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Evaluation of Physical Chemical and Biological Characteristics of Underground Wells in Badra City, Iraq

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Abstract:

The quality of groundwater should be improved by keeping safe water sources from contaminants in protective way by doing regular measuring and checkup before it supplied for usage. Private Wells do not receive the same services that wells supplying the public do. Well owners are responsible for protecting their drinking water. This work was carried out in Badra city, Iraq from December 2017 to May 2018, six wells water were investigated to determine the general characteristics of wells as well as studying the effect of environmental factors on the quality of water. The average of six wells were eleven parameters that is out of permissible limits were EC, Sal., Alk., TH, TDS, Na, Ca, Cl, SO_4, Fe, Zn (4402-5183μS/cm, 2.76-3.9 ppt, 302-366mg/L, 3164-4248 mg/L, 604-675 mg/L, 375-524 mg/L, 635-871 mg/L, 631-1107 mg/L, 2430-4570μg/L, 114-392 μg/L). Respectively, microbiological investigations involved the total coliform, total plate count, as well as the detection for the presence of *E. coli*, *Salmonella* and Cholera. Results shows that there is a significant relation between the increasing of the TDS and Turbidity, TDS gives an indication for the significant increasing of chemical ions. Wells number 3, 4 and 5 showed gave positive results for *E.coli* growth which as a source of microbial pollution. Detection for the presence of chemical and microbial contaminate is an important alarm since this water has a direct effect on the human and animal's health. Advance method of rapid detection for the well water quality is highly recommended to avoid any health issue and prevent the outbreak of health risk and ecological contaminants.

Key words: Bacterial indicator, Badra city, Heavy metals, Groundwater pollution, Physicochemical parameters.

Introduction:

Groundwater's is the major source of drinking water in both urban and rural areas. Approximately 1.4x10^9 cubic kilometers of water in the earth holds in the form of seas, inland surface waters and groundwater, but only 3% of the total available water resources are in the form of freshwater found in rivers, lakes and groundwater. Rural and urban areas use groundwater's as a type of freshwater. 90% of freshwater are coming from groundwater's as a source in the earth. Water in a well is a model created in the ground by many methods either digging, or drilling in order to access the groundwater in underground aquifers. The way for drawing well water is by pumping, or by using containers, such as buckets that are hold mechanically or manually by hand. (1, 2,3). Driven wells can be initiated in unconsolidated material with a well whole structure, this is normally consisting of a hardened drive point and a screen of perforated pipe,after which a pump is installed to collect the water (3). Well water usually contains more minerals in solution than surface water and therefore may need treatment before being potable. Soil sanitation can occur as the water table falls and the surrounding soil begins to dry out (4).

Microorganisms which originate from human activities (urban, industrial, and agricultural) and released into the environment by direct discharge, insufficiently treated wastewater leaking sewage and septic systems can contaminate groundwater (5, 6, 7, 8).

People in surrounding places are on the outskirts of health problem in small communities and rural areas rely on wells in drinking water. If a well is located and designed correctly. It can be a source of good drinking water for decades. Presently, there is increasing evidence of the contamination of foods staff by irrigation water and an association of foods prone outbreaks with contaminated vegetables and other products (9, 10, 11).

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Water quality should be monitored for the irrigation of cropland and for product health quality such as vegetable and fruits that eaten raw. Pathogens present in water used for irrigation including *Shigella*, *Salmonella*, *Escherichia coli*, and *Cryptosporidium*, affect the host by infecting and replicating in GJT system (10,11).

Wells should be provided with more protection such as a sanitary, well cap, proper grout seals or a well casing that extends above the surface, and with every passing year, structural detoriation makes more risk, also microbial and chemical contaminant evaluation is very important (12,13).

The aim of this study is to assist the physicochemical and microbiological pollution degree of wells, Badra city.

Materials and Methods:

Description of Study Area

The study area is in Badra city, is located east boarding Iran and within Wasit province, 70kms northeast the city of Kut and 190kms southeast of the capital Baghdad. The research area is located between latitude 32° 2̀0 to 32° 5̀5 north and longitude 46° 1̀5 and 45° 5̀0 east and elevation 64m. the wells are located in the following distance from the center of Badra, Well No. one 1km, Well two 1.5km, Well three and four 3km, Well five 11km from Badra but within Zurbatia city, Well six half km (Fig.1). The water from the above wells used for human, animals and irrigation purposes.

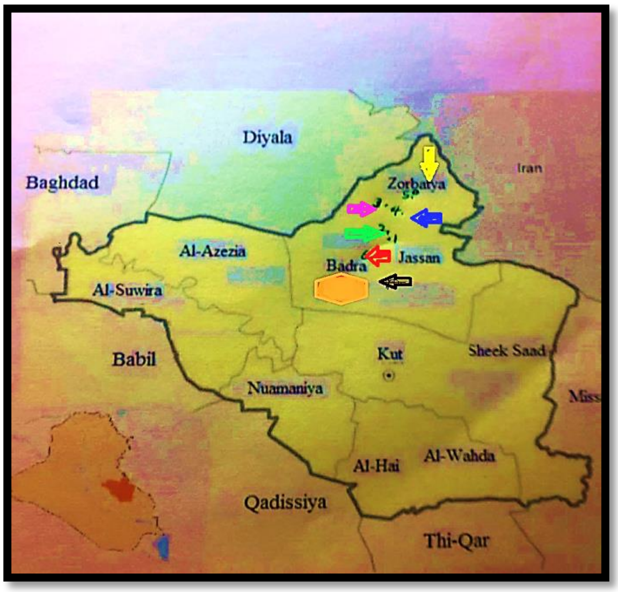


Figure 1. Location maps of the study area.

Badra city **well 1** **Well 2** **Well 3** **Well 4** **Well 5** **Well 6**

Sampling and Analysis

Many parameters were collected from six wells (Water Temp., pH, Electrical conductivity (EC), Salinity, Turbidity, Alkalinity, Total hardness (TH), Total dissolved solids (TDS), cations (Na^+, K^+ , Ca^{+2} , Mg^{+2} , $NH3^+$) anion (Cl^-, F^-, NO_2^-,NO_3^- PO_4^{-3} , SiO_2^{-2}, SO_4^{-2}) and heavy metals (Fe, Al, Cr, Cu, Mn, Zn, Cd, Pb, Hg) . Duplicated samples were taken three months in the morning hours from December 2017 to May 2018, to collection the samples were used sterilized glass bottle of 0.5L capacity, the samples were collected and transported to laboratory by ice box for analysis. Water temperature was measured directly using graduated thermometer (0° – 100°). pH was measured by pH meter type WTW after calibration by standard solutions. EC measured by conductivity meter type WTW. Salinity was calculated depending on EC values and according to method described in (Golterman, *etal.*, 1978) (14). Turbidity measured by Turbidity meter type HACH 2100 AN. Alkalinity was used methyl orange method. TH was used Na2 EDTA and Erichrom Black-T method. TDS measured by Konduktometer (SCHOTT). Na and K used Flamphotometric method, Flamphotometer, PFP7, Jenway, UK. Another ionic concentration (Ca, Mg, Cl, F, NO_2, NO_3, NH_3, PO_4, SiO_2, SO_4) were determined according to the American Public Health Association (2012) (15). The heavy metals (Fe, Al, Cr, Cu, Mn, Zn, Cd, Pb, Hg) were measured by Atomic absorption spectrometry, AAS 6300, Shimadzu, Japan, in Environmental Research Center, University of Technology.

Bacteriological Analysis

Sample was tested for bacteriological properties immediately after collection. Each sample was duplicated then the mean value was taken. Followed by analysis according to the standards methods for examination of water and wastewater (APHA, 2012). Total viable Bacterial Counts ($TVBC_S$) were determined by using the spread plate method and incubated at $37°C$ for 24hrs. The test of Total Coliform Bacterial Counts (TCBC) were determined by using Most Probable Number (MPN) method. One milliliter from each dilution containing 5ml of luryal trptose bile broth, was added to the duplicated tunes, these tubes were incubated at $37°C$ for 48hrs for Total Coliforms Bacteria and at $44°C$ for 24hrs for Fecal Coliforms Bacteria Counts (FCBC), positive results by formation gas that lead to rise derhum tubes and change the color of media from purple to yellow, the results of growth compared according to standard tables (APHA, 2012). Identification by microscope examination and biochemical test were done.

The detection of *Salmonella* spp. in wells water used selective enrichment medium consisting of selenite cystin broth (15). And for *Cholera* spp. used APW media and incubated at $37°C$ for 6hrs, then streaking on (T.C.B.S) agar plate (16). For diagnosis of both these two bacteria used, cultural diagnosis, Biochemical tests, API 20 Ekit. Mean monthly Min. and max. temp., RH % and Rainfall (mm). From December 2017 to November 2018, were collected by Meteorological office center in Baghdad.

Statistical Analysis

The statistical analysis-SAS (2012) program was used to determine the least significant difference between the means of the parameters. Least significant difference (LSD test) was used to significant compare between means in this study (17). P values less than (0.05) were considered as statistically significant.

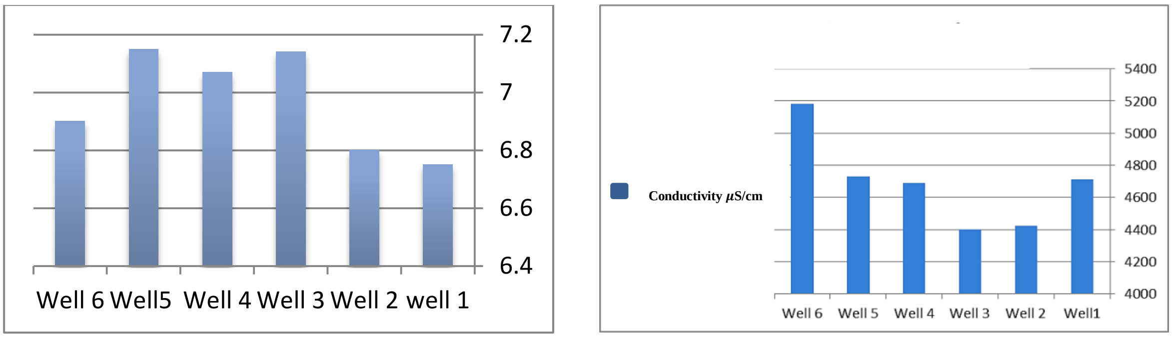
Results and Discussion:

This study included six wells from Badra area, Fig.1. The chemical investigation covered the most common factors that may effect on the quality of the wells.

Water Analysis

Table 3. Shows the values of different parameters measured during the sampling period between December 2017 to May 2018. Water temperature showed no variation between the six sites, also it was not much fluctuated during the season, average water temperatures range from$19.3 - 21.8°C$.

The statistical analysis shows the results of water temperatures were no significant difference ($P < 0.05$) among the wells, as well as the other parameters (pH, Alkainity, Na, K, NO_2). The pH of the water at all sites was nearly constant throughout the study period and ranging from 6.75 in well No.1 to 7.15 in well No.5, a result varies from moderate acidic to neutral, and this could be due to the environmental factors affecting the level of this factor. Many studies showed that the environment has a direct effect on the pH (Fig.2) (9).



A **B**

Figure 2. A. pH value & B. Conductivity of water from different wells.

Conductivity showed somewhat difference along the collecting period, and was ranging between 4402 in well No.3 to 5183 μS/cm in well No.5 (Fig.2). This study disagreed with (18).

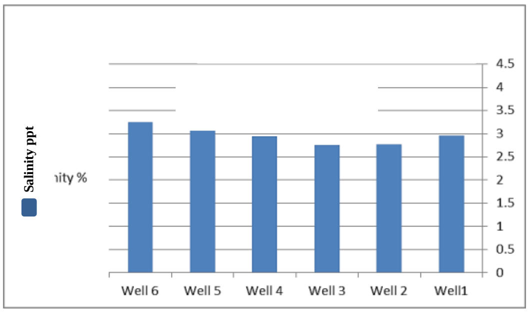


Figure 3. Variation of salinity among different wells.

Salinity is a measurement of the total dissolved solids in water. The average salinity of the world's ocean is 35ppt. the average salinity of the wells between 2.76 in well No.3 to 3.90ppt in well No.5 (Fig.3).

The variation of the value detected in the current study effect on the presence of biological containments level of water. Turbidity reflects the transparency in water and it is caused by the presence of substances in water. The results recorded the lowest value 1.02 in well No.6 and the highest value of turbidity was 29.3 NTU in well No.1. The desirable level less or equal to 1 NUT was recommended by WHO. Turbidity value up to 5 NUT indicate inadequate water and correlate with increased total coliform bacteria (19).

Alkalinity as $CaCO_3$ is one of the chemical compound that normally detected in water, the lowest value 303 in well No.5 and the highest value was 367mg/L in well No.6 (Fig.4). The results agreed with (20).

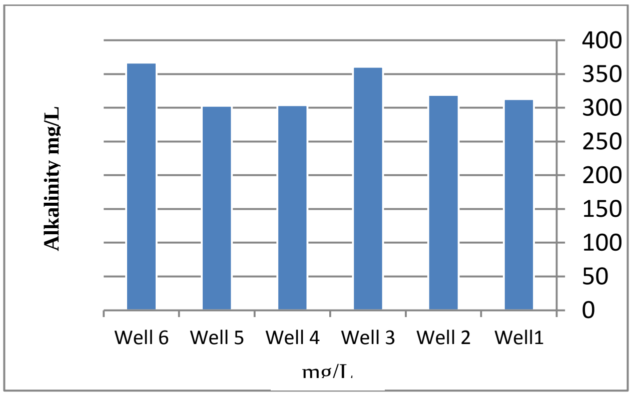


Figure 4. Illustrates the Alkalinity among different wells.

Total Hardness as $CaCO_3$, Hardness of water mainly depends upon the amount of Ca or Mg ions or both. The T.H results range between 1352 in well No.1 and 2034mg/L in well No.6 as show in (Fig.5). Many studies showed that hard water have some benefits, Humans need minerals for healthy life, and the National Research Council (National Academy of Sciences) states that hard drinking water generally gives a small amount toward total Ca and Mg human dietary needs (12).

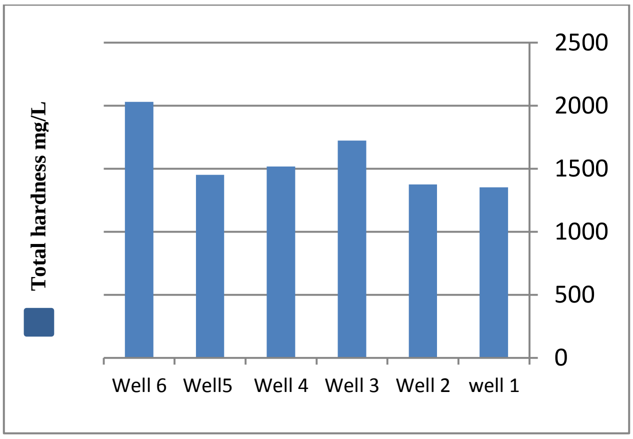


Figure 5. Illustrates the Total hardness among different wells.

The values for six wells were more higher than the prescribed limit (21).

Total dissolved solids has relation to the EC in the water. Ions in the TDS water can create the ability for that water to conduct an electric current which can be measured using a conventional conductivity meter or TDS (13). TDS range between 3119 in well No.2 and 4248mg/L in well No.6. The values for six wells sample were too higher than the prescribed limit (Fig.6).

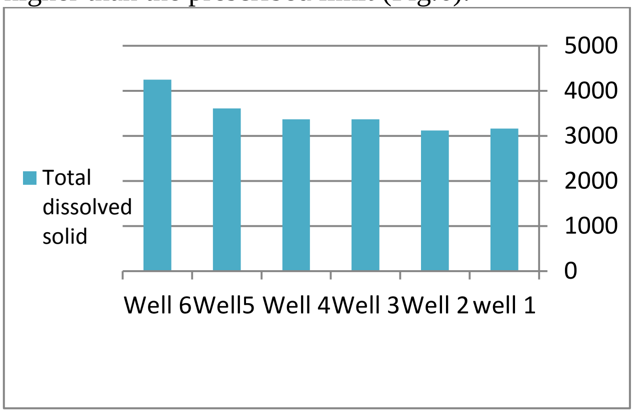


Figure 6. Illustrates the Total dissolved solid among different wells.

Sodium and potassium: The ionic levels of the water indicated that Na ion was generally high for all sites and ranging between 605 in well No.4 and 675 mg/L in well No.1 (Fig.7). Results weathering of rocks are the major source of K ion in natural fresh water. K ions was low in all wells and clear trend of its level along the collecting dates was observed, ranging between 4.55 in well No.5 and 5.70mg/L in well No.1. Results showed low K ions concentration than the prescribed limit (22).

Calcium and magnesium are directly related to hardness. Ca ion concentration showed high for all sites and ranging between 375 in well No.4 and 524 mg/L in well No.1 as showed in (Fig.7). Mg ions was low in all wells. The results showed ranging between 89 in well No.3 and 174 mg/L in well No.6 agreed with (21).

Chloride concentration serves as an indicator of pollution by sewage. In general the source of Cl ion due to big discharge of sewage near the sampling wells. Cl ion concentration were high in all the sites. It was found in the range of 635 mg/L in well No. 2 to 872 mg/L in well No. 6 as shows in (Fig.7). The study disagreed with (9).

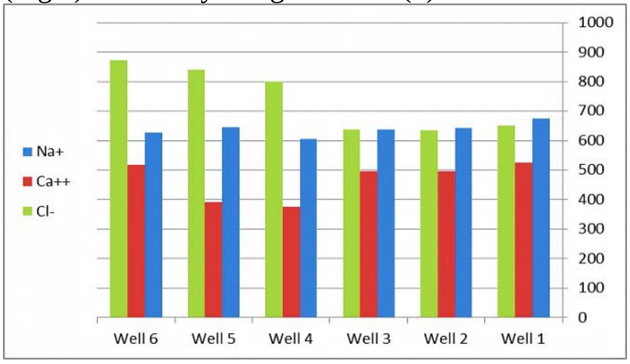


Figure 7. Illustrates the concentrations of different elements Na^{+}, Ca^{+2} and Cl^{-} (mg/L) among wells.

Fluoride ion was low in all sites studies the range of ion was 1.22 in well No. 1 and 1.75 mg/L in well No. 5.

Nitrite ion is much less toxic than ammonia, and toxicity decreases as the availability of mineral salts increases. The result showed ranging between 0.01 in well No.1 and 0.04 mg/L in well No.3. Nitrite ion leaching with percolating water in the wells also contaminated by sewage and other wastes rich in NO3 ion. It is ranging between 2.97 in well No.3 and 5.7 mg/L in well No.4

Ammonia ion ranging between 0.01 in well No.1 and 0.17 mg/L in well No.6.

Phosphate is necessary for all organisms' growth. The source of PO_4 ion enter the wells from human and animal wastes, rocks, cleaning, rains wash fertilizer and pesticides. It was ranging between 1.13 in well No.2 and 3.23 mg/L in well No.6 agreed with (24).

Silicates ions are not an essential element unlike nitrogen and phosphorus. it was ranging between 16.7 in well No. 3 and 26.3 mg/L in well No.4.

Sulphate ions occurs naturally in groundwater as a result of leaching from gypsum and other common minerals and other sources it was ranging between 631 in well No. 2 and 1107 mg/L in well No.6. as shows in (Fig. 8), (23,24,25).

According to the environmental protection agency (EPA) and the centers for disease control and preventation (CDC), drinking water with high levels of sulphate can cause diarrhea, especially in infants. Although some studies has shown that bathing in water high in sulfur or other minerals for its presumed health benefits known as balneotherapy (21).

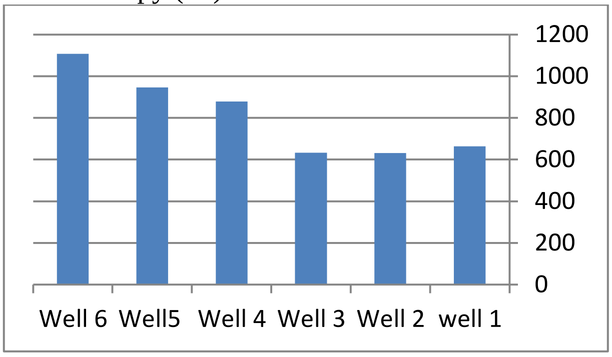
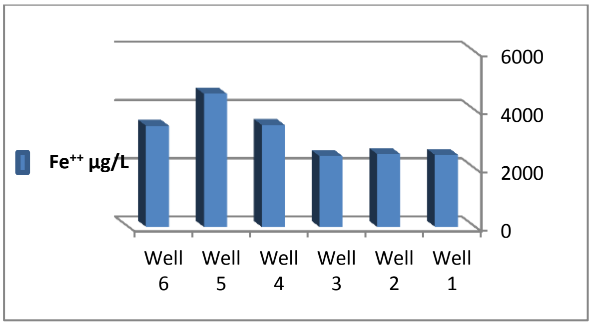
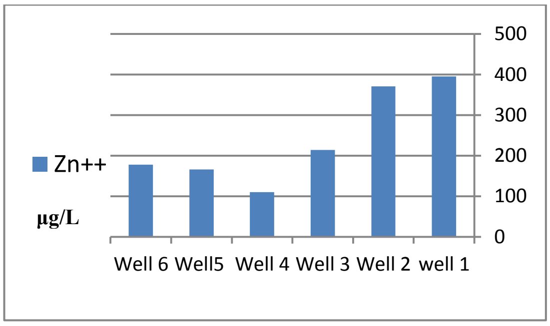


Figure 8. Illustrates the sulphate (mg/L) effect on wells.

Heavy metals enter the aquatic environment from natural and anthropogenic sources include, dust storms, erosion, weathering, and decomposition of the biota in the water, whereas the anthropogenic sources include, industrial effluent, sewages wastes, fertilizer automobile effluent and petroleum (26). Heavy metals incorporated through the food chain. Heavy metals exist in small quantities in the earth surface not exceeding 0.1 %. Those have density exceed 5 g/cm (27).

Table 4. Show s the value of concentrations of some heavy metals in water for six wells in study area. Results obtained shows that heavy metals (Fe , Al , Cr , Cu , Mn , Zn , Cd , Pb , Hg). The results of study nine elements shows, five elements not detected (Al, Cr, Cd, Pb, Hg). Two elements (Cu and Mn) lowest than the prescribed limit. The iron and zinc ions were highest as shows in (Fig. 9).





A **B**

Figure 9. A. Illustrates the Iron (µg/L) concentration & B. The concentration of Zinc (µg/L) as a heavy metals among wells.

Fe and Zn ions contaminated natural water due to various factors, transport, industry, agriculture, point sources as sewage water leakage, and lake of sewage systems in crowded populated areas (28). The results showed the highest value of Fe ion was 4570 in well No.5 and the lowest value 2430 μg/L in well No.3 This ions is too high for drinking water for humans , animals and irrigation. (29). Zinc ion concentrations were high in all the sites, The highest value of Zn ion 392 in well No.1 and the lowest value 113 μg/L in well No.4.

Total coliform was detected among different wells, well 3,4 showed high level of coliform number (Fig.10), these microorganisms can be transferred to the well either through soil, waste of animals and many other environmental factors. Water pollution caused by fecal contamination is a dangerous problem because it's a potential for contracting diseases from pathogens (disease causing organisms). Normally the total, concentrations of pathogens from fecal contamination maybe high or low. As a result, it is not practical to test for pathogens in every water sample collected. Instead, the presence of pathogens were determined with indirect evidence by testing for an "indicator" pathogens such as coliform bacteria. Coliforms come from the similar sources for instance pathogenic organisms. Coliforms are relatively easy to detect, they are usually appear in huge numbers than more dangerous and life threating pathogens, and react the environment, wastewater treatment, in a similar to many pathogens. Evaluation of fecal coliform bacteria can be an important indication of whether other pathogenic bacteria are present (30).

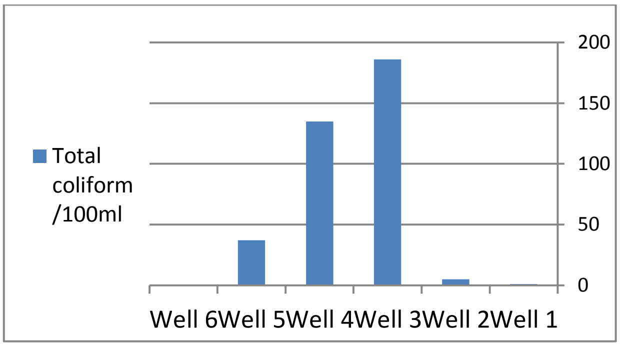


Figure 10. Illustrates the Total number of fecal coliform (MPN/100 ml).

Hundreds of strains of the *Escherichia coli, E.coli* O157:H7 is a serious cause of food borne and waterborne illnesses. Although most strains of *E.coli* are harmless and presence normally in the digestive system of healthy humans and animals, some strain produces a potent toxin that can cause severe illness. *E.coli* O157:H7 was first recognized as a cause of illness during an outbreak and caused a problem in water quality and affect the human health (Fig.11) (31).

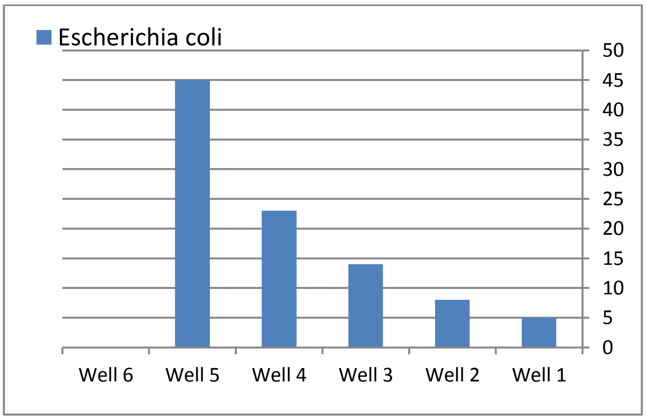
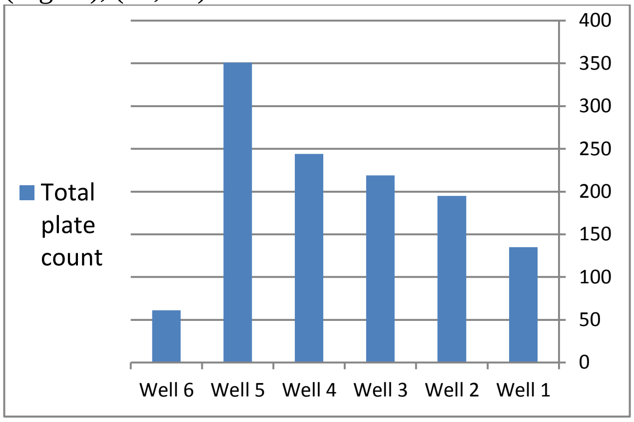


Figure 11. Illustrates the presence of *E.coli* (MPN/100) among six wells.

The results in this study revealed high level of TVBC in well No.5 due to effect of different environmental factors leads to increase a microbial activity, those in influencing in bacterial growth (Fig.12), (24, 32).



Fuger12. Total plate count (cfu/1ml) for different wells.

Salmonella spp. and Cholera are not detected in the current study, further advance technique maybe required to confirm the presence of these pathogens in well water.

Table 1. Illustrates the descriptive statistics for turbidity and total dissolved solids

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	30.00[a]	25	.224
Likelihood Ratio	21.501	25	.664
Linear-by-Linear Association	.783	1	.376
N of Valid Cases	6		

a. 36 cells (100.0%) have expected count less than 5. The minimum expected count is .17.

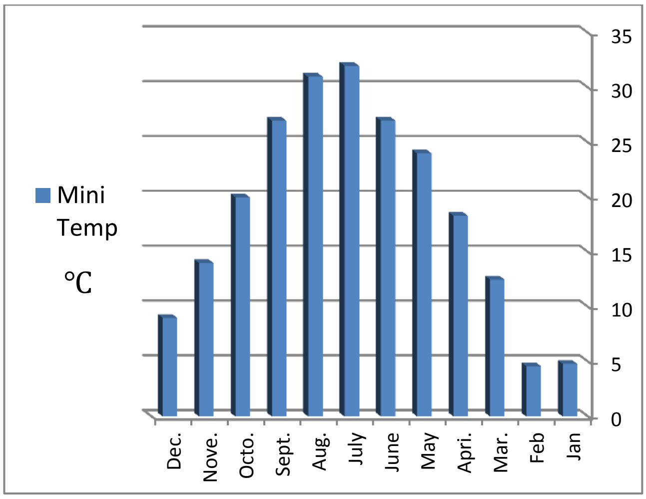
Chi –Square test for the relation between turbidity and total dissolved solid, the like hood ratio represent value of .664 which represent significant correlation between two variable, which means the increasing of turbidity can give us an indication of the contaminant which could be chemicals or biological as shown in table (1). For the descriptive statistics for these two variables, mean and standard deviation was measured as shown in table (2)

Table 2. Illustrates the Measuring of mean , median and standard deviation for Turbidity and total dissolved solid of different samples

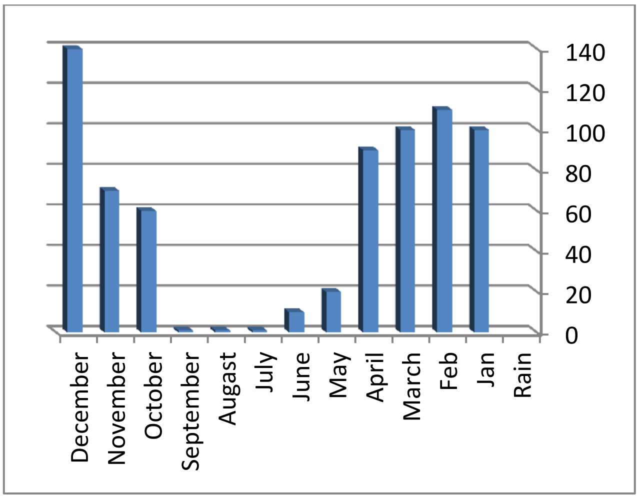
Descriptive Statistics					
	No of wells	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Turbidity	**6**	**2.93**	**29.27**	**9.0217**	**10.08971**
Total dissolve solid	**6**	**3119.00**	**4000.00**	**3438.8333**	**326.18732**
Valid N (listwise)	**6**				

Climate

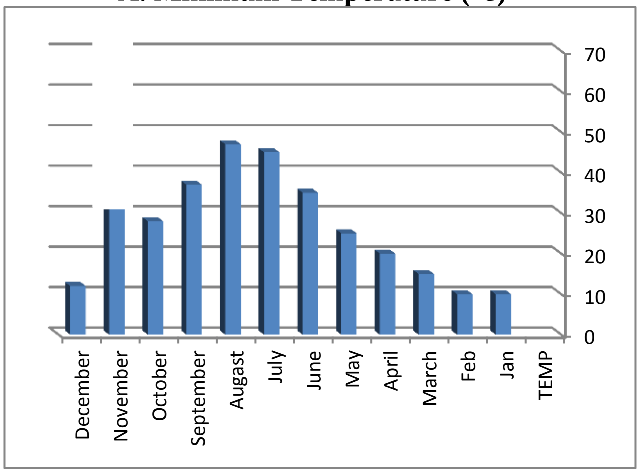
The climate of Iraq is mainly of the continental, subtropical arid type (33). The lowest mean monthly minimum temperature in Badra area study is 8.8$°C$ in December and highest mean monthly maximum temperature is 48.8$°C$ in August. The mean monthly precipitation at Badra area with peak rainfall in February 83.2mm, with monthly inputs Zero from the period from June to November. Yearly averages can range 185mm. relative air humidity ranging from 18% in August to 62% in February, the climatic factors as show in (Fig.13). Distribution of bacteria not only depends on quality of water, but also depends on season and environmental factors.



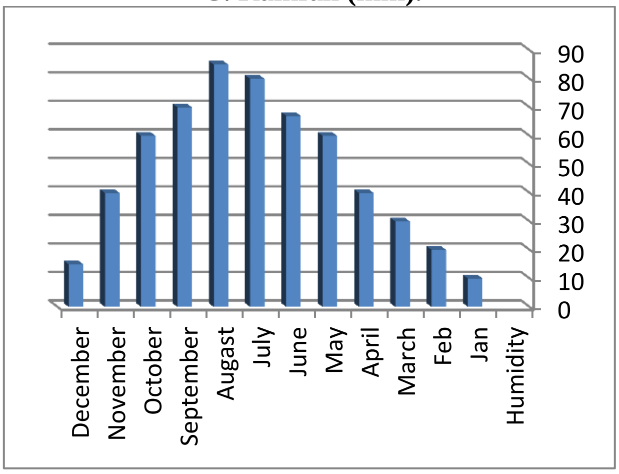
A. Minimum Temperature (℃)



C. Rainfall (mm).



B. Maximum Temperature (℃)



D. Relative Humidity (%).

Figure 13. Meteorological information (Dec. 2017 – Nov. 2018) in Badra city.

Conclusions:

Physical, chemical, and biological factors can play a major role in well water quality, as well as human and animals health, contaminated well water with heavy metals and other contaminant may pass through the food chain through agricultural side and this will affect the human directly therefore further study is required to investigate the effect of water from the clinical side on individual health in Badra city.

Table 3. The physicochemical on water of wells within Badra city.

Parameters	Well No. 1				Well No. 2				Well No. 3				Well No. 4				Well No. 5				Well No. 6				LSD
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	
Water Temp. ℃	18.50	20.50	19.33	1.040	19.00	20.00	19.33	.577	22.00	22.00	21.00	1.000	21.00	22.50	21.83	.763	21.50	22.00	21.66	.288	20.00	22.00	21.16	1.040	3.63 NS
pH	6.70	6.80	6.74	.050	6.76	6.85	6.80	.045	7.10	7.20	7.13	.055	7.04	7.09	7.07	.026	7.10	7.20	7.15	.050	6.90	6.91	6.90	.005	0.581 NS
Cond. $\mu S/cm$	4710.0	4715.0	4713.3	2.886	4405.0	4430.0	4421.6	14.43	4390.0	4410.0	4401.6	10.40	4680.0	4695.0	4688.3	7.637	4720.0	4740.0	4730.0	10.00	5100.0	5300.0	5183.3	104.08	402.7 *
Salinity ppt	2.96	3.95	3.29	.571	2.76	2.78	2.77	.011	2.75	2.76	2.75	.005	2.93	2.94	2.93	.005	2.96	2.97	2.96	.005	3.20	3.32	3.25	.0624	0.309 *
Turbidity NTU	24.60	37.20	29.26	6.906	.80	1.20	.96	.208	5.10	6.30	5.73	.602	4.90	5.04	4.94	.080	7.60	8.50	8.03	.450	.90	1.10	1.01	.10408	2.61 *
Alka.as$CaCO_3$mg/L	311.00	316.00	313.00	2.645	316.00	322.00	318.66	3.05	358.00	365.00	361.33	3.511	301.00	307.00	304.00	3.000	295.00	312.00	302.66	8.621	366.00	663.00	466.66	170.048	138.4 NS
T.Hard.as$CaCO_3$ mg/L	1320.0	1370.0	1352.0	27.78	1370.0	1381.0	1375.3	5.50	1705.0	1735.0	1723.3	16.07	1507.0	1527.0	1518.3	10.26	1445.0	1460.0	1452.0	7.54	2029.0	2038.0	2034.3	4.725	379.2 *
T.Diss.solids mg/L	3150.0	3173.0	3164.3	12.50	3119.0	3121.0	3119.6	1.15	3366.0	3374.0	3370.3	4.041	3357.0	3381.0	3369.33	12.013	3605.0	3617.0	3611.0	6.00	4241.0	4253.0	4248.0	6.245	503.6 *
Sod.Na^+ mg/L	671.00	681.00	675.00	5.291	639.00	645.00	641.66	3.055	635.00	641.00	638.00	3.000	601.00	610.00	604.66	4.725	641.00	649.00	645.16	4.010	624.00	629.00	626.66	2.516	72.84 NS
Pota. k^+ mg/L	5.71	5.78	5.74	.036	5.10	5.40	5.26	.152	5.20	5.30	5.23	.057	4.30	6.93	5.27	1.439	4.51	4.60	4.55	.045	4.80	5.10	4.94	.15044	1.08 NS
Calc.Ca^{+2} mg/L	520.00	532.00	524.33	6.658	492.00	501.00	496.00	4.582	492.00	502.00	497.33	5.033	371.00	379.00	375.33	4.041	391.00	395.00	393.00	2.000	515.00	521.00	518.00	3.000	94.53 *
Mag. Mg^{+2} mg/L	94.00	96.00	95.00	1.000	88.00	91.00	89.33	1.527	87.00	92.00	89.33	2.516	131.00	141.00	137.00	5.291	108.00	113.00	110.33	2.516	169.00	179.00	174.33	5.033	42.75 *
Chlor.Cl^- mg/L	648.00	656.00	651.66	4.041	631.00	638.00	635.00	3.605	631.00	642.00	638.00	6.082	802.00	811.00	805.66	4.725	839.00	841.00	840.00	1.000	868.00	874.00	871.66	3.214	67.94 *
Flor.F^- mg/L	1.20	1.25	1.21	.028	1.10	1.40	1.23	.152	1.20	1.30	1.23	.057	1.40	1.50	1.46	.057	1.71	1.80	1.75	.045	1.72	1.75	1.74	.0173	0.336 *
Nitrite as NO_2^- mg/L	.01	.02	.01	.005	.02	.04	.03	.010	.03	.04	.03	.005	.01	.02	.01	.007	.02	.04	.02	.011	.01	.02	.01	.0055	0.033 NS
Nitrate as NO_3^- mg/L	3.80	4.10	3.93	.152	3.30	3.60	3.50	.173	2.90	3.00	2.96	.057	5.40	5.90	5.70	.264	2.90	3.60	3.30	.360	3.95	4.10	4.05	.0866	1.263 *
Amm. NH^+_3 mg/L	.01	.01	.01	0.000	.01	.02	.01	.005	.01	.03	.02	.010	.04	.05	.04	.008	.05	.06	.05	.006	.16	.17	.16	.0057	0.066 *
Orth.pho as PO_4^{-3} mg/L	1.36	1.40	1.38	.023	1.10	1.20	1.13	.057	1.10	1.20	1.16	.057	2.03	2.08	2.04	.028	3.05	3.20	3.11	.076	3.18	3.30	3.22	.064	1.252 *
Silicatc as SiO_2^{-2} mg/L	19.00	21.00	20.00	1.000	18.00	19.00	18.33	.577	15.00	18.00	16.66	1.527	25.00	27.00	26.33	1.154	20.00	24.00	22.00	2.000	25.00	27.00	25.66	1.154	4.492 *
Sulf. as SO_4^{-2} mg/L	660.00	665.00	663.00	2.645	629.00	634.00	631.33	2.516	631.00	633.00	632.00	1.000	875.00	880.00	878.33	2.886	942.00	951.00	946.33	4.509	1100.00	1115.00	1107.33	7.505	162.7 *

Table 4. Summary of heavy metals $(\mu g/L)$ on water of wells within Badra city.

Metals	Well No. 1				Well No. 2				Well No. 3				Well No. 4				Well No. 5				Well No. 6				LSD
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	
Fe^{+2}	2.400	2.500	2.467	0.058	2.300	2.600	2.500	0.173	2.300	2.600	2.433	0.153	3.000	4.100	3.533	0.551	4.500	4.600	4.567	0.058	3.200	4.570	3.823	0.693	0.842 *
Al^{+3}	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cr^{+3}	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cu^{+2}	13.100	14.000	13.500	0.458	14.000	16.000	14.667	1.155	14.000	15.500	14.667	0.764	20.000	23.000	21.333	1.528	32.000	32.400	32.133	0.231	30.800	33.000	31.977	1.108	5.72 *
Mn^{+2}	17.900	18.500	18.300	0.346	16.500	17.000	16.833	0.289	14.500	15.700	15.233	0.643	12.500	16.000	14.167	1.756	23.200	25.000	24.400	1.039	10.800	11.000	10.933	0.115	7.84 *
Zn^{+2}	388.000	395.000	392.167	3.686	365.000	378.000	371.167	6.526	214.300	215.000	214.767	0.404	110.000	120.000	113.667	5.508	155.000	166.000	160.400	5.503	175.300	181.000	178.100	2.851	52.63 *
Cd^{+2}	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pb^{+2}	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
$Hg^{=2}$	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND: Not detected.

Conflicts of Interest: None.

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تقييم الخصائص الفيزيائية والكيميائية والبيولوجية للمياه الجوفية في آبار مدينة بدرة في العراق

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الخلاصة:

للحفاظ على نوعية مياه الابار بعيداً عن مصادر الملوثات يجب عمل فحوصات وقياسات مستمرة قبل استعمالها للأغراض المتعددة. لا تتلقى الآبار الخاصة نفس الخدمات التي توفرها الآبار العامة. أصحاب البئر هم المسؤولون عن حماية مياه الشرب، لذلك يجب أن يكون مالك البئر على دراية بينة من إمكانية تلوث ابارهم بشكل مباشر او غير مباشر وكذلك متابعة التأثيرات الصحية المحتملة التي يمكن أن تحدثها تلك الملوثات المحتملة. تم تنفيذ هذا العمل في مدينة بدرة في العراق في الفترة من ديسمبر 2017 إلى مايس 2018، وتم فحص ست آبار مياه لتحديد الخصائص العامة للآبار بالإضافة إلى دراسة تأثير العوامل البيئية على جودة المياه. وأجريت الاختبارات الفيزيائية والكيميائية والمكروبيولوجية بما في ذلك تم تضمين العديد من العوامل بما فيها العوامل المناخية ومنها درجة حرارة الهواء والمطر الرطوبة وكذلك الكشف عن وجود المعادن الثقيلة، وشملت التحقيقات المكروبيولوجية، مجموع عدد البكتريا والكشف عن وجود الكوليرا والسالمونيلا. أظهرت نتائج الدراسة وجود احدى عشر قياس تكون خارج الحدود المسموح بها ضمن المواصفات العالمية للمياه وكذلك العراقية، وهي: التوصيلية الكهربائية، الملوحة، القاعدية، العسرة الكلية، الاملاح الذائبة الكلية، الصوديوم، الكالسيوم، الكلوريد، السلفات، الحديد، الزنك ومعدلات قيمها للآبار الستة المدروسة هي على التوالي:

(4402-5183μS/cm, 2.76-3.9 ppt, 302-366mg/L, 3164-4248 mg/L, 604-675 mg/L, 375-524 mg/L, 635-871 mg/L, 631-1107 mg/L, 2430-4570μg/L, 114-392 μg/L).

وشملت الدراسة التحقيقات المكروبيولوجية مجموع القولونيات، مجموع عدد البكتريا، والكشف عن وجود السالمونيلا و الكوليرا. وتظهر النتائج أن هناك علاقة ذات دلالة إحصائية بين زيادة مجموع العكارة والمذابات، تعتبر الاشريشيا كولاي من الملوثات البيولوجية المهمة المسببة للتلوث البكتيري ووجدت المواد الكيميائية مثل الحديد والزنك والسلفات وبقية العوامل الكيميائية مؤشراً هاماً لوجود مصدراً للتلوث الكيميائي. ووجد ان الابار 3،4،5 فيها مؤشرات معنوية عن وجود *E.coli* التي تعتبر مصدراً مهماً للتلوث المايكروبي، والذي يعد إنذارًا مهماً لأن هذا الماء له تأثير مؤثر هاماً ومباشراً على صحة الإنسان والحيوان. ينصح بشدة بطريقة متقدمة للكشف السريع لمياه الآبار لتجنب أي مشاكل صحية ومنع وصول الملوثات لتفادي المخاطر الصحية والبيئية.

الكلمات المفتاحية: المؤشر البكتيري، مدينة بدرة، المعادن الثقيلة، تلوث المياه الجوفية، العوامل الفيزيائية الكيميائية.