliant Green Lactose Broth) medium, LB (Lactose Broth) medium, and EMBA (Eosin Methylene Blue Agar) medium.

An interview with the village/subdistrict head is part of the direct observation process, which gathers information on infrastructure, sources of pollution, and socioeconomic aspects. In addition, measurements and observations were made of the elements that affect water pollution, including the use of the well, the cleanliness of the area surrounding it, the existence or nonexistence of a septic tank, the distance from the septic to the well, and a sample of both river and well water.

Statistical data analysis

To test the problem statement, namely analyzing the factors that influence water pollution from the microbiological aspect of water sources n Tikrit City, regression and correlation tests were used.

3. RESULTS AND DISCUSSION

Results

The Lactose Broth (LB) medium, which is used to isolate the groups of coliform bacteria, was utilized in this study's prediction test. If gas builds up in the Durham tube and the solution becomes hazy, the test would be considered successful. In the meantime, if no gas forms in the Durham tube and no cloudiness appears, the test is considered negative. The test displays the type of gas that suggests fecal coliform is present. Brilliant Green Lactose Broth (BGLB) medium for Coliform bacteria and E.C. Broth medium for E. coli bacteria were the selective media employed in the confirmation test. A valid confirmation test is defined as the generation of gas in a vivid green lactose bile broth fermentation tube at any point throughout the 48-hour period at 35 °C. The results in table 1, showed the number of isolates found in the each sample from the river and well. E. coli was mostly isolated followed by P. aeruginosa, as well as some parasites such as Giradial cyst and amebial cyst.

Table 1: Microbial load of water sample

Microbial isolates	River			Well		
(CFU/mL)	S1	S2	S3	S1	S2	S3
E. coli	1.1×10^2	2.2×10^2	4.7×10^5	0.6×10^2	1.8×10^2	1×10^2
P. aeruginosa	2.4×10^2	1.6×10^2	5.2×10^5	1.9×10^2	-	4.6×10^5
Parasites	+	+	+	+	+	+
Fungi	-	-	+	-	-	+

Temperature is one of the most important indicators of water quality as it affects various organic, inorganic, and chemical components of the water, as well as its taste. In addition, it influences geochemical and chemical reactions. Temperature affects water's ability to retain oxygen and the resistance of living organisms against certain pollutants (WHO, 2006).

Table (2) illustrates the monthly and locational variations in the water temperature of the studied wells over a specific period. It can be observed that the water temperature of the wells changes across different months, with values varying between different wells as well as within each well over the studied period.

There are statistically significant variations in water temperature between some months, as indicated by the letters that go with the monthly averages table. At a significance level of $P \leq 0.05$, distinct letters indicate statistically significant differences between the compared months; identical letters indicate no statistically significant differences between the months.

Table 2: Monthly and spatial variations in water temperature (°C) for the wells under study.

Month Well	September 2022	October 2022	November 2022	Average
W1	26.9	25.4	23.1	25.1a
W2	25.7	25.2	24.0	25.0a
W3	26.0	24.5	23.9	24.8a
Average	26.2a	25.0ab	23.7c	

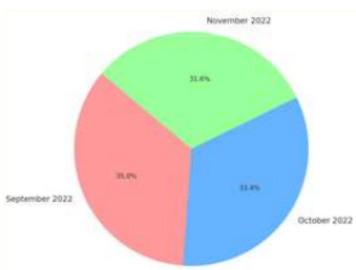

Figure 2 Average Monthly Water Temperatures for the Studied Wells

Table (3) shows the monthly and locational variations in the ambient air temperature around the study wells over a specific period, according to the provided data .Significant changes in the ambient air temperature around the wells can be observed across different months, with values varying between different wells as well as within each well over the studied period. The highest air temperature was recorded in September 2022 (42.2°C), while the lowest was recorded in November 2024 (16.3°C). The data also shows variation in air temperatures between different months and wells, highlighting the impact of locational and temporal factors on air temperature.

Table 3: Monthly and spatial variations in ambient air temperature (°C) around the study wells.

