Study the Effect of Baghdad City on the Tigris River Water Pollution

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Abstract: Water pollution is the most important tasks facing all countries in the world to obtain suitable water for municipal, industrial, and agricultural uses. This study concerns with the effect of Bagdad city waste water on pollution and quality of Tigris River water using index of Aquifer water quality (IAWQ). The accuracy of chemical analyses of the selected water samples are conduced according to world standards of health classifications. Results of these analysis show that only two types of the 13th tested sample are (certain) ,while the other patterns (models)are of the (probable certain). Cluster analysis is applied to evaluate the studied water characteristic. The results of the cluster analysis show the presence of three varying groups in their impact on their chemical properties on water .According to the cluster analysis and permissible limits of the variables, three chemical variables cadmium, lead, and calcium are selected to indicate its impact on the studied area. It is found that when using (IAWG) for the Tigris River, there is an increase in the values of the index along the river from its entry to Baghdad until it meets the Diyala river, showing a clear pollution of the Tigris river water.

دراسة تأثير مدينة بغداد على تلوث مياه نهر دجلة

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الخلاصة: يعد تلوث الميـــــــاه من أهم الصعاب التي تواجه اغلب دول العالم للحصول على المياه الصالحه للاستعمالات البلدية والصناعية والزراعية. تناول البحث دراسة تأثير المخلفات السائلة الناتجة من مدينة بغداد والملقات في مياه نهر دجلة عن طريق تطبيق المؤشر العام لنوعية المياه Index of Aquifer Water Quality (IAWQ). تم فحص دقة التحاليل الكيميائية لنماذج المياه و حسب تصنيف الصحة. بينت هذه التـــحاليل إن نموذجين من الثلاثة عشر نموذج التي تم اختيارها هي من نوع (certain) و باقي النماذج من نوع (Probable certain). تم تطبيق التحليل العنقودي لتقييم خصائص المياه واظهرت نتائج التحليل وجود ثلاث مجاميع تتباين في تأثيرها على الخصائص الكيميائية. بالاعتماد على التحليل العنقودي و النسب المئوية المسموح بها للمتغيرات تم اختيار المتغيرات الكيميائية الثلاث الكادميوم والرصاص والكالسيوم لبيان تاثيرها على منطقة الدراسة. لقد تبين من خلال دراسة قيم مؤشر نوعية مياه على مياه نهر دجلة ان هنالك زيادة في قيم المؤشر على طول النهر من بداية دخولة لمدينة بغداد و انتهاء بالتقائة بنهر ديالى مما يدل على تلوث نهر دجلة بشكل واضح .

*** Keyword: water pollution, water quality, IAWQ, cluster analysis**

Introduction:

The aquatic environment is one of the environmental elements and exists side by side with the environment (air, soil) and is associated with a range of factors and conditions influence the living organisms [1]. In connection with the pollution, one of the elements of the environment or the debris, this can include any change in the balance of the elements of the natural environment [2]. The water pollution of both types (natural and industrial) is the most important problems faced by most countries of the world, but the amount of pollution is different from one country to another. However, the major pollution of the water comes from the population and the industrial basis [3]. The idea of studying the impact of the city of Baghdad waste disposal in the waters of the Tigris River using the application of the general index of the quality of water for drinking, giving a wide range to evaluate the people activities and industry of the city and their effects on river water, especially that there is a clear reduction in the discharge of the river in recent years. The health and economic importance lies in giving a clear picture of health and environmental impact in the population of the city of Baghdad and cities south of Baghdad, which depends on the withdrawal of water from the river and directly used for different purposes (domestic and industrial) using general index of the quality of drinking water for human use.

The purpose of present study is to investigate the effect of Baghdad city waste disposal on the water quality of the Tigris River. The Index of Aquifer Water Quality (IAWQ) method is used to indicate the impact of selected pollutants resulting from human and industrial activities of Baghdad city on Tigris River.

The study area:

The study area is located in central part of Iraq, within the alluvial plain sector, which represents the western part of the unstable shelf , between latitudes (33°25'-33°44') and longitudes (44°16'-44°29') as shown in Fig. (1). Tigris River runs through the city of Baghdad in the mature stage forming river meandering and a number of islands due to the decrease of river velocity and increase in sedimentation. Tigris River divides Baghdad into two parts (Karkh and Rusafa). Diyala River with a (300) km length meets the Tigris River south of east of Baghdad. Also, the military channel receives water from the Tigris River in the northern part of the study area and flow in the southern part of the Diyala River. On the other hand, the city of Baghdad consists of nine units, five of them belong to Municipality of Rusafa and the other four to the Karkh district, and each unit contains a number of small municipal districts, and linked to all units of the municipal network of highways. The area of the Municipality of Baghdad is about (869.031) km^2 [4].

Hydrochemical characteristics:

The spatial and temporal changes contribute in the creation of changes in water quality, whether they were surface or ground water. The chemical, physical and biological properties of water are considered as a fundamental criterion to evaluate the validity and quality of that water. Therefore, a set of tests and measurements must be conducted to determine the properties and behavior of water. In the present study, the hydrochemical characteristics are investigated depending on data performed by Al-Maliki [4], which includes (13) site, distributed on the Tigris River from the beginning of its entry to the city of Baghdad and the end of it meets the River Diyala as shown in Fig. (1). Table (1) illustrates the sites name and their latitudes and longitudes. The chemical analyses of these data are examined by the researchers according to the Health classification [5]. The results of analysis (Annexure A) show that the two models (3, 11) of type (certain) and the rest of the models of the type (Probable certain), so it can rely on chemical analysis in the hydrochemical interpretations. Table (2) shows statistical parameters of the chemical analysis. Also, the time series of concentrations of cations and anions of the selected data are studied. It has been shown that there is a direct relation of the polynomial type of the third degree and a high correlation (R-square value is more than 0.7) for most elements as shown in Fig. (2). These results gave an evidence of deterioration of water quality during the flow of Tigris River within the city of Baghdad due to factors resulting from population and land use that contribute directly to water pollution. It is observed that all the parameters under study almost follow same developed curve except SO4, NO3 and HCO3 which recorded irregular high concentration at different stations. The reason for the high sulfate (SO4) ion concentrations in the waters of the Tigris River in some stations is due to the impact of sewage and soil drainage processes of the banks as well as the industrial waste water. Also, it is observed that the high concentration station is in an area of industrial activity represented with the oils factories. Similarly, The reason for the high nitrate concentrations in the waters of the Tigris river is due to the impact of industrial divorced water, wastewater and drainage water resulting from soil fertilization processes as well as rain water that dissolves these components and interact with them and carry up with flooding to the water of the Tigris River. Also, it observed that the high concentration station is in an area of industrial activity oils factories. In contrast, The main reasons make the different in concentrations of (HCO3) in the waters of the Tigris River are the different rainfall rate and the value of (pH). This is due to the ability of carbon dioxide to decomposition and mixing with other elements. In addition, the concentrations of (HCO3) also vary as a result of differences in temperature and air pollution due to the interaction of (CO2) with rain water and atmospheric gases which transforms into (HCO3). This is found in the stations with the gathering traffic and high population density (Kadhimiya and Jadiriya).

Also, Fig. (2) shows the amount of influence of the selected sample locations on the Tigris River where it is observed the turbulent increase in concentration of most variables under study with the progress of the Tigris River. These concentrations reach to the highest level at the point connect between Tigris and Diyala Rivers (Diyala River effluent). This gives an indication of the extent of the impact of pollutants transported with the water of this river.

Water quality and validity of use:

As mentioned earlier the water quality in general depends on the chemical, physical and biological characteristics of water. The power of water for different uses is determined by the above mentioned characteristics. The quality of water depends on the concentrations of inorganic contaminants, which includes elements such as (Nitrates and Boron and Fluoride) and the group of rare or scarce elements (such as Cadmium, Lead, Manganese, Iron, Copper, Zinc, Nickel and Chromium) [6].

The water quality is important regarding to regardless of its water availability. The water may be valid for a particular use and unsuitable for other [7].

World wide a multi-standard specifications were developed for drinking water, including the limits of salinity, and the limits of concentrations of positive and negative ions in the water. The main specifications are (USPHS) [8], (WHO) [9] and Iraqi slandered (1996). These specifications are based on the concentration of each individual ion and its impact on health and do not depend on the presence within the group. Therefore, the importance of this study appears to determine the general indicator of water quality (IAWQ).

Index of Aquifer Water Quality (IAWQ):

The subject of water quality assessment is considered of the most recent research topics and there is a very limited number of research's on this topic. The Index of Aquifer Water Quality (IAWQ) is selected, which was proposed by Melloul and Collin [10] to be used in this research. The general formula of the index is:

$$IAWQ = C/n\left[\sum_{i=1}^{n}(Wri.Yri)\right] \qquad (1)$$

Where, the value of C is equal to 10 and representing the highest extent of the variables, n is the number of variables used and the value of $W_{ri} = (W_i / W_{max})$, Where Wi represents the weight of the variable, W_{max} represents the proposed maximum weight (equal to 5). The value of $Y_{ri}=Y_i/Ymax$, Where, Y_i is computed from the following equation:

$$Y_i = -0.712\ X_i^2 + 5.228\ X_i + 0.484 \qquad (2)$$

The value of Y_{max} represents the maximum proposal mean (equal to 10). The index has been applied by Melloul and Collin [10] of two variables only (Cl and NO_3). The adoption of the researcher's personal diligence in giving weights to these two variables.

Cluster analysis:

Cluster analysis is used where the chemical groups formed a cluster of variables depending on the similarity of properties of these variables with each other, thus giving an idea of the impact of these variables in the quality of the waters of Tigris River as shown in Fig. (3). Evaluation of the results of cluster analysis for characteristics of water, which represents (13) models based on (17) variables demonstrate the existence of three groups vary in different impact of these variables on the chemical properties. The first group is a group (EC, TDS), where there is a convergence between the two variables and such group is considered with a strong and direct impact due to the representation of these two variables a sum of positive and negative elements. The second group is the set of elements (HCO_3, SO_4, Cl, Ca, Na). The third group are the chemical variables (Ni, Zn, Co, Fe, Cu, Cd, Pb, K, Ph, Mg), which share the feature to moral correlation of smaller magnitude compared with the second group. Also, the concentrations of the variables are almost closer to each other.

The percentage of the allowable limits:

In order to determine the most important elements in the study area, the percentage of the number of elements that exceed the permissible limits and according to international standards WHO is computed as shown in Fig. (4). It is clear from that figure that all the ions are less than (10%) and this is within the permissible limits except the ions of cadmium, calcium and lead. The ratios of these ions are (100% and 78% and 45% respectively). It is known that the above elements (cadmium, calcium and lead) cannot be removed by conventional water treatment methods currently used in most water treatment plants in Baghdad. Therefore, the use of water of the Tigris River as raw water for these treatment plants leads to the produced water containing the same concentrations of the above elements and for this reason the results are compared with international standards WHO of drinking water.

Based on cluster analysis and the permissible limits for the elements the following three chemical variables are selected for the application of the equation of the water quality index of reservoirs. This results from the fact that the percentages of permissible models for these three variables are high as well as the high correlation with the rest of the variables.

Cadmium Cd:

The most important sources are the minerals Pyroxene and Apatite and Biotite and Feldspar rich in Calcium [11]. It is also presents in a mixture of Cadmium Sulphide with Zinc, Copper, and Lead. They are also present in soils, rocks, sand and oil [12]. The Phosphate fertilizer, domestic waste water and outputs of industrial activities are considered the sources of cadmium too [13]. When the value of pH in water increases, Cadmium in the water is adsorbed by the sediment [14] and on the surfaces of minerals Calcite [15]. The Cadmium has tendency to associate with Sulphide and is deposited under reduced conditions in the form of cadmium sulfide [16]. Cadmium is considered as poison and pollutant of the environment and is of less importance in life processes and does not have significant benefit in building neighborhoods [17]. The status of Cadmium is favored in the acidic and oxidizing environment is dissolved condition [18].

The concentration of Cadmium in the water of study area ranges between (0.005 - 0.5) mg / l and an average of (0.048) mg / L and all values are more than the permissible limits (0.005 mg/l) in drinking water. It is believed that the reason for that due to the existing minerals and the soil containing Cadmium, using of phosphate fertilizer and the impact of domestic and industrial waste water.

Lead Pb:

Lead is located in many of rocks like the igneous rocks above the base, such as olvine, Pyroxene, amphibole, feldspar, potassium, and chlorite. It is also found in clay some minerals like Montmorillomte and sulfides minerals such as (Galena, Cerusite, Anglesite) and slightly in the ground water due to lack soluble of lead compounds in water [19] and its solubility in water is in oxidizing conditions and acidic environment. Lead is considered as a toxic element and the increase of its concentration causes many diseases [20]. Lead appears in the waste water and also other sewages results from the installation of polymers, printing operations, and fuel. It is a toxic element and its effect on the soft water more than hard water [21].

The concentration of lead in the water of the study area ranges between (0.007-0.4) mg / l and an average of (0.043) mg / l. Almost half of the symbols are of concentration more than the permissible limits (0.05 mg/l) in drinking water. This increment of lead in the waters of the Tigris River within the study area due to the influence of divorced laboratories and factories, which empties pollutants into the river without treatment, especially in the stations located in the Al-Zaafranya and down to the Diyala River.

Calcium ion Ca +2:

The main source of calcium ion in water comes from chemical weathering of rocks containing this ion, which present in sedimentary rocks such as limestone, dolomite, gypsum, Ragonite and other minerals in igneous rocks such as Fildspar, Amphiboles and Pyroxenes [22]. The ratio of calcium in the sedimentary rocks (approximately 30.23%) [20].

Calcium reacts rapidly with water forming calcium oxide and combines with the bicarbonates of calcium and calcium bicarbonates are responsible for a temporary basis on the composition of hardness of water [23]. The processes of photosynthesis leading to increased carbon oxide CO_2 in the atmosphere and therefore melt in the rain and increasing CO_2 in the water and increase the ability of melting lime stone and in turn, increase the ratio of calcium ion. The increase in temperature leads to increase pH and composition of non-acidic conditions, which in turn reducing the melting of rocks and minerals contain calcium [24]. The concentration of calcium in the waters of the study area ranges between (60-244) mg / l and an average of (95) mg/l. Almost, two third of the symbols are of concentration more than the permissible limits (75 mg/l) in drinking water due to the reasons as mentioned above.

Computation of IAWQ value:

The values of (IAWQ) of the variables (Cd, Pb, and Ca) are calculated by applying equation (1). The weight of the variables (Cd, Pb, Ca) are determined depending on the degree of influence and significant of these variables. The weight of calcium is determined as minimum weight and equal to (1) (as with less impact importance to human health), while cadmium and lead are given the highest weight and equal to (5). The importance of these two variables comes from their impact on human health). The results of applying equation (1) and proposed weights of the three variables are tabulated in Table (3). Also, the variation of (IAWQ) with the sample location is shown in Fig. (5). It is observed that the value of (IAWQ) increases with the progress of Tigris River from location 1 to 6, then decline and the variation become turbulent reaching to the maximum value in location 13 which represent the intersection of Tigris River with Diyala River (effluent of Diyala River).

Conclusions:

In order to studying the impact of Baghdad city on the Tigris river water pollution, the hydrochemical characteristics are investigated depending on data performed by Maliki [4], which includes (13) site, distributed on the Tigris River from the beginning of its entry to the city of Baghdad and the end of it meets the River Diyala**.** The results of analysis show that the two models of type (certain) and the rest of the models of the type (Probable certain), so it can rely on chemical analysis in the hydrochemical interpretations. Cluster analysis is used and the evaluations of the results for characteristics of water, which represents (13) models based on (17) variables demonstrate the existence of three groups vary in different impact of these variables on the chemical properties. Based on cluster analysis and the permissible limits for the elements the three chemical variables (cadmium, calcium and lead) are selected for the application of the equation of the water quality index of reservoirs.

Based on the index values of the quality of water reservoirs of the Tigris River it is found that there is an increase in the values of the index along the river from its entry to the city of Baghdad to the end of its connection with the River of Diyala. This increase in (IAWQ) index is due to several reasons; such as, low water levels divorced, impact of industrial plants and factories scattered widely along the river especially in the area of Al-Zafaranya, the effect of vegetable oils factories, and the impact of irrigation water and sanitation stations, which launches directly into the river from humans and industrials activities without any treatments.

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Table (1) Locations of Selected Water Symbol

Station. No.	Station	X	Y
S01	Al-Rashediya	44.3119	33.4628
S02	Al-Adhamiya	44.3457	33.3877
S03	Al-Kadhimiya	44.3498	33.3613
S04	College of Medicine	44.3721	33.3439
S05	Bab Al-Sharqi	44.4065	33.3177
S06	Al-Jaderiya	44.3741	33.2829
S07	Al-Dora Refinery	44.4117	33.2828
S08	Al-Dora Power Station	44.4431	33.2886
S09	The Oils	44.453	33.2482
S10	Al-Zaafaraniya	44.467	33.2308
S11	Al-Zaafaraniya/Saaeda	44.4959	33.23
S12	Al-Zaafaraniya/Bastana	44.5149	33.2251
S13	Diyala River Effluent	44.5042	33.2185

Table (2) Statistical Results of Chemical Analysis of Water Symbol

Characteristics	Min.	Max.	Mean	Median	SD	WHO standard
Physical						
pH, (standard units)	7.05	8.89	7.52	7.30	0.52	6.5-8.5
Specific conductance, (μmhos/cm)	806.00	1249.00	961.98	896.00	132.84	-
Total dissolved Solid, (mg/L)	305.00	1260.00	617.77	595.00	241.74	500
Major ions (Dissolved) (mg/L)						
Calcium (Ca^{2+})	60.00	244.00	95.85	85.00	46.00	75
Magnesium (Mg^{2+})	22.00	120.00	36.38	30.00	25.41	
Potassium (K^{+})	1.50	10.00	2.40	1.70	2.29	12
Sodium (Na^{+})	55.00	350.00	94.85	70.00	78.01	
Biocarbonate (HCO_3^{-})	122.00	225.70	157.93	152.50	28.72	
Sulphate (SO_4^{2-})	113.00	343.00	159.04	140.00	60.07	250
Chloride (Cl^{-})	70.80	375.20	110.32	81.40	80.99	250
Nutrients (mg/L)						
Nitrate(NO_3^{-})	1.63	8.30	4.05	3.24	2.10	
Phosphate (PO_4)	2.60	5.40	3.47	3.20	0.85	
Metals (Total) (mg/L)						
Cadmium (Cd)	0.005	0.500	0.048	0.010	0.136	0.005
Iron (Fe)	0.040	2.000	0.256	0.140	0.525	0.3
Copper (Cu)	0.020	2.000	0.179	0.025	0.547	0.1
Cobalt (Co)	0.005	0.400	0.051	0.010	0.108	
Zinc (Zn)	0.060	5.000	0.528	0.150	1.346	0.5
Lead (Pb)	0.007	0.400	0.043	0.010	0.107	0.05

Table (3) Computation of (IAWQ) for Different Sample Locations

No	Code	Ca					Pb					Cd						IAWQ
		Wi= 1, Wri = 0.4					Wi=5 , Wri = 1.0					Wi=5, Wri = 1.0						
		Con. (ppm)	Xi	Yi	Yri	Wri * Yri	Con. (ppm)	Xi	Yi	Yri	Yri * Wri	Con. (ppm)	Xi	Yi	Yri	Wri * Yri	∑Wri Yri	
1	S01	60	0.73	3.92	0.39	0.16	0.01	0.70	3.79	0.38	0.38	0.01	1.67	7.23	0.72	0.72	1.26	4.20
2	S02	72	0.80	4.21	0.42	0.17	0.01	0.80	4.21	0.42	0.42	0.01	2.33	8.80	0.88	0.88	1.47	4.90
3	S03	70	0.76	4.05	0.40	0.16	0.01	0.80	4.21	0.42	0.42	0.01	2.33	8.80	0.88	0.88	1.46	4.88
4	S04	95	1.00	5.00	0.50	0.20	0.02	1.50	6.72	0.67	0.67	0.02	5.67	7.24	0.72	0.72	1.60	5.32
5	S05	85	0.87	4.49	0.45	0.18	0.01	1.00	5.00	0.50	0.50	0.01	3.00	9.76	0.98	0.98	1.66	5.52
6	S06	80	1.33	6.18	0.62	0.25	0.02	2.00	8.09	0.81	0.81	0.01	3.33	10.00	1.00	1.00	2.06	6.85
7	S07	80	0.93	4.73	0.47	0.19	0.01	1.00	5.00	0.50	0.50	0.01	2.67	9.37	0.94	0.94	1.63	5.42
8	S08	100	1.13	5.48	0.55	0.22	0.03	3.00	9.76	0.98	0.98	0.02	6.67	3.68	0.37	0.37	1.56	5.21
9	S09	90	1.05	5.19	0.52	0.21	0.02	2.00	8.09	0.81	0.81	0.02	5.00	8.82	0.88	0.88	1.90	6.33
10	S10	85	0.89	4.57	0.46	0.18	0.01	1.00	5.00	0.50	0.50	0.01	3.33	10.00	1.00	1.00	1.68	5.61
11	S11	85	0.93	4.73	0.47	0.19	0.02	1.50	6.72	0.67	0.67	0.01	3.33	10.00	1.00	1.00	1.86	6.20
12	S12	100	1.33	6.18	0.62	0.25	0.01	1.00	5.00	0.50	0.50	0.01	3.00	9.76	0.98	0.98	1.72	5.74
13	S13	244	4.67	9.37	0.94	0.37	0.4	40.00	10.00	1.00	1.00	0.5	166.67	10.00	1.00	1.00	2.37	7.92

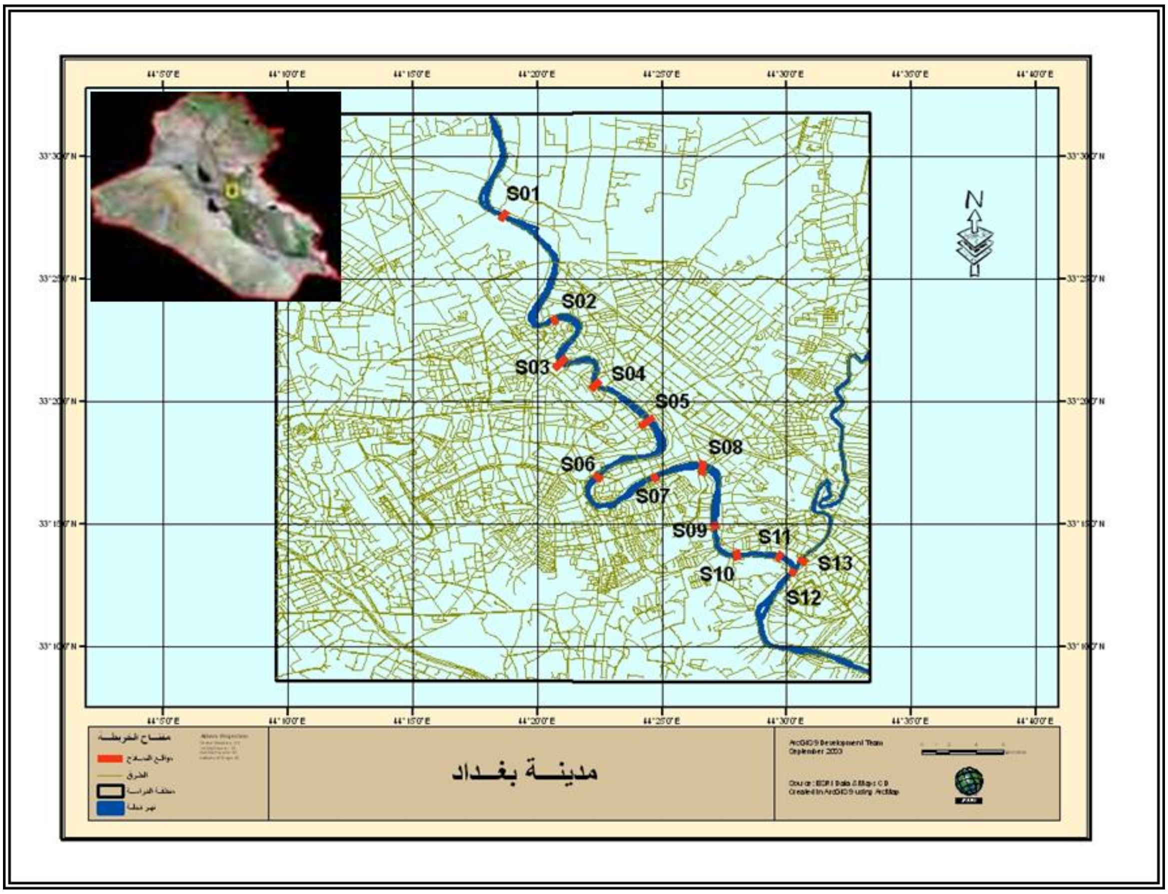

Fig. (1) Latitudes and Longitudes of the Study Area

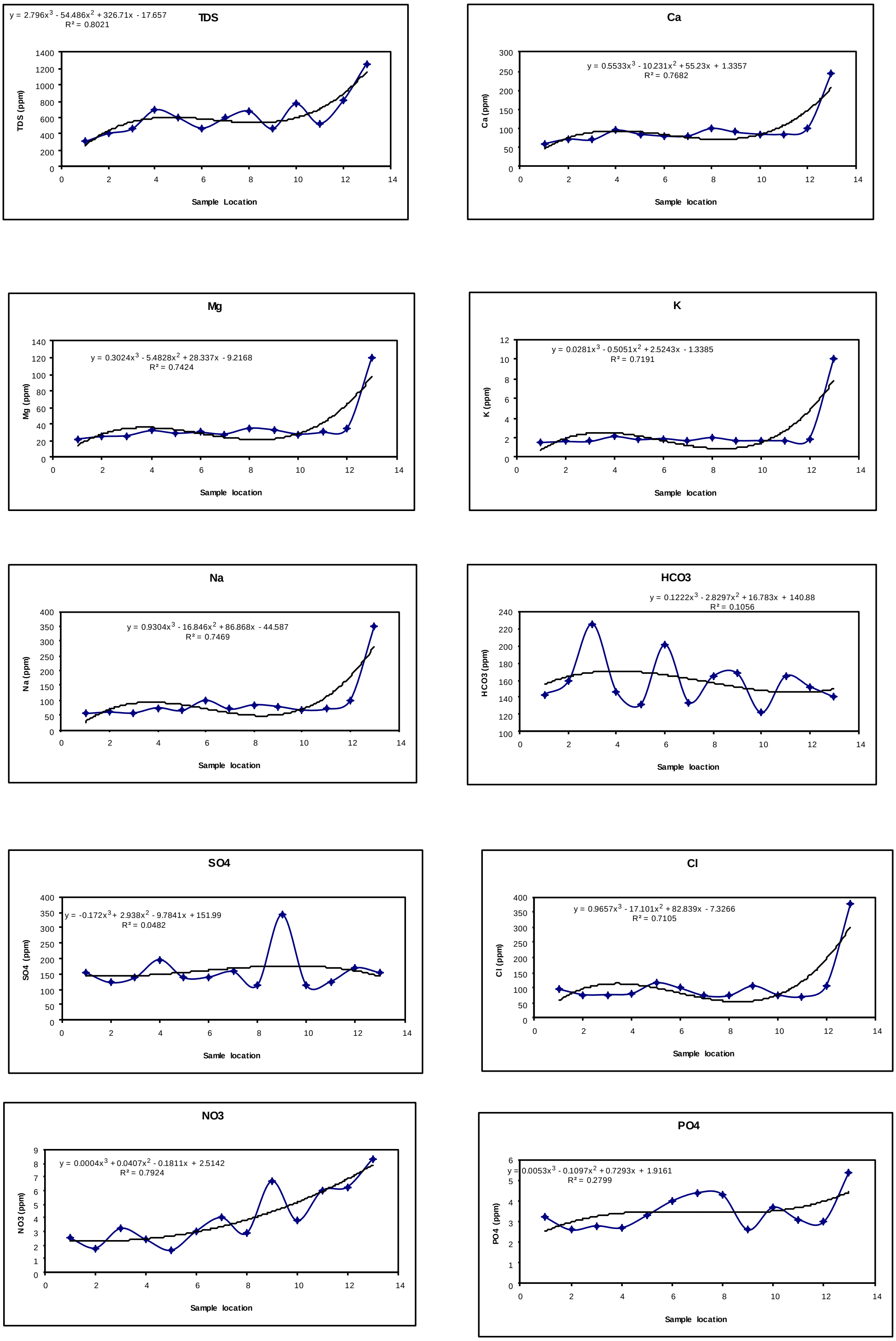

Fig. (2) Variation of the Concentration of Different Elements with Sample Location

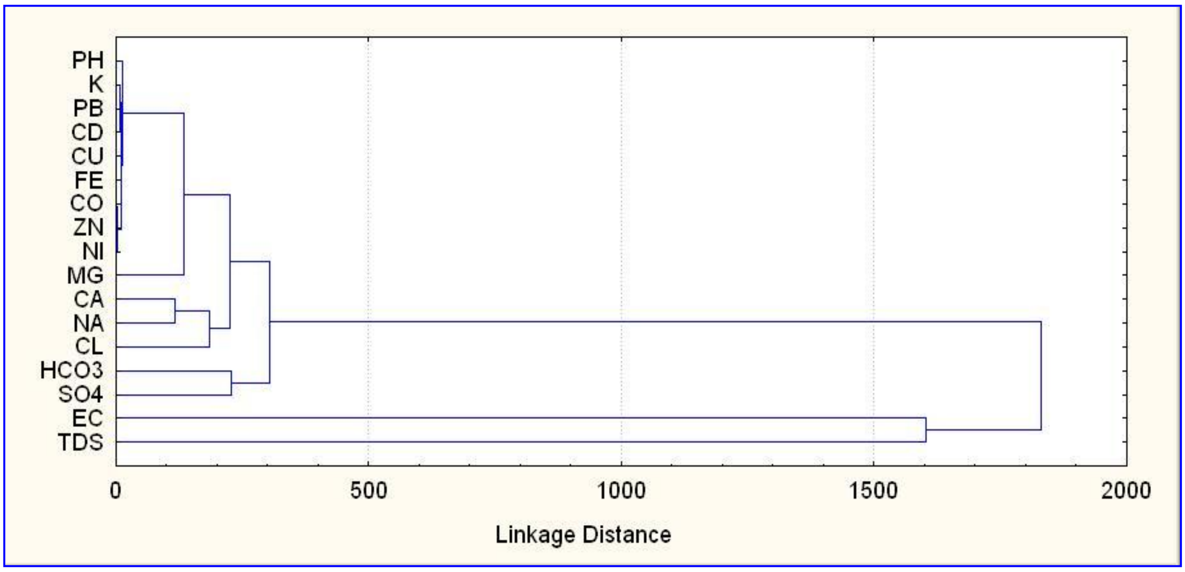

Fig. (3) Cluster Analysis

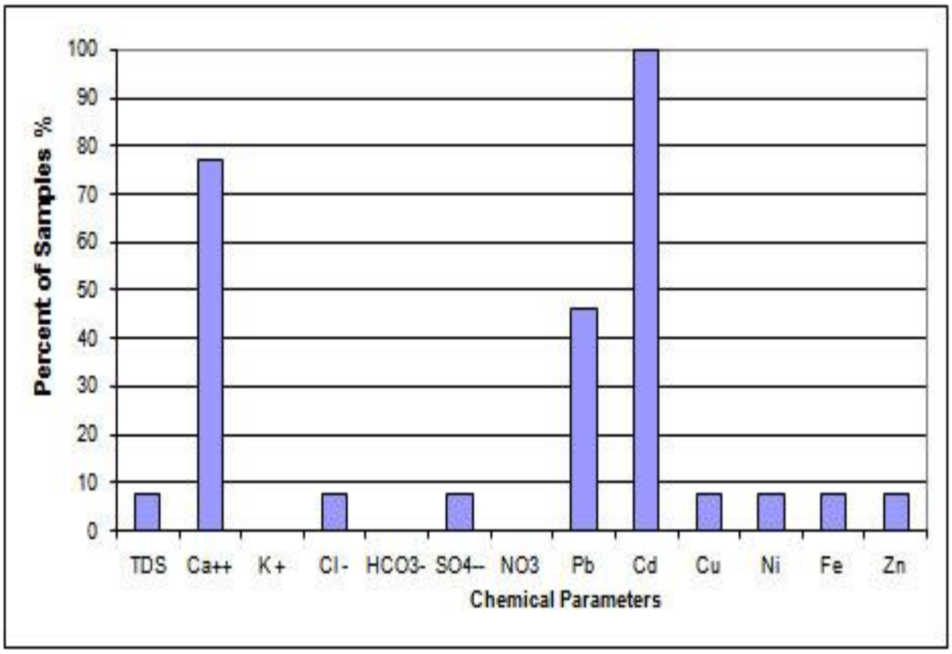

Fig. (4) Percent of samples exceeding the WHO Standard

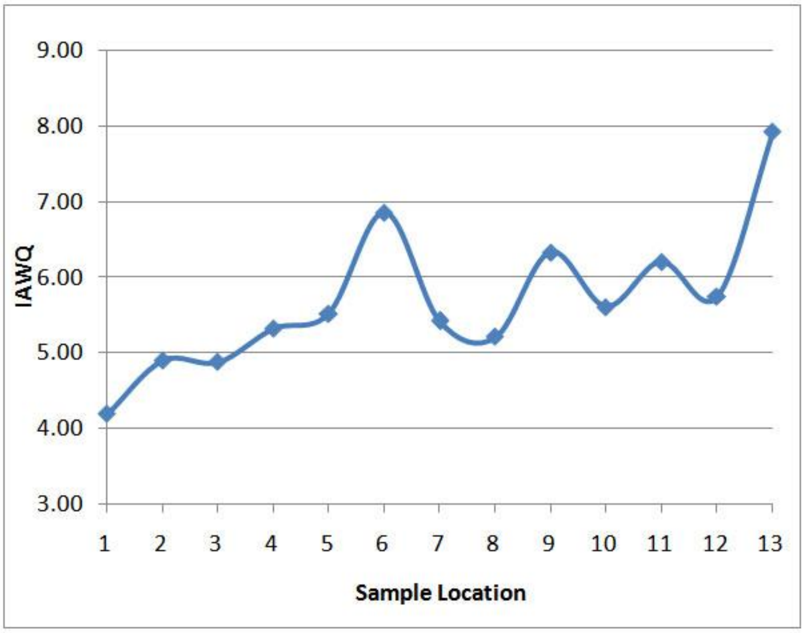

Fig. (5) Variation of IAWQ with Sample Location

Annexure A

Code	Name	X	Y	pH	EC	TDS	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	NO3	PO_4^{-3}	Accuracy (A)	Type of Accuracy	Pb	Cd	Cu	Co	Ni	Fe	Zn
S01	Al-Rashediya	44.312	33.463	7.06	885.4	305	60	22	55	1.5	95.9	143.4	154.3	2.5	3.2	93.09	Probable certain	0.007	0.005	0.02	0.005	0.004	0.04	0.06
S02	Al-Adhamiya	44.346	33.388	7.05	840.6	405	72	25	60	1.6	77.9	158.6	122.2	1.8	2.6	94.07	Probable certain	0.008	0.007	0.02	0.006	0.007	0.07	0.08
S03	Al-Kadhimiya	44.350	33.361	7.2	858.8	460	70	26	57	1.6	77.9	225.7	138	3.24	2.8	96.05	Certain	0.008	0.007	0.02	0.006	0.005	0.06	0.07
S04	College of Medicine	44.372	33.344	7.74	1249	695	95	32	75	2.1	81.4	146.4	197	2.41	2.7	90.51	Probable certain	0.015	0.017	0.025	0.09	0.008	0.1	0.15
S05	Bab Al-Sharqi	44.406	33.318	7.14	877	595	85	29	65	1.8	116.8	131.5	138	1.63	3.3	93.55	Probable certain	0.01	0.009	0.02	0.01	0.008	0.1	0.12
S06	Al-Jaderiya	44.374	33.283	7.3	988	472	80	30	100	1.9	99.1	201.3	140	3.04	4	90.97	Probable certain	0.02	0.01	0.025	0.008	0.007	0.15	0.12
S07	Al-Dora Refinery	44.412	33.283	7.1	1110.5	595	80	28	70	1.7	74.3	134.2	158	4.03	4.4	89.83	Probable certain	0.01	0.008	0.025	0.008	0.007	0.08	0.1
S08	Al-Dora Power Station	44.443	33.289	7.28	1017	680	100	35	85	2	153	164.7	114	2.88	4.3	89.64	Probable certain	0.03	0.02	0.03	0.01	0.01	0.15	0.2
S09	The Oils	44.453	33.248	7.83	982.4	466	90	33	79	1.7	106.5	167.8	343	6.7	2.6	90.21	Probable certain	0.02	0.015	0.04	0.07	0.01	0.14	0.2
S10	Al-Zaafaraniya	44.467	33.231	7.53	868	768	85	28	67	1.7	134	122	113	3.8	3.7	92.61	Probable certain	0.01	0.01	0.027	0.015	0.009	0.14	0.4
S11	Al-Zaafaraniya/Saaeda	44.496	33.230	7.61	1127	526	85	30	70	1.7	135	164.7	126	6	3.1	97.01	Certain	0.015	0.01	0.04	0.02	0.01	0.15	0.2
S12	Al-Zaafaraniya/Bastan	44.515	33.225	8	896	804	100	35	100	1.9	136	152.5	170	6.26	3	89.71	Probable certain	0.01	0.009	0.03	0.015	0.009	0.15	0.17
S13	Diyala River Effluent	44.504	33.218	8.89	806	1260	244	120	350	10	465	140.3	154	8.3	5.4	90.16	Probable certain	0.4	0.5	2	0.4	0.3	2	5