International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 7 Issue 1, January-2018, Impact Factor: 4.059

Quality characterization of groundwater by using water quality index in Al- Kasik district Northeastern of Mosul City, Iraq

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ABSTRACT

Ground water 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 to assess some physicochemical parameter (pH, Ec_{25}, T. Alkalinity, T. Hardness, Ca, Mg, Na, K, Cl, SO_4, PO_4, and NO_3) of groundwater of Al- Kasik district and present the complex water quality data of the ground water in a form that can easily be understood by the technical and non-technical personal. To achieve the aim, water quality index (WQI) was applied on the analytical results of the parameters to obtain a single value that was used to rank the groundwater at each well. The results of the water quality index showed that four of the five wells investigated can be ranged as poor and the remaining one very poor, The high values of WQI has been found to be mainly from the higher values of EC_{25}, T. Hardness, Ca, Na, Cl and SO_4 in the groundwater. The implications are that the groundwater not suited as a source of drinking water and needs some degree treatment before consumption.

Key word: Groundwater quality, Water quality index, Al-Kasik district.

INTRODUCTION

Drinking water is an important resource that needs to be protected from pollution. Underground water is clean but it depends upon quality and quantity of materials dispersed and dissolved in it. Water picks up impurities in during its flow, which are harmful to man and plants. The reason for contamination and pollution of water in the natural surroundings and in the storage are fertilizers, pesticides, inorganic salts from top soil and geological strata[1]. The quality of ground water is highly related with local environmental and geological conditions. The quality of soil and rock and the water table determines the quality of groundwater[2]. Excess amount of physico-chemical components, cause a certain ecological and physical problems to human. Water with high EC_{25} values have salty taste and produce scale on water heaters and cooking utensils[3], High concentration of sulfate caused catharsis in adult males. Cathartic effects are commonly reported to be experienced by people consuming drinking water containing sulfate in concentrations exceeding 600 mg. l^{-1} although it is also reported that humans can adapt to higher concentrations with time[4]. Dehydration has also been reported as a common side effect following the ingestion of large amounts of magnesium or sodium sulfate. There are subpopulations that may be more sensitive to the cathartic effects of exposure to high concentrations of sulfate. Children, transients and the elderly are such populations because of the potentially high risk of dehydration from diarrhea that may be caused by high levels of sulfate in drinking water[5].

High concentration of sodium produced DNA damage in mammalian assays employing mouse lymphocytes, induced unscheduled DNA synthesis in rats, and caused DNA damage in hamster ovaries, Sodium by itself is not believed to cause cancer. However, several studies suggest that sodium chloride may enhance the cancer risk caused by other chemicals[6]. A chloride present in excess imports the salty taste to water and people who are not accustomed to high chlorides are subjected to laxative effect, due to chloride present in excess amount the salinity of water also increases[7]. The presence of nitrate in water has been associated with certain diseases, like methemoglobinemia, stomach cancer, thyroid cancer, Brain tumors etc. and also certain disease in animal[8,9]. Nitrates may act as procarcinogens, interacting with amines and amides in the stomach to form a variety of *N*-nitroso compounds (NOC) (nitrosation), most of which are potent animal carcinogens[10,11].

Water quality index (WQI), which is one of the most effective ways to describe the quality of water. The WQI which was first developed by Horton (1965) is basically a mathematical means of calculating a single value from multiple test results[12]. After that a number of workers developed WQI based on rating water quality parameters. A Water Quality Index (WQI) is a useful statistical tool for simplifying, reporting and interpreting complex information obtained from any body of water. A simple number given by any WQI model explains the level of water contamination[13,14].

The present study focus on the Water quality index (WQI) of ground water in some wells of Al- Kasik district determined by the physicochemical properties are compared with data international WHO together with recommended water guidelines for drinking and domestic uses.

MATERIALS AND METHODS

Study site: The study was conducted on ground water of Al- Kasik district northeastern Mosul City, Iraq, (Fig. 1).

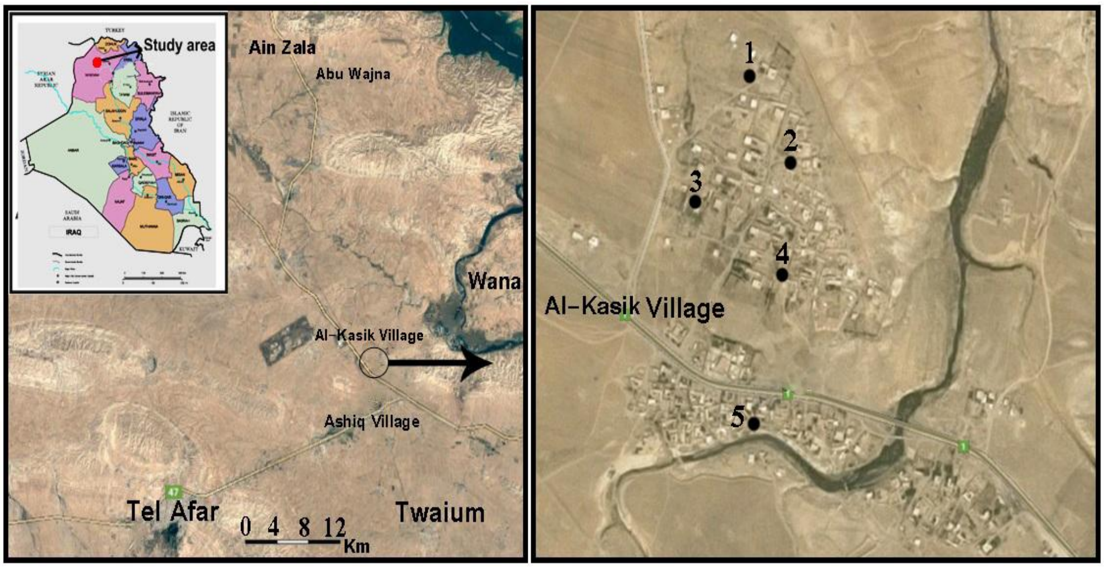

Figure (1): Map of Nineveh Governorate showing study area.

The groundwater in the study area using for drinking, washing and bathing. Al-Alkasik district, has an elevation of about 320 m above sea level[7]. The geological formation in it is Al-Fatha (Lower Fars) which consisting mainly of gypsum, anhydrite, evaporated salts, limestone and marl etc. Therefore, the water well be contains high concentration of sulfur compounds as sulfate, sulphite which combined with other cations as Sodium, Calcium and Magnesium[15].

In present investigation fifteen water sample taken from five different wells (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 sample before it is filled[16].

METHODOLOGY

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[16] as, describes in (Table 1).

Table (1): Methods used for analysis of water samples.

Parameters used	Methods employed
pH	pH meter
Electrical Conductivity (EC_{25})	Conductivity meter
Total hardness(TH)	EDTA titration
Calcium	EDTA titration
Magnesium	By calculation
Sodium	Flame photometer
Potassium	Flame photometer
Total Alkalinity (T, Alk.)	Titration with H_2SO_4
Chloride	Titration by $AgNO_3$
Sulfate	Turbidmatric Method.
Nitrate	Ultra violet screening M.

Estimation of Water Quality Index (WQI):

Eleven physico-chemical parameters consisting of EC, pH, T.Alk, T. Hard., Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-},and NO_3^- were considered in the calculation of WQI. Water Quality Index (WQI) calculation involve three stages. In the first stage, each of the 11 parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes (Table 2). The maximum weight of 5 has been assigned to the parameter nitrate due to its importance in water quality assessment. Magnesium is given the minimum weight of 1 which indicates that, it may not be deleterious. In the second stage, the relative weight (Wi) is computed from the following equation[14,17]:

$$Wi = wi / \sum_{i=1}^{n} wi \quad \ldots\ldots\ldots\ (1)$$

Where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters. Calculated relative weight (Wi) value of each parameter are also given in Table (2).Third stage, a quality rating scale (qi) for each parameter is assigned by dividing its concentration in each groundwater sample by its respective standard according to the guidelines by WHO & BIS[18, 19] and the result multiplied by 100[20]:

$$qi = (Ci / Si) \times 100 \quad \ldots\ldots\ldots\ (2)$$

Where, qi is the quality rating, Ci is the concentration of each parameter in each water sample, and Si is the WHO drinking water standard for each parameter.

For computing the WQI, the sub index is first determined for each parameter, which is then used to determine the WQI as indicated by the following equation[20]:

$$SIi = Wi \times qi \quad \ldots\ldots\ldots\ldots(3)$$

$$WQI = \Sigma\ SIi \quad \ldots\ldots\ldots\ldots\ (4)$$

Table (2): Relative weight (Wi) values of each parameter.

parameter	Si	Weight (wi)	Wi
pH	6.5 – 8.5	4	0.1175470
EC_{25}	1400	4	0.1175470
T. Alk.	200	2	0.0588235
T. Hard.	500	3	0.0882352
Ca^{+2}	200	3	0.0882352
Mg^{+2}	150	1	0.0294117
Na^{+1}	200	3	0.0882352
K^{+1}	200	2	0.0588235
Cl^{-1}	250	3	0.0882352
SO_4^{-2}	400	4	0.1175470
NO_3^{-1}	50	5	0.1470588
Total		Σ wi = 34	Σ Wi = 0.9999

Standard permissible Value (si). (WHO, 2004; BIS, 2010)

Where, SIi is the sub index of ith parameter; qi is the rating based on concentration of ith parameter. The computed WQI values are classified into five types, “excellent water” to “water, unsuitable for drinking”.

RESULTS AND DISCUSSIONS

The values of physico-chemical parameters and WQI of fifteen samples are given in Table (3). The pH of water is an important indication of its quality and provides significant information in many types of geochemical equilibrium solubility calculation[4]. The pH of the groundwater in the study area varied from 6.89 to 7.43. The slight acidic of some of the samples in both wells (4 and 5) may be due to the presence of dissolved carbon dioxide and organic acids (fulvic and humic acids) in the groundwater, which are derived from the decay and subsequent leaching of plant materials[21], However, the pH values of the samples under study are well within the limits prescribed by BIS and WHO for various uses of water including drinking and other domestic supplies.

EC is the most important parameter to demarcate salinity hazard and suitability of water for domestic and irrigation purposes, and changes in its concentration signify water quality deterioration[4] . The mean values ranged from 3091 to 4396 µS. cm^{-1}, all samples were found to be above the maximum permissible limit of BIS[19]. As water moves through geological layers and rocks, it dissolves amounts of minerals and holds them in solution[21].

Table (3): Groundwater physico-chemical characteristics of Al- Kasik district (mg.l^{-1}).

wells		pH	EC_{25}	Alk.	T.H	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3
1	Min.	7.09	3380	179	2167	601	146	225	5.0	218	225	1008	0.63
	Max.	7.27	4716	207	2400	681	219	249	15	253	366	1128	1.39
	mean	7.15	4122	192	2306	636	182	235	8.4	234	309	1066	1.01
	± Sd	0.11	678	14	123	41	37	12	5.1	17.7	74	49.7	0.41
2	Min.	7.00	3558	172	2267	600	182	235	10	210	315	814	0.61
	Max.	7.43	4789	196	2400	661	195	254	15	239	331	1365	2.90
	mean	7.27	4243	186	2322	621	188	245	12	227	323	1066	1.72
	± Sd	0.20	614	12.3	69.0	35	6.6	7.9	2.9	150	8.0	249	1.25
3	Min.	7.01	2591	192	1900	561	85	45	15	234	81	551	0.57
	Max.	7.17	3540	204	2000	661	122	67	20	249	97	818	0.62
	mean	7.11	3091	198	1944	607	104	58	17	242	90	675	0.59
	± Sd	0.08	457	6.0	51.0	50	19	12	2.9	7.5	8.3	110	0.03
4	Min.	6.90	3540	165	2167	601	134	346	5	201	514	1158	0.52
	Max.	7.18	5369	174	2300	681	195	353	16	212	640	1673	2.77
	mean	7.04	4396	170	2239	632	161	350	11	208	565	1412	1.59
	± Sd	0.15	890	4.70	67.0	45	31	4.0	5.7	5.9	66	258	1.23
5	Min.	6.89	3058	190	2000	541	130	121	4.8	232	215	597	0.28
	Max.	6.90	4154	205	2250	641	158	156	10	250	238	820	1.67
	mean	6.9	3851	199	2117	603	149	136	6.6	243	228	736	0.97
	± Sd	0.01	529	8.14	126	54	16	18	2.9	9.87	11	121	0.77

EC_{25}: Electrical conductivity uS/cm., Alk: Alkalinity T. H: Total Hardness., Na: Sodium., K:Potassium Ca: calcium., Mg: magnesium., Cl: chloride., SO4: sulfate., NO3: Nitrate.

Alkalinity is a total measure of substance in water that has “acid- neutralizing” capacity. The main source for alkalinity is due to weathering of rocks. Higher alkalinity value contributes sour and saline taste to water. Although, alkalinity is not harmful to human beings yet the water supplied with less than 200 mg. l^{-1} is desirable, So, all the samples are within the permissible limit of BIS[19].

The major sources of hardness in water are dissolved calcium and magnesium ions from sedimentary rocks whereas minor contribution to the hardness of water is made by ions of aluminum, barium, manganese, iron, zinc etc[22]. The range of total hardness, calcium and magnesium in all the studied groundwater samples were between 1900 - 2400, 541-681 and 130-219 mg. l^{-1} respectively. However, all the water samples showed the range of hardness and calcium exceeded the permissible WHO limits. This high concentration in groundwater is due to the natural accumulation of salts from contact with soil and geological formations[21].

Chloride occurs in all natural waters in widely varying concentration. Excessive concentration in drinking water is not particularly harmful and the criteria set for this ion are based primarily on palatability and its potentially high corrosiveness[23]. Chloride in excess (> 250 mg. l^{-1}) impart a salty taste to water and people who are not accustomed to high chlorides may be subjected to laxative effects[21]. Chloride values ranged from 81at well 3 to 640 mg. l^{-1} at well 4 (40.66% of samples are within the permissible limit). Sulfate found naturally in groundwater from the dissolving of minerals like gypsum and anhydrite[23], In the study area sulfate mean concentration ranged from 675 mg. l^{-1} at well 3 to 1412 mg. l^{-1} at well 4 (Table 3). The maximum value for SO_4^{-2} should be less than 400 mg/l, but all of samples exceeded this limit, a high concentration of sulfate in drinking water may induce diarrhea[21].

Nitrate is an important parameter in water quality assessment, It may be found naturally in groundwater or due to the human activities such leaching of animal manure or chemical fertilizers[24]. In the present study NO_3^- values ranged from 0.28 mg. l^{-1} at well 5 to 2.77 mg. l^{-1} at well 1 (Table.3). Nitrate concentration should be less than 50 mg. l^{-1} in drinking water (all of samples are within the permissible limit)

Water quality index (WQI):

The main objective of a water quality index is to turn complex water quality data into information that is understandable and useable by the population of the area. Water quality index based on some very important parameters can provide a simple indicator of water quality. It gives the public a general idea of the possible problems with water in a particular region[29]. As per the classification based on water quality index and the computed WQI values and the water quality during the study period have been indicated in Tables (4, 5). WQI values ranged from

132.36 at well 3 to 201.23 at well 4. Groundwater samples ranged from poor water quality at wells 1, 2, 3, 5 to very poor water at well 4. The high value of WQI at these wells has been found to be mainly from the higher values of EC_{25}, total hardness, calcium, sodium, chloride and sulfate may be responsible for poor and very poor water quality at these wells and water from these wells are unfit for drinking purpose. About 80% of water samples are poor quality and 20 percent of water samples are very poor quality and should not use directly for drinking purpose. The results reveals that the groundwater of the area needs some degree of treatment before consumption by partial or complete freezing which reduced conductivity, T. hardness, T. alkalinity Chloride and sulphate[3] and it also needs to be protected from the perils of contamination.

Table (4): water quality classification based on WQI value [20].

WQI value	Water status
<50	Excellent water quality
50 - 100	Good water quality
100 - 200	Poor water quality
200 - 300	Very poor water quality
>300	Unsuitable for drinking

Table (5) Water Quality Index and water status at each well.

Well No.	WQI	Water status
1	172.98	Poor water quality
2	168.94	Poor water quality
3	132.36	Poor water quality
4	201.23	Very poor quality
5	153.83	Poor water quality

REFERENCES

[1]. Tambekar D. H. and B. B. Neware, B. B. (2011). Water quality index and multivariate analysis for groundwater quality assessment of villages India. Sci. Res. Reporter. 2(3): 229-235.

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

[3]. 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.

[4]. 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.

[5]. WHO. (2004). Sulfate in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality World Health Organization.

[6]. US. EPA. (2003). Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Sodium. U.S. Environmental Protection Agency Office of Water (4304T). *www. epa. gov/safewater/ccl/pdf/sodium.pdf.*

[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]. Ward, M. H., Kilfoy,B. A., Weyer,P. J., Anderson, K. E., Folsom, A. F. and Cerhand, J. R. (2010) Nitrate Intake and the Risk of Thyroid Cancer and Thyroid Disease. Epidemiology. 21(3): 389- 395.

[9]. Weng, H., Tsai,S., Wu,T., Sung, F., and Yang, C. (2011). Nitrates in drinking water and the risk of death from childhood brain tumors in taiwan. J. Toxic. & Environ. Health, Part A, 74:769–778.

[10]. Yang, C.Y., Chiu, H. F,. Chiu, J. F. Cheng,M. F, and Kao, W. Y. (1997). Gastric cancer mortality and drinking water qualities in Taiwan. Arch. Environ. Contam. Toxicol. 33, 336–340.

[11]. Al-Saffawi, A. Y. T. (2018). Assessment of groundwater for irrigation and domestic suitability by using (WQI) in Singiar district eastern of Mosul city. Iraq. Proceeding of 2nd Int. conference of science and Art. University of Babylon and Liverpool John Moores Univer., UK. Mesopotemia Environ. J. Special Issue F: 75-84.

[12]. Bakari, A. (2014). Hydrochemical assessment of groundwater quality in the Chad Basin around Maiduguri, Nigeria, J. Geol. Min. Res. 6(1): 1-12.

[13]. Ishaku, J. M., Ahmed, A. S. and Abubakar, M. A. (2012). Assessment of groundwater quality using water quality index and GIS in Jada, northeastern Nigeria. Int. Res. J. Geol. and Mining. 2(3): 54-61.

[14]. Priya, K. L., Jebastina. And Prince, A. G.(2012). Assessment of water quality indices for groundwater in the singanallur sub-basin, Coimbatore, India. : http://dx.doi.org/10.4172/scientificreports.186.

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

[16]. American Public Health Association (APHA), (1998). Standard method for the examination of water and waste water (20th ed.) Washington D.C. USA.
[17]. Howladar, M. F., Al-Numanbakth, A. M. and Faruque, M. O. (2017). An application of water quality index (WQI) and multivariate statistics to evaluate the water quality around Maddhapara granite mining industrial area, Dinajpur, Bangladesh. Envirn. Syst. Res. 6(13): 1-18.
[18]. WHO, (2004). Guidline for drinking water quality, Word Health Organization, Geneva.
[19]. Bureau of Indian Standards (BIS), "Indian Standard specifications for drinking water", IS 10500, 1991 with third amendment, July 2010. In: Sapkal, R. S. and S. S. Valunjkar, S. S. (2013).Development and sensitivity analysis of water quality index for evaluation of surface water for drinking purpose. Int. J. Civil Engin. & Techn. (IJCIET). 4(4): 119-134.
[20]. Boateng, T. K., Opoku, F., Acquaah, S. O. and Akoto, O. (2016). Groundwater quality assessment using statistical approach and water quality index in Ejisu-Juaben Municipality. Ghana Environ Earth Sci. 75(489): 1-14.
[21]. Kablan, A. Y. H., Al-Hamdany, I. O. S. and Al-Saffawi, A. Y. T. (2018). Application of CCMEWQI to assessment the environmental status of ground water for drinking and domestic uses in left bank of Mosul city. north Iraq. Accepted for publication in Alutroha J. Environ. Sci.No. 6.
[22]. 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.
[23]. 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.
[24]. Al-Saffawi, A. A. Y. T. and Al-Maathidi, A. T. H. (2017). Assessment of Wady Eqab wastewater quality for irrigation and livestock in the north of Mosul city. Iraq. Tekriet J. for Pure Sci. 22(12): 14-20.