MonthWell	September 2022	October 2022	November 2022	Average
W1	42.2	34	16.3	30.8a
W2	36.3	34.5	15.2	28.7c
W3	38.1	34.5	14.5	29.0b
Average	38.9a	34.3b	15.3c	

According to WHO (1984), turbidity is a term used to describe certain light scattering and absorption properties of a water sample that are brought on by the presence of colloidal particles, suspended debris, clay, silt, plankton, and other microorganisms. The quantity of suspended materials in the water determines its turbidity. The test is used to determine the quality of waste discharge with regard to colloidal matter. It measures the light-emitting capabilities of water. Consumers typically find water with turbidity below 5 NTU acceptable, as this is the natural threshold for turbidity. Table (4) shows the monthly and spatial variations in turbidity levels (NTU) in groundwater over the study period. The table reveals significant variation in groundwater turbidity levels across different months and between different wells. It is noted that some wells exhibited very high turbidity levels during certain months compared to their levels in other months. These values are attributed to colloidal materials, silt, clay, humic substances, organic debris, and various plants and animals present in the water. The table also shows differences in turbidity levels between different months. For example, October and November 2022 appear to have relatively high turbidity levels in most wells.

Table 4: Monthly and spatial variations in groundwater turbidity levels during the study period (Turbidity Unit NTU).

Month Well	September 2022	October 2022	November 2022	Average
W1	0.5	0.857	0.721	0.7b
W2	0.177	0.576	0.86	0.5c
W3	2.51	0.761	0.841	1.4a
Average	1.1a	0.7b	0.8b	

There are statistically significant variations in turbidity levels between some months, as indicated by the letters that go with the monthly averages table. At a significance level of $P \leq 0.05$, distinct letters indicate statistically significant differences between the compared months; identical letters reveal no statistically significant differences between the months. The ability of one cubic centimeter of water to transmit electrical current at 25°C is known as electrical conductivity (EC). Temperature and the amount of dissolved salts in the water determine conductivity (Hem, 1985).

The research period's monthly and regional variations in groundwater electrical conductivity (EC) values, measured in microsiemens per centimeter (μS/cm), are presented in Table (5). The table shows that during the designated months, there was variation in the electrical conductivity of groundwater in each well and between wells. Additionally, the data demonstrates that certain wells record lower electrical conductivity values in some months while exhibiting high levels in others. November 2022 saw the greatest electrical conductivity value of 5210 μS/cm, while September 2022 saw the lowest value of 3650 μS/cm. The increase in these values is slight, and the reason for the rise in conductivity is attributed to a slight increase in the amount of salts as well as the saline content of the soils surrounding the river (SDWF, 2008).

There are statistically significant variations in electrical conductivity values between some months, as indicated by the letters that go with the monthly averages table. At a significance level of $P \leq 0.05$, distinct letters indicate statistically significant differences between the compared months; identical letters reveal no statistically significant differences between the months.

Table 5 Monthly and spatial variations in groundwater electrical conductivity during the study period (μS/cm).

Month Well	September 2022	October 2022	November 2022	Average
W1	4910	4830	4920	4,886.7
W2	5000	5210	5180	5,130.0
W3	3650	3470	3620	3,580.0
Average	4,520.0	4,503.3	4,573.3	

Table (6) displays the values that varied over the research months and throughout well locations, ranging from 0.1 to 0.22 mg/L. There are statistically significant changes in salinity levels between some months, as indicated by the letters that go with the monthly averages. At a significance level of $P \leq 0.05$, distinct letters indicate statistically significant differences between the compared months; identical letters indicate no statistically significant differences between the months.

Table 6 Monthly and spatial variations in groundwater salinity during the study period (mg/L)

Month Well	September 2022	October 2022	November 2022	Average
W1	0.20	0.20	0.20	0.20a
W2	0.16	0.13	0.13	0.14a
W3	0.15	0.14	0.15	0.15a
Average	0.17a	0.16a	0.16a	

The concentration of calcium and magnesium that can precipitate when heated and adversely impact the dissolving of soap in water is referred to as total hardness (Faure, 1998). For foam to form in hard water, a lot of soap is needed. Groundwater can reach several thousand degrees below the surface, making it often harder than surface water. Wastewater, surface runoff from soils, especially those with limestone formations, construction materials containing calcium oxide, textiles, and paper goods containing magnesium are some of the sources of hardness.

Total hardness levels varied over the course of the research months, as shown in table (7), with September 2022 recording the highest value at 2265 mg/L and October and November 2022 recording the lowest values at 805 mg/L. At a significance level of $P \leq 0.05$, the letters that go with the monthly averages show statistically significant variations in total groundwater hardness levels across a few months, suggesting fluctuation in water hardness between these months.

