Use GIS to Draw the concentrations Maps of the Heavy Elements and Boron of Groundwater In Southwest Karbala Governorate/Iraq

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Abstract

The area of study is located at southern east of Karbala governorate, in basin of Dibdiba formation (upper Miocene-Pliocene), between longitudes (43^o 57' 34.2" & 44^o 09' 49.2″) and latitudes (32^o 23' 16.4" & 32^o 36' 03.2"), this area about (336) km^2. It is consists the geochemical and hydrochemical studies of heavy elements (Co, Ni, Mn, Cd, Pb, Zn, Fe) and (B^{+3}) and measure the concentration of elements from samples of groundwater of 16 wells. After data collection from the analysis of the samples of water we are saving the results on the computer, with GIS software techniques, and draw different maps which represent the zones of the distribution of concentrations the metals. From the maps we are seen the zone of higher concentrations toward south and southeast toward the movement of groundwater(the area of discharge), and from the chemical analysis of water we can seen all water samples exceeded the limit for (B^{+3}) and (Ni,Pb), while the other elements (Mn, Zn, Cd) within the permissible limits, while (Co)was within the permissible limits except in the well (14), and (Fe) was within the permissible limits except in the wells (13,15,16 and 20). From the results of the study we are finding that all water of the wells are contaminated because the farmers are used many kinds of fertilizers to the vegetations of the surrounding area, the chemical compositions of these fertilizers mainly composed from heavy metals, and when the farmers irrigated the farms the dissolved minerals penetrated the soils to reach the aquifer of groundwater, therefore the water of wells used just for irrigation the vegetations, and when compare the results with the Iraqi and International standers for drinking water, we can’t used all the water of the wells to human s drinks.

Keywords: Fe:Iron, Ni:Nickel, Co:Cobalt, Pb:Lead, Cd:Cadimium, Zn:Zinc, Mn:Mangense, B:Boron, NPK and NP:Urea-argued, TSP:Triple –Super Phosphate, MPA:Mono-ammonium phosphate.

أستخدام نظم المعلومات الجغرافية GIS لرسم خرائط تراكيز العناصر الثقيلة والبورون للمياه الجوفية جنوب غرب محافظة كربلاء/العراق

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الخلاصة:

تقع منطقة الدراسة في الجنوب الغربي من محافظة كربلاء بين خط طول -- ″44° 09′ 49.2 ″43°57′2 وخط عرض ″16.4 ′23 °32 -- ″32° 36′ 03.2 على مساحة 336 كيلومتر مربع ضمن حوض تكوين الدبدبة (المايوسين الاعلى – البلايوسين) . لقد تضمن البحث دراسة هيدرولوجية وجيوكيميائية العناصر الثقيلة، Co,Ni, Mn, Cd, Pb, Zn, Fe وعنصر البورون B حيث تم قياس تراكيز هذه العناصر من خلال تحليل نماذج المياه الجوفية المأخوذة من 16 بئر محفور ضمن منطقة الدراسة

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، وتم حفظ قيم تراكيز هذه العناصر بالحاسبة الالكترونية وباستخدام برنامج نظام المعلومات الجغرافية GIS تم رسم خرائط مختلفة توضح مناطق توزيع التراكيز العالية لتواجد هذه العناصر في مياه ابار المنطقة ، وقد بينت الخرائط بان التراكيز العالية تركزت باتجاه الجنوب والجنوب الشرقي لمنطقة الدراسة باتجاه

حركة المياه الجوفية بصورة عامة (اتجاه حركة التصريف)، كما اظهرت التحاليل الكيميائية على نماذج مياه الابار بان جميع نماذج المياه كانت تحتوي على نسب عالية(اعلى من الحد المسموح بها)بالنسبة لعنصر النيكل Ni والرصاص Pb والبورون B بينما كانت نسب عنصر المنغنيس Mn و عنصر الخارصين Zn وعنصر الكادميوم Cd ضمن الحد المسموح به، اما عنصر الكوبالت Co فكان ضمن النسبة المسموح بها عدا في مياه البئر رقم 14 فكانت هناك زيادة عن الحد المسموح به ، كما ان عنصر الحديد Fe كان ضمن النسبة المسموح بها فيما عدا في مياه الابار رقم 20،16،15،13 كانت اعلى من الحد المسموح به. من خلال النتائج اعلاه وجد بان جميع مياه الابار في منطقة الدراسة تعتبر ملوثة بالعناصر الثقيلة اعلاه وذلك بسبب استخدام المزارعين للاسمدة المركبة التي تزيد من نمو وخصوبة النباتات الزراعية، والتي تحتوي في تراكيبها الكيمياوية كثير من العناصر الثقيلة وعند سقي المزروعات تنتقل هذه العناصر مع مياه السقي الفائضة وتتوغل الى مياه الابار الجوفية الموجودة في المنطقة ، لذلك تعتبر جميع مياه الابار ملوثة ولايمكن استخدامها الا لاغراض ري المزروعات فقط. كذلك عند مقارنة النتائج مع المواصفات العراقية والعالمية يتبين بانه لايمكن استعمال مياه هذه الابار لشرب الانسان مطلقا.

Introduction:

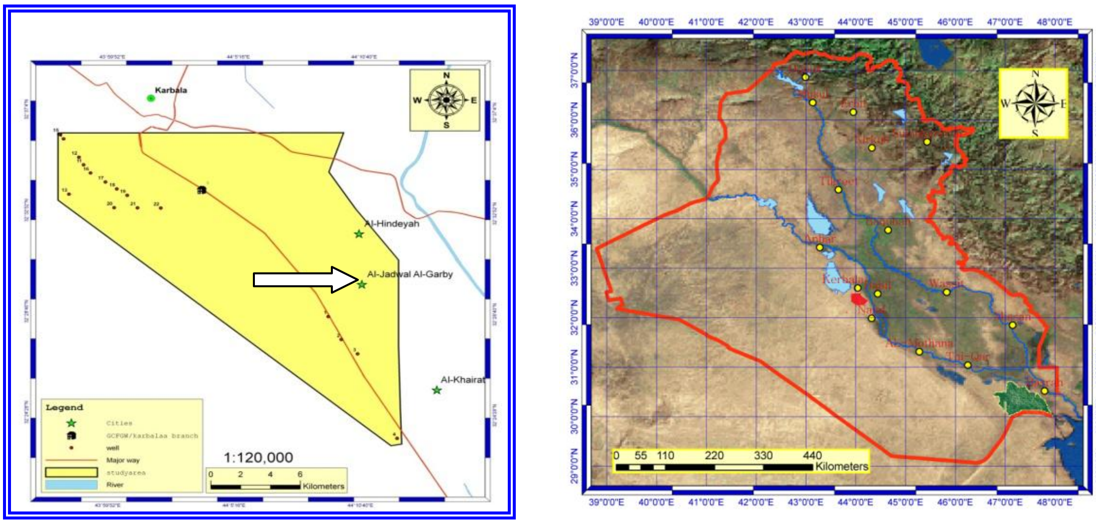
Detailed studies on groundwater contamination involve the development of the large chemical database. Those data must analyze the changes in pollutant concentrations in spatial distributions over time with respect to available surrounding environmental data. Therefore, serious researches and tests should be established in order to lay proper solutions prior to any kind of pollution might occur relevant to existing environment changes[1], one of these important studies geochemical study of groundwater which examined the chemical composition of water which entering the aquifer.[2] The study includes hydro-measuring the concentrations of heavy elements (Co,Ni, Mn,Cd,Pb,Zn,Fe), and the concentration of the secondary component (B^3) of groundwater from (16) well, figure (1a). We are doing the chemical analyses of heavy elements and boron of water samples in two laboratories of the Iraqi Ministry of water resources by atomic absorption spectrometer instrument /Model GBC933Plus.

Location of the Study Area:

The study area is located between the Karbala and Najaf governorates, between longitudes(43° 57' 34.2" & 44° 09' 49.2") and latitudes (32° 23' 16.4" & 32° 36' 03.2"), this area about (336) km^2 figure (1b).

Aim of Study:

1. Effective the Fertilizers on the groundwater of the area.
2. Study the higher concentrations of many heavy elements in the groundwater of the area.
3. Using Geographic Information System (GIS) techniques to draw concentration maps of the elements.



a **b**

Figure 1- Study Area(a,b)

Geology of Dibdiba formation:

The studied area is characterized by a flat plain covered by recent sediment sand and gravels come from weathering of Dibdiba and other subsurface formations**,** Dibdiba formation are distributed randomly as shallow, wide depressions of different shapes and filled with loose sand and residual gravels. These depressions are formed by deflation in Dibdiba plain [3]. It is a simple topography associated with the underlying sedimentary formation having a gently regional dipping [4]. Dibdiba formation (Upper Miocene – Pliocene) exposed as triangular alongside the western desert, its head is inside the Saudia boarder from the west, while its base is located inside Iraq and Kuwait to the east up to Euphrates's plain to Shatt Al- Arab river [5], the area is located on Arabian Nobian of unstable shelf, Dibdiba sediments mainly composed of sand and gravels and sands mixed with gypcrete [6], The gravels are derived from lava flow from an older formation exposed at the north of Saudi Arabia. The lava flow formation was reported to be Pliocene and Pleistocene age, and the gravels could not have been deposited before the late Pleistocene [7].The upper surface of Dibdiba formation is covered by recent sediments of Quaternary age [8]. The soil of the area is characterized by light soil, high permeability, which helps to grow the roots of the vegetations, therefore the farmers used saline and brackish groundwater wells in the area, for irrigation vegetations and drinking for animals only [1]. The elevation of study area is about 80 meters above sea level toward southwest and degrees toward west and south [9].

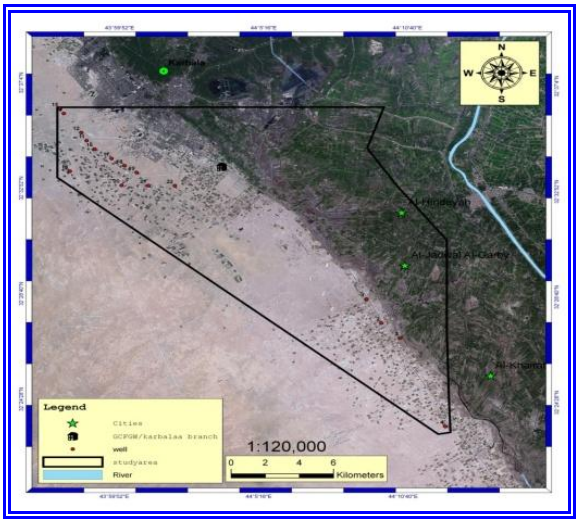


Figure 2- Space image of study area.

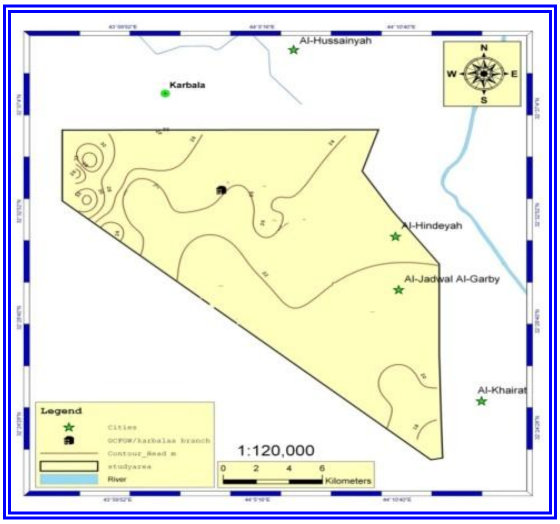


Figure 3- Depth of wells.

Dibdiba Aquifer:

Various studies in this area have found a Dibdiba sandstone formation is a good aquifer and extends along the Iraqi, Kuwait, Saudia Arabia international borders [10].The Landsat image shows the Dibdiba˚s sediments have a cone shape radiating down slope, figure (2).The greater part of the study area, is occupied by unconsolidated detrital rock mass transported by water channels at the foot of the gentle slope decreasing downstream. The underground water was accumulated within the Dibdiba formation(Upper-Miocene-Pliocene),Dibdiba aquifer is unconfined aquifer, Ahmed and Kraft mention that Dibdiba aquifer is one of the most important area for groundwater supply in Iraq, their study depends upon the previous study to draw map to define levels of ground water and its quality[11], Dibdiba aquifer covered by sand and recent materials these sediments has high permeability, therefore the aquifer fed directly from rainfall. Some previous studies have verified that the wells of the studying area are fed from the valleys of the same area, and it is isolated aquifer, it doesn't contact with any other aquifers, the wells of Dibdiba aquifer are dug between10m down to50m and increased toward the east to70m [12].Figure three show the zones of depth of wells in the study area.

Hydrogeological setting of Dibdiba Aquifer:

The drainage of this region is very shallow, short, wide and terminated in closed depressions, partly few of the drainages is continued through the alluvial fan body, and all of the wadis are filled with loose sands high permeable sediments [13],so the surface water quickly penetrated to the Dibdiba aquifer, therefore no water surface flow to any surrounding water body [12].Most the wells are drilled near the highway street and uses for irrigation.

Heavy Metals:

The term heavy elements mean all metallic minerals have atomic number more than 20 [14]. These elements classified into two groups: The first group tends to react with anions such as (Co, Mn) therefore the results of the reaction with it, precipitation, adsorption, and flocculation, while the other group, the results of its reaction are strong chains of complicated compounds with organic substances, therefore this group more stable, and transport in aquatic environments such as (Pb, Cd, Ni, Zn, Fe) [15]. These elements formed too, from the weathering of rocks and human effectiveness [14]. Significance the Study of heavy elements helped to have known the pollutions which came from the human activities like industrial, agricultural activities and wastewater and other [16]. The data analysis of the wells table(1) . The names, locations and concentrations of the elements in the groundwater of the wells of the study area are shows in the table (2, 3).The following characteristics of seven heavy elements and boron analyzed, by atomic absorption spectrometer are represents bellow:

1.Iron(Fe): The cation of iron is a present in the natural water as[Fe^{+2}, Fe^{+3},Fe $(oH)_2$], besides the cation of Fe^{+3} is precipitated in alkaline s medium and disappear when the PH increased. The range of concentration of iron in the wells of study area figure (4) is (between 0.07 to 0.32) and the average is (0.27).

2. Nickel (Ni): Nickel presentس in many types of Iraqi Fertilizers (Mono-ammonium phosphate, Triple-superphosphate, Urea-argued and NP) as percentage (34,44,73,76)ppm part per million respectively, these fertilizers are composed mainly from nitrogen, phosphorus, potassium and they are used for agriculture of the study area therefore nickel reach the ground water with the water of irrigations which penetrate the soil of the area[17]. Nickel present too in the sewage and with the manufacture of the batteries[16]. The range of concentration of nickel in the wells of study area, figure 5- are between (0.03 to 0.22) and the average is (0.11).

3.Cobalt (Co): Cobalt is one of the secondary elements, which compose with the other elements carbonate rocks [18]. It is present in many types of Iraqi Chemical Fertilizers (NPK, TSP, MPA, and NP) as a percentage (10, 13, 9, and 17) ppm respectively [17]. The most important sources of pollution by cobalt come from the industries of manufacture of paints and fertilizers.The concentration of Cobalt in the study area Figure (6) is between (0.01 -0.07) and its average about (0.04).

4.Lead (Pb): Lead is present in most types of rocks, while it is a little amount or absent on the surface and ground water because it's a slightly dissolved with water eg. $pbco_3$, $pbso_4$ [19]. It is a naturally present as a free lead as a result of chemical weathering of rocks. Iraqi fertilizers (NPK, NP, MPA, TSP) are consisting about (17, 17, 17, 42) ppm respectively lead [17], its present too in the sewage and with the manufacture of the batteries, paints and industries of lubricating oil and polymers and print-works [16]. The concentration of lead in the study area is (between 0.03 to 0.26) figure 7-, with average (0.16).

5.Cadmium (Cd): Pollution of water by cadmium are derived the phosphate fertilizers and the phosphate rocks, they are the main source of dissolved cadmium in the water [19]. Iraqi chemical fertilizers (NPK, NP, MPA, and TSP) are consisting about (9, 11, 19, and 20) ppm [17]. The concentration of cadmium in the study area is between (0.01 to 0.04) figure 8- with average (0.02).

6.Zinc (Zn): Zinc presents together with copper and nickel in the rocks of the Earth's crust but zinc less common than the others [18]. Iraqi chemical fertilizers (NPK, NP, MPA, and TSP) consists zinc about (233,353,563,475) ppm respectively, the organic wastes of animal and fertilizers are the main source of zinc [17]. The concentration of zinc in the study area is (between 0.03 to 0.10), see figure 9-, with average (0.04).

7.Manganese(Mn): Chemical compounds of manganese and iron are joined together in different circumstances, the high concentrations of these metals depending upon the increasing the concentration of oxygen and virