Assessment of groundwater quality status by using water quality index in Abu-Jarboaa and Al-Darrawesh Villages, Basiqa subdistrict, Iraq

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ABSTRACT

Groundwater is a natural resource for drinking water. Like other natural resources, it should be assessed regularly and people should be made aware of the quality of drinking water. The present study is aimed at assessing the water quality index (WQI) for the groundwater of Abu-Jarboaa and Al-Darrawesh villages, Basiqa district. This has been determined by collecting 30 ground water samples during summer season and subjecting the samples to a comprehensive physicochemical analysis. For calculating the WQI, the following eleven parameters have been considered: pH, EC_{25}, total alkalinity, total hardness, calcium, magnesium, sodium, potassium, chloride, sulfate, phosphate. The WQI for these samplesunfit for drinking and domestic uses and ranges from 162 to 172. The high value of WQI has been found to be mainly from the higher values ofdissolved ions in ground water. The results revealed that the groundwater of the area needs some degree of treatment before consumption.

Keywords: Groundwater, Basiqa district, water quality index, water quality.

HOW TO CITE THIS ARTICLE

Abdul-Aziz Y. T. Al-Saffawi, Noor M.S. Al-Sardar, “Assessment of groundwater quality status by using water quality index in Abu-Jarboaa and Al-Darrawesh Villages, Basiqa subdistrict, Iraq”, International Journal of Enhanced Research in Science, Technology & Engineering, ISSN: 2319-7463, Vol. 7 Issue 6, June -2018.

INTRODUCTION

Groundwater is an inevitable source of drinking water for both urban and rural development countries. Besides, it is a vital source of water for the drinking, agricultural and the industrial purpose. Being a significant part of the hydrological cycle, its occurrence and availability depends on the rainfall and recharge conditions. The suitability of groundwater for various uses majorly depends on quality of groundwater. Hence protecting the quality of groundwater is a major concern [1].

In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization. Rapid urbanization, especially in developing countries, has affected the availability and quality of ground water due to its overexploitation and improper waste disposal [2,3].The hydro-geochemical processes of the ground water vary spatially and temporally, depending on the geology and chemical characteristics of the aquifer. Groundwater contains minerals carried in solution, the type and concentration of which depends upon several factors like soluble products of rock weathering and decomposition in addition to external polluting agencies and changes in space and time. As a result of chemical and biochemical interaction between groundwater and contaminants from urban, industrial and agricultural activities along with geological materials through which it flows, it contains a wide variety of dissolved inorganic chemical constituents in various concentrations [4]. In some areas of the world, people face serious water shortage because groundwater is used faster than it is naturally replenished. Human development and population growth exert many and diverse pressures on the quality and the quantity of water resources and on the access to them [5]. Water quality monitoring and assessment is the foundation of water quality management, the Physicochemical study could help in understanding the structure and function of particular water body [6].Water quality index is one of the most effective tools to communicate information on the quality of water to the concerned people and comprehend the spatial and temporal variation of quality. It acts as the indicator of the quality of water. The objective of the water quality index is to turn multifaceted water quality data into simple information that is useable by the public. Several researchers have conducted a study on groundwater quality by estimating the water quality index to substantiate the variation of groundwater quality [7,8].The presented study investigated the groundwater qualityin Abu-Jarboaa and Al-Darrawesh villages, Basiqa district by analyzing the different physiochemical parameters presented in the groundwater. It determines the suitability for drinking purpose by using water quality indexing method (WQI).

MATERIALS AND METHODS

The study was conducted on groundwater of Abu-Jarboaa and Al-Darrawesh villages, Basiqa subdistrict southMosul City, Iraq, which considared as agricultural areas that rely on groundwater as the main source of water for different purposes(Fig.1). These two villages located in the northern part of Iraq.The geological formation in it is Al-Fatha (Lower Fars)which consisting mainly of gypsum, anhydrite, evaporated salts, limestone and marl etc. [9].

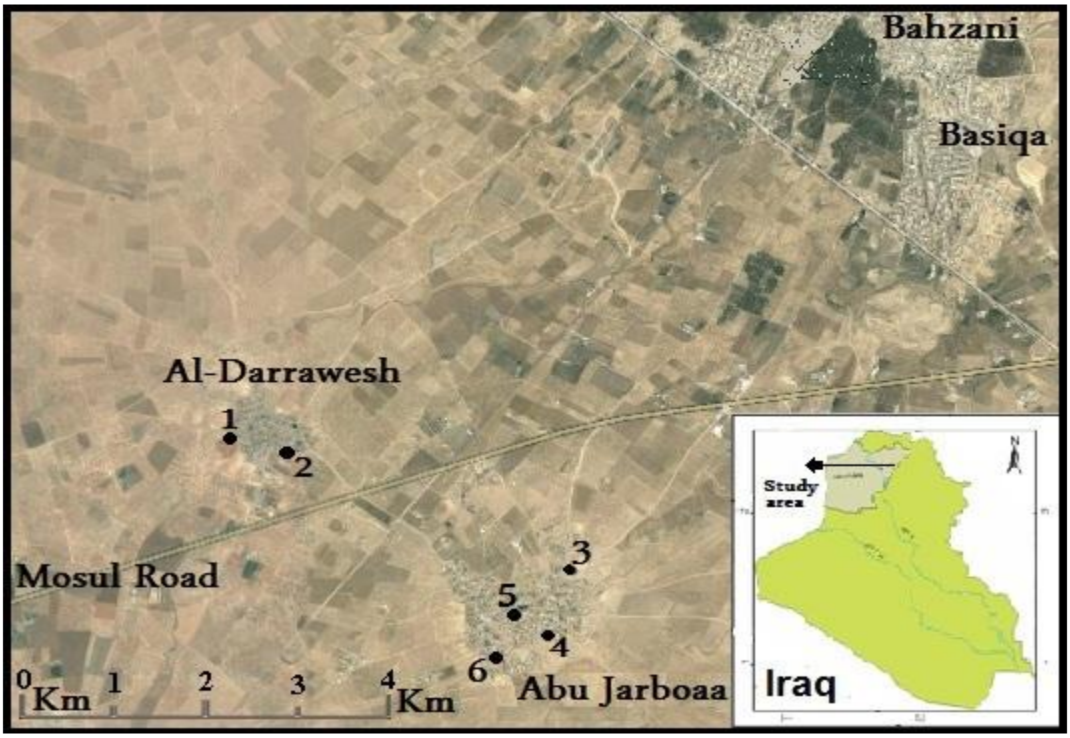


Figure (1): Map of Basiqa subdistrict showing study areas.

Therefore, the water well be contains high concentration of sulfur compounds as sulfate which combined with other cations as Sodium, Calcium and Magnesium[10]. In present investigation thirty water samples taken from sex different wells, four of them at Abu-Jarboaa village and the remain at Al-Darrawesh village (through dry seasons, for three months) were collected in polythene bottles which were cleaned with distilled water; followed by rinsing the sample container with the water sample before it is filled[11]. The parameters like pH Electrical conductivity (EC_{25}), Total Alkalinity, Total Hardness (TH), Calcium, Magnesium, Sodium, Potassium, Chloride, Sulfate and Nitrate were estimated by using standard methods[12].Also, these parameters were considered in the calculation of WQI.

RESULTS AND DISCUSSION

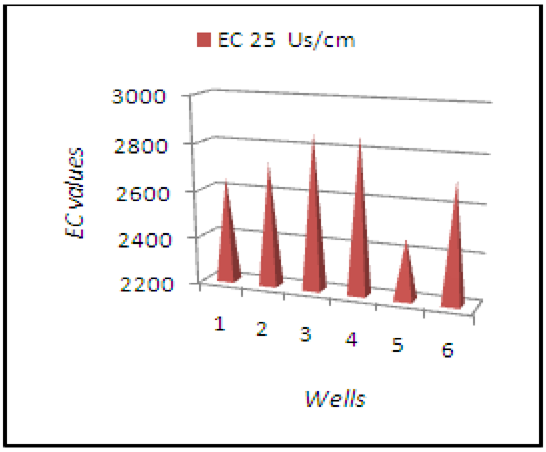
Site-wise determined values of eleven physicochemical parameters with their prescribed (WHO, 2004) standards are presented in (Table 1 and 2) and (Fig. 2, 3, 4). A critical analysis of the data revealed following facts regarding to groundwater quality atAbu-Jarboaa and Al-Darrawesh Villages, Basiqa district. We have showed that the tempreture in the groundwater samples are between 21°C to 23°C with the

Groundwater quality parameters of the study area (mg. l^{-1}).Table (1):

Wells	Al-Darrawesh village				Abu-Jarboaa village							
	1		2		3		4		5		6	
Paramet.	Min	Max.	Min.	Max.	Min.	Max.	Min	Max.	Min.	Max.	Min	Max.

Temp. °C	21.5	22.5	21.0	23.0	20.0	22.0	21.5	22.5	21.0	23.0	21.0	22.0
pH	6.63	6.46	6.88	6.67	7.17	7.04	7.45	7.13	6.79	6.63	6.85	6.70
$Ec_{25\mu S/cm}$	2755	2497	2920	2322	2930	2830	2913	2800	2650	2270	2760	2650
T.alk.	410	348	450	348	392	380	388	380	416	356	400	384
T. Hard.	2250	2470	2350	2500	2270	2390	2250	2380	1900	2000	2100	2200
Ca	416	420	428	440	404	436	408	440	360	400	392	412
Mg	292	347	309	340	292	316	294	316	238	250	262	285
Na	220	280	209	244	262	340	266	333	174	291	235	273
K	2.6	4.9	4.2	6.7	2.7	3.4	2.4	3.3	1.3	2.9	1.2	1.6
SO_4	1376	2260	2046	2526	1728	2220	2000	2462	1650	2532	1664	2543
Cl	160	190	165	200	170	175	175	185	145	155	175	185
PO_4	4.18	5.60	4.27	6.87	5.25	6.46	3.32	5.50	5.12	7.58	4.04	5.67

EC_{25}: Electrical conductivity at 25 °C., T. Alk.: Total alkalinity., Ca: calcium., Mg: Magnesium., T .Hard.: Total Hardness., Na: Sodium., K: Potassium., SO_4: Sulfate., Cl: Chloride., PO_4: Phosphate



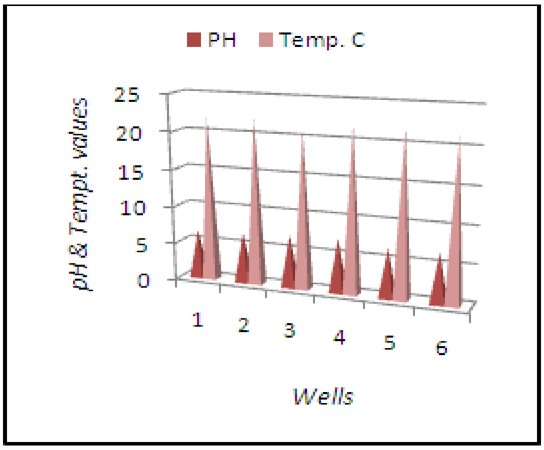


Fig. (2): Mean values of pH, EC_{25}. And Tempt. recorded among sample wells.

Average varied from 21°C to 22 °C (Fig.2).These results agree with Al-Saffawi and Al-Shanona [13].

The pH of water beyond permissible range can affect mucous membrane of cells and cause corrosiveness effect. It is also important for indicating of water quality and providing significant information for many types of geochemical equilibrium solubility[14].The pH of the groundwater in the study area varied from 6.46 to 7.45 with the average between (6.55 to 7.28) (Table 1 and Fig 2). These values of the most samples understudy indicated that groundwater is slightly acidic. However, all samples fall within the permissible limit of WHO [15].EC is the most important parameter to demarcate salinity hazard and suitability of water for different uses. The mean values were in the range of 2458to 2865 μS. cm^{-1} (Fig. 2). The high value of conductivity in all of the samples is likely due to prolonged and intensive agricultural practices and geological conditions acquiring high concentrations of the dissolved minerals [16].

Hardness is caused by polyvalent metallic ions dissolved in water, which in natural water are principally magnesium and calcium. So, the adverse effects of such hard water are i. Soap consumption by hard water cause economic loss to water, ii. Magnesium sulfate has laxative effects in person unaccustomed to it, iii. Precipitation by hard water adhere to the surface of tubs and sinks and may stain clothing, dishes and other items [17]. Total Hardness, Ca and Mg varies from (1900 -2500), (392-440) and (238-340) mg. $l^{-1}$with an average values ranged between (1958-2428), (383-435) and (272-345) mg. l^{-1}.respectively (Table 1and Fig.3). The hardness, Ca and Mg values for the study area are found to fall above the permissible limit of WHO standard. These high values are likely due to Calcite and Magnesium calcite dissolution by carbonic acid. This process has increased the total hardness, calcium, and magnesium ion as given below [4] Eqs. (1, 2, 3):

$CO_2 + H_2O \rightarrow H_2CO_3$ ----------------1
$CaCO_3 + H_2CO_3 \rightarrow Ca^{2+} + 2HCO_3^{-1}$ ---------------2
$CaMg(CO_3)_2 + 2H_2CO_3 \rightarrow Ca^{2+} + Mg^{2+} + 4HCO_3^{-}$ ------- 3

According to National Academy of Sciences, the higher concentrations of sodium can be related to cardiovascular diseases and in women toxemia associated with pregnancy [18]. The sodium andPotassium content at studied water samples ranged from (203 to 305) and(1.4 to 5.7) mg. l^{-1} respectively (Fig. 3), the mean values of Na for all water samples exceed the permissible limit given by WHO.The major portion of alkalinity in natural water is caused by carbonate and bicarbonate. Alkalinity in itself is not harmful to human beings [19].The major portion of alkalinity in natural water is caused by carbonate and bicarbonate. Alkalinity in itself is not harmful to human beings [18,19].The total alkalinity an average values of water samples ranged from 384 to 414 mg. l^{-1} (Fig. 4), All water samples of study area were found exceed value of total alkalinity with compare to prescribed value given by WHO.

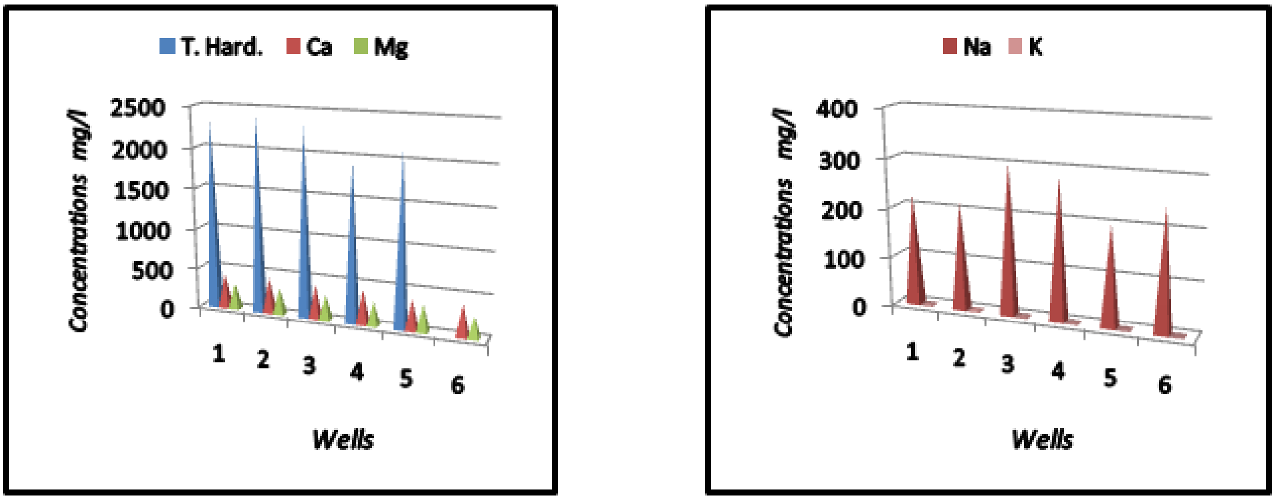


Figure (3): Mean values of T. H., Ca, Mg, Na and K recorded among sample wells.

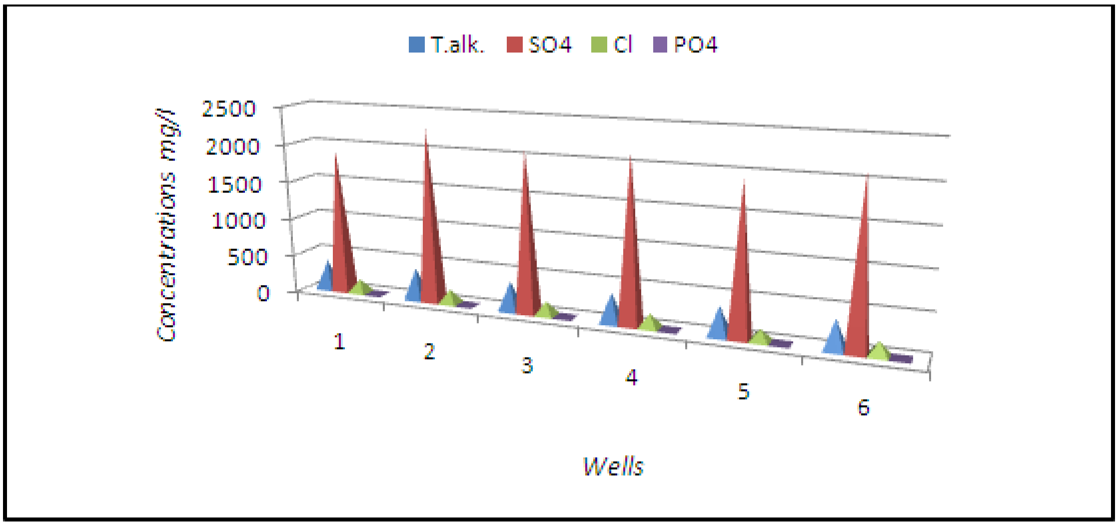


Figure (4): Mean values of T. alk. SO_4, Cl and PO_4 recorded among wells.

These high concentrations arelikely due to Calcite and Dolomite dissolution by carbonic acid as given in Eqs. (1, 2, 3) above [20].The concentration of sulfate is likely to react with human organs if the concentration exceeds the maximum allowable limit of 400 mg/l and causes a laxative effect, gastro-intestine irritation and catharsison human system with the excess magnesium in groundwater [3,21]. All water samples of studied area were showed sulfate content ranged from 1376 to 2543 mg. l^{-1}, which is within the prescribed value given by WHO. Excessive chloride concentration increase rates of corrosion of metals, this can lead to increased concentration of metals in the drinking water, and small amounts of chlorides are required for normal cell functions in plant and animal life [16]. The chloride content of groundwater samples of Abu-Jarboaa and Al-Darrawesh villages ranged from 145 to 200 mg. l^{-1} (Table, 1) which within the permissible limit given by WHO. Phosphate are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate. Phosphate itself does not have notable adverse health effects [17]. However, phosphate levels greater than 1.0 mg. l^{-1} may interfere with coagulation in water treatment plants. As a result, organic particles that harbor microorganisms may not be completely removed before distribution. Phosphate level in ground water samples collected are in the range of 3.32-7.58mg. l^{-1}, All samples within the permissible limit given by WHO.

Water quality index (WQI):Assessment of

Water Quality Index is a very useful tool for communication the information on the overall quality of water. The WHO standard has been considered for calculation of WQI. This calculation is performed by using following notations [22]: i: no. of the parameter., W i: unit weightage of i^{th} parameter., k: constant of proportionality.,

Si: highest permitted value for i^{th} parameter., Q i: sub index of i^{th} parameter and O i: is the observed value of the i^{th} parameter.WQI was calculated using 3 steps:

In the first step: the calculation of weightage of i^{th} parameter is calculated by using the equations [22]:

$Wi = 100 *(k /Si)$………. 1
$k = [1/ (\Sigma\ 1/Si=1, 2,…,i)]$………2

Calculated weightagevalues of each parameter are given in (Table 2).
In the second step: the quality rating for each of the water quality parameter was computed by using the equation [1,22]:

$Q\,i = O\,i \times 100 / S\,I$ …....3
In the third step: the water quality index is calculated by using theequation [1,23]

$$WQI = \frac{\sum_{1=1}^{n} Qi * Wi}{\sum_{i=1}^{n} Wi} \quad …….. 4$$

The computed WQI values are classified into five types, excellent water to water unsuitable for drinking, (Table 3). The chemistry of groundwater is often used as a tool for discriminating the drinking and irrigation water quality [24]. Water quality index (WQI) is an important parameter for identifying the water quality and its sustainability for drinking purposes [25].

Table (2): Unite weightage of parameters based on the drinking water standard.

Parameters	Highest permitted values (WHO)	Unit weightage (Wi)
Temp. °C	25	0.1293602070
pH	8.5-6.5	0.4312006900
EC_{25}	1400	0.0023100036
T. alkalinity	200	0.0161700250
T. Hard.	500	0.0064680103
Ca	200	0.0161700250
Mg	150	0.0215600345
Na	200	0.0161700250
K	200	0.0161700250
Cl	250	0.0129360200
SO_4	400	0.0080850129
PO_4	10	0.3234005176
		Σ = 1.0000

Table (3): Water quality classification ranges and types of water based on WQI values (Packialakshmi et al, 2015).

Water Quality Index Level	Class	Water Quality Status
0.0 - 25	I	Excellent
26 - 50	II	Good
51 - 75	III	Poor
76 - 100	IV	Very poor
> 100	V	Unfit for drinking

The calculation of WQI for ground water samples is shown in (Table 4). A total of 30samples were analyzed for WQI, 100% of the samples fell under class V, and water unfit for drinking and domestic purposes. This may be due to effective leaching and dissolution process of rock salt and gypsum-bearing rock formations. High concentration of EC, Total alkalinity, Sodium followed by calcium clearly suggests that rock–water interaction process is the main source for degrading the water quality in the study area.

CONCLUSION

The chemical composition of groundwater of the study area is strongly influenced by rock water interaction and dissolution such as calcium carbonate dissolution, ion-

Table (4): WQI values and water status of study area.

Well No.	WQI values	Class	Water Quality Status
1	164	V	Unfit for drinking & domestic uses
2	171	V	Unfit for drinking & domestic uses
3	173	V	Unfit for drinking & domestic uses
4	170	V	Unfit for drinking & domestic uses
5	162	V	Unfit for drinking & domestic uses
6	163	V	Unfit for drinking & domestic uses

exchange processes, silicate weathering of minerals, which leads to high concentrations of Salinity, Total Hardness, Cations and Anions in the water. During rainfall(winter) recharge followed by a rising water table, reverse ion exchange is predominant; but during the summer followed by the lowering of the water table and ion exchange is dominant.

Based on the WQI classification majority of the samples are falling under class V and unfit for drinking and domestic purposes.

RECOMMENDATIONS

1. To improve groundwater quality for drinking by the villagers, it is possible to use the electric refrigerator to remove the salts by partial freezing method [26].
2. A groundwater assessment study should be conducted every year for under- standing of groundwater qualitystatus.

REFERENCES

[1]. Packialakshmi,S., Deb, M. and Chakraborty, H. (2015). Assessment of ground water quality index in and around Sholinganallur area, Tamil Nadu. Indian J. Sci. and Techn. 8(36): 1- 7.

[2]. Al-Saffawi. A. Y. T., Ali. F. H. and Kanna A. M.A. (2008). Physical-chemical evaluation of ground water in Sherkhan &Kubah and suitability for drinking and domestic uses. The proceeding of the 6th period. Sci. Conference for Dam & Water Res. Center. Mosul Univ. Iraq. 69- 78.

[3]. Al-Saffawi , A. Y. T(2018). Water qualityindex assessment of ground water in Al- Nimrud district of Southeastern Mosul City. Iraq. (in press).

[4]. Dehnavi, A. G., Ramin Sarikhani, R. and Nagaraju, D. (2011). Hydro geochemical

[5]. and rock water interaction studies in East of. Kurdistan, N-W of Iran. Int. J. Envir. Sci. and Res. 1(1): 16 – 22.

[6]. Ramesh, K. and Bhuvana J. P. (2012). Hydrochemical characteristics of ground water for domestic and irrigation purposes in Periyakulam Taluk of Theni District, Tamil Nadu, I Res. J. Envir. Sci. 1(1):19-27.

[7]. Al-Saffawi. A. Y. T. (2013), Qualitative Evaluation of Ground Water in North-Western Mosul City Region. J. Raffid. Environ. 1(1): 33-44.

[8]. Krupa, U. and Parikh, P.(2018). Water Quality Index of Harni Pond, District Vadodara, GujaratInt. J. Allied Pract., Res. and Rev. (IJAPRR). 7(1): 6 – 1.

[9]. Akakuru, O. C. and Akudinobi, B. E. B.(2018). Determination of water quality index and irrigation suitability of groundwater sources in part of coastal aquifers of eastern Niger Dalta, Nigeria.Int. J. Appl. And Natural Sci. (IJANS). 7(1):1- 6.

[10]. Al-Sawaf, F.D.S. (1977). "Sulfate reduction and sulfur deposition in the lower fars formation, Northern Iraq". Economic Geology, 72: 608-616.

[11]. Al-Saffawi, A. Y. T., Al-Snanona,R. A. A. and Al-Sardar, N. M. S. (2018 a). Assessment of water quality by using WQI for some water resources in Abu Maria village, Tall Afar district, Iraq. Educat.& Ssi. J. for pure sci.27(3): 81- 98.

[12]. Al-Saffawi, A. A. Y. T., Al sinjari, W. E. and AL-Taee, Y. A. J. (2018 b). Assessment of groundwater quality using (WQI) in Gleewkhan village northeastern of Iraq. Int. J. Enhanced Res. In Sci.,Tech. & Engin. 7(5): 1 - 7.

[13]. APHA. Standard method for examination of water and waste water. 20^{th} ed., Washington, DC, USA. 1998.

[14]. Al-Saffawi. A. Y. T, and Al-Shanona. R. A. A.(2013), Ecological and Bacteriological study of Ground Water Quality Southeastern Mosul City. The proceeding of the 2^{ed} Scientific Environmental Confer. Univ. of Mosul. Iraq. 137-153.

[15]. Mumtazuddin, S., Azad, A. K., Firdaus, R. and Kumari, A.(2013).Water Quality Evaluation in Some Groundwater Samples along the Budhi Gandak Belt of Kanti Block in Muzaffarpur District during Post-Monsoon Season.J. Chem. Bio. Phy. Sci. 3(1): 605-611.

[16]. WHO.(2002). The guideline for drinking water quality recommendations, World Health Organization, Geneva, 2002.

[17]. Vema, N. Kumar, N.(2014).Quality Characterization of Groundwater at Amroha (Uttar Pradesh). Int. J. Pharmac. & Chemi. Sci.3(1): 274 – 279.

[18]. Rupal, M., Bhattacharya T. and Chakraborty S. (2012). Quality characterization of groundwater using water quality index (WQI) in Surat city, Gujarat, India. Int. Res.

[19]. J. Envir. Sci. 1(4):14–23.

[20]. Shah, M. C., Prateek, G. S., and Pradip, B. A. (2008).Ground Water Quality of Gandhinagar Taluka, Gujarat, India. J. Chem. 5(3): 435-446.

[21]. 19.Al-Saffawi, A. A. Y and Al – Maathidi, A. H (2013)Environmental aspects of Wady Eqab and its effect on Tigris River north of Mosul City. Iraq. J. of Environmental Studies [JES]. 12: 55-61.

[22]. Al-Saffawi, A. A. Y. and Al-Sanjari, W. E. K. (2018).Assessment of water quality for irrigation by using (WQI) in Al-Karrazi valley at Mosul city. Iraq. Al-utroha for Envion. Sci. (5): 57 – 71.

[23]. Kumar , S. K., Logeshkumaran , A., Magesh,N. S., Prince S. Godson, P. S. and Chandrasekar, N. (2015).Hydro- geochemistry and application of water quality index (WQI) for ground water quality assessment, Anna Nagar, part of Chennai City, Tamil Nadu, India. Appl. Wat. Sci. 5:335–343.

[24]. Gorai, A. K. and Kumar, S. (2013). Spatial distribution analysis of ground water quality index using GIS: A case study of ranchi municipal corporation (RMC) area. Sci. Techn. J. 1:1–11.

[25]. Reza , R. and Singh,G.(2010). Assessment of ground water quality status by using water quality index method in Orissa, India. World Appl. Sci. J. 9 (12): 1392-1397.

[26]. Vasanthavigar, M., Srinivasamoorthy, K., Vijayaragavan, K., Rajiv, G. R., Chidambaram, S., Anandhan, P., Manivannan, R. and Vasudevan, S. (2010). Application of water quality for groundwater quality assessment: Thirumanimuttar Sub basin, Tamil Nadu, India. Environ Monit Assess 171(1-4):595–609.

[27]. Magesh, N. S., Krishnakumar, S., Chandrasekar, N. and Soundranayagam, J. P. (2013). Groundwater quality assessment using WQI and GIS techniques, Dindigul district, Tamil Nadu, India. Arab. J. Geosci. 6(11):4179–4189.

[28]. Al-Saffawi, A. A. Y. T. and Al-Sardar, N. M. S. (2018). The possibility of some physical and biological methods to improve the groundwater quality.Educat.& Sci. J. for pure sci. 27(2): 47 – 60.