Table 7: Monthly and spatial variations in groundwater total hardness expressed as calcium carbonate (CaCO3) during the study period (mg/L).

Month Well	September 2022	October 2022	November 2022	Average
W1	1729.0	1035.0	1380.0	1381.3b
W2	2265.0	1725.0	920.0	1636.7a
W3	1880.0	920.0	1150.0	1316.7b
Average	1958.0a	1226.7b	1150.0c	

Measured in milligrams per liter (mg/L), Table (8) shows the monthly and regional fluctuations in groundwater's calcium hardness during the study period. The range of calcium hardness was 602–1290 mg/L. With a significance level of $P \leq 0.05$, the letters that go with the monthly averages show statistically significant variations in calcium hardness levels between a few months, reflecting variability in calcium hardness between these months.

Table 8: Monthly and spatial variations in calcium hardness in groundwater during the study period (mg/L).

Month Well	September 2022	October 2022	November 2022	Average
W1	374	602	366	447.3a
W2	242	344	258	281.3b
W3	286	344	258	296.0b
Average	300.7b	430.0a	294.0b	

Magnesium is an alkaline earth metal with a single oxidation state in water (Mg^{2+}), and it is an important element for both plant and animal life. Along with calcium, it contributes to water hardness. The geochemical behavior of magnesium shows that it is smaller in size compared to calcium and sodium, and magnesium ions also enter groundwater through leaching from minerals such as calcite, gypsum, and dolomite (Al-Amar, 2015). Table (9) illustrates the monthly and spatial variations in magnesium hardness of groundwater during the study period, measured in milligrams per liter. The average magnesium hardness of groundwater ranged between 67.67 and 897.6 milligrams per liter.

Table 9 Monthly and spatial variations in groundwater magnesium hardness during the study period (mg/L).

Month Well	September 2022	October 2022	November 2022	Average
W1	261	607	153	340.3c
W2	311	635	638	528.0a
W3	238	411	498	382.3b
Average	270.0c	551.0a	429.7b	

The results in Table (10) show significant variations in the total bacterial counts in groundwater across different months and wells during the study period. In the initial months of the study (up to January 2024), total bacterial counts were very low or not detectable in most wells, with some values being zero. This may indicate an unsuitable environment for bacterial growth in these wells or other factors reducing bacterial presence in the groundwater. However, counts in some wells reached 560 CFU/ML, exceeding permissible limits in certain wells, such as W1 and W2 .

In November 2022, total bacterial counts ranged from 285 CFU/ML to 104 CFU/ML, suggesting that these wells may be more conducive to bacterial growth compared to others. This reflects a significant variation in total bacterial counts in groundwater during the study period.

Table 10 Monthly and spatial variations in total bacterial count (Total Plate Count - T.P.C) in groundwater during the study period (CFU/ML)

Month Well	September 2022	October 2022	November 2022	Average
W1	560	450	285	431.7a
W2	452	350	290	364.0b
W3	350	250	104	234.7c
Average	454.0a	350.0b	226.3c	

Numerous aerobic bacteria, including Pantoea agglomerans, Kocuria kristinae, Streptococcus sensustricto, Raoultella planticola, Rhizobium radiobacter, Aeromonas hydrophila, Acinetobacter haemolyticus, Staphylococcus epidermidis, and Staphylococcus vitulinus, were discovered to be present in all of the examined water samples. The fact that all of these were higher than the allowable limits for drinking water—which are less than 50 CFU/ML means that the water is polluted with bacteria.

Discussion

Open defecation, livestock feces, contaminated water seeping from neighboring latrines, poor source management, inadequate protection, and unsanitary conditions seem to be the most common causes of faecal contamination in drinking water sources. These findings are consistent with research from Ethiopia (Amenu et al., 2014), northern Pakistan (Baig et al., 2012), Zimbabwe (Navab-Daneshmand et al., 2018), and the Ethiopian Shashemane Rural

District (Amenu et al., 2014), all of which found that contaminated water sources and a lack of water source protection contributed to high counts of E. coli in drinking water sources. Navab-Daneshmand et al. 'Study on the prevalence and factors associated with faecal contamination of water sources in Zimbabwe' attributed the presence of E. coli in water point sources to livestock dropping off their dung in drinking water sources across Zimbabwe while in the Shashemane District of Ethiopia, the main source of faecal contamination was open defecation as earlier noted by Negera et al. , in their research work. Gizaw et al. (2018) also came up with similar observation whereby a high percentage of the households in rural Dembiya northwest Ethiopia used water which is unsafe for human consumption; they also noted high vulnerability of the households to intestinal parasite infections that were as a result of helminth and protozoa. The results of the cross-sectional study on E. coli found in water samples indicates that this may be arising from poor sanitation and hygiene of the region.

Based on the study, there is a likely hood of contamination of source water which is dangerous to the health of the people in the studied area. In their study, Ibrahim and Patrick (Ibrahim et al. , 2018) pointed out that increased public concern towards practices that protect land use might assist in curtailing drinking water pollution. Ibrahim et al. (2018) noted that source water protection is recognized as the first line of defence in the multiple barriers' concept to reduce the chances of contaminated drinking water. Thus, considering the results of the study, governments' essential role in source water protection planning, management, and regulating through laws and strategies in rural areas has to be questioned. The government needs to support communities in enhancing their capability to protect their water sources since currently there is a dearth of human resource for source water protection at this level. The following risks are identified where the quality of water supplies is poor, because they contain bacteria and viruses, and protozoa. Based on the research done by Jin and Flury, 2002, groundwater intensifies its susceptibility to germs that shifts from surface water. These scientists opined that ground water has been associated with 70% of microbial water borne illness in the US. Viruses are still smaller than bacteria and protozoa, and many of them have the capability of penetrating raw water through fractured zones of the water bearing aquifers. Since Jin and Flury, 2002 presented a literature review over virus sorption and its modeling, they gave the analysis of virus fate and transport in porous media. They eventually was able to argue that factors such as the solution chemistry, properties of the virus, properties of the soil, temperature, and its interaction with the particle surface helped to define the survival, transport and adsorption of the virus in porous media.

It is also important to mention that the water temperature was rather high in the wells in September 2022 - 27°C, and rather low in November 2022 – 23. Maximum value of the wells in the Al-Alam subdistrict of Salah Al-Din was 23 as reported by Dalaas & Abduljabar (2018). In November the temperature was recorded at 0°C and the minimum water temperature was was 19°C. 0°C (Dalaas & Abduljabar, 2018) Of all the regions in the world and all four seasons; summer, autumn winter and spring, it is now much colder at '0 Celsius.

It is possible to note that there are statistical differences between some months as far as air temperature is concerned, which are marked by the letters next to the table with monthly averages. For a level of confidence of 95%, or at 5% level of significance (P≤0. Although differences between the compared months are not very big, the following letters will help to understand statistical significance of the differences more convenient: 05, distinct letters mean that between the compared months there are statistically significant differences; identical letters mean that for the compared months there are no statistically significant differences. There is a parity made between the findings of the present study and Dalaas and Abduljabar (2018), where they actually indicated that the maximum air temperature was 32°C in October while the minimum remained 9°C in December (Dalaas & Abduljabar, 2018). However, it is worth pointing out that the air temperature and the water temperature around the wells are notably different – an indicator of the effect of the external conditions on each.

The result is comparable with the study carried out by Dalaas and Abduljabar (2018) and showed higher turbidity value in October of 3. 95 NTU and the lowest of 0. 00 NTU in November according to Dalaas and Abduljabar (2018). The findings of this work were relatively lesser comparing with that of Mahdi (2008) study in which the turiedities varied from 1 to 70 NTU. This reduction is attributable to the fact that groundwater is considerably slower-moving as compared to surface water. Also, the findings were less than those found by Jleeb & Ali (2022,) whose score ranged between 2. 18 to 101 NTU. This therefore means that the quality of the water observed in the present study significantly fluctuated over time and that location and time factor influenced the degree of turbidity in such waters.

The findings of the present paper are consistent with the study of Dalaas and Abduljabar conducted in 2018 reporting fluctuation in conductivity values in different wells varying from 2210 μS/cm in October and up to 6350 μS/cm in December. Our current results are also in the same order as what was reported by Al-Obaedy our previous research that varied from 1920 to 7675 μS/cm at the northern part of Salah Al-Din Province (Al-Obaedy, 2010). Also these results are in parallel with the studies done by Al-Jubouri (2006) and Al-Safawi (2008), though they are higher than the degree reported by Kamel et al. , (2014).

These values were lower when compared with the findings of Dalaas and Abduljabar (2018) who found that total hardness in some of the wells ranging from 1480 mg/L in January to 4600 mg/L in March in the Al-Alam subdistrict. In general, there are only minor first-order variations in well water first order chemical and physical characteristics between the areas: It is therefore evident that all the well water samples are similar. This could be due to a shared water source of repletion among the two aquifers and possible reefs that line the two water sources. Natural water characteristics depend on the type of rocks and soils that come in contact with water; the length of time during which this contact is made and how close the particular wells are located from one another (Hem, 1970)

Calcium is one of the most significant of the positive ions or cations in relation to the generic quality of groundwater. The sources of calcium ions in the groundwater are as follows: Non-silicates such as gypsum and dolomite and silicates such as albite and pyroxene. The solubility in igneous and metamorphic rocks is much less as compared with sedimentary rocks, hence the calcium content is very low in water derived from these rocks. Sedimentary calcium occurs in the form of carbonates; calcite and aragonite; calcium-magnesium carbonates; dolomite; and sulfates; gypsum and anhydrite. Hence, water from some of the sedimentary rocks contain hardness because of its solubility (Al-Amar, 2015).

Our study findings are also in tune with Abdul-Jaleel and Al-Khafaji (2016) for wells in the Fallujah City in the western part of Iraq in that vale of calcium was between 106. 36 to 707. In base on the earlier research done by Abdul-Jaleel & Al-Khafaji (2016) stated that the optimal threshold is 07 mg/L. These values are lower compared to Dalaas and Abduljabar (2018) who recorded the maximum calcium hardness of 2000 mg/L and minimum of 760 mg/L in October in different wells. For a similar reason our results are less than the encountered values of Safawi et al. (2008) in the wells of Sherkhan-Quba region in Nineveh Province, and they include 720 – 1900 mg/L of calcium (Safawi et al. , 2008).

The findings of the present study are in accord with Abdul-Jaleel and Al-Khafaji (2016) for wells in Fallujah, western Iraq, where calcium level was between 106. 36 to 707. 4 ppm and the minimum concentration of COD is 07 mg/L as reported by Abdul-Jaleel and Al-Khafaji in 2016. These figures are comparatively lower to the findings for example Dalaas and Abduljabar (2018) where the highest calcium hardness was 2000 mg/L in December while the lowest was 760 mg/L in October recorded across the wells. Thus, our results are lower than those got by Safawi et al. (2008) in the study of the wells in the Sherkhan-Quba area of Nineveh Province where calcium levels vary between 720 and 1900 mg/L (Safawi et al. , 2008).

The findings of this study were in agreement with the study conducted by Abdul-Jaleel et al (2016) on the well water in Fallujah, western Iraq where concentration of magnesium varied between 51. 42 and 706. 47 mg/L.

These results were lower than those reported by Dalaas and Abduljabar (2018), in which magnesium hardness values fluctuated between 160 and a max of 2600 mg/l. These high concentrations of magnesium at these sites are as a result of higher discharge rates and longer period rainfalls which cause effective runoff and soil leaching from the surrounding region of the river particularly the central of Iraq where the soil is more dominated by magnesium. The particular significance of the magnesium is also highly important for fish reproduction and as a component of chlorophyll in green plants and algae forming the aquatic ecology system. It also decreases the interelement toxicity of some elements such as zinc.

The letters attached to the monthly averages suggest the difference, where some of the monthly magnesium hardness of groundwater is significantly different, at a significance level of $P \leq 0.05$.

The proximity of wells to the surface has also been said to play a major role since they are easily invaded by bacterial infection as as compared to deeper wells (Alexander, 2002). They further support population densities of bacteria, meaning high levels of organic matter in the water in support these huge bacterial loads.

Bacterial presence is influenced by several factors, including the nature and quality of the water and aeration, which involves the exchange of gases between air and water, affecting bacterial levels (Conboy & Gross, 2000). High temperatures can kill large numbers of bacteria, while lower temperatures help preserve them (Detay, 1997) . The bacteriological analysis results indicate that the studied well waters are contaminated and unsuitable for drinking without treatment with disinfectants. Regular monitoring of total bacterial levels in groundwater is necessary to ensure safety standards are not exceeded and to confirm the water quality for human use.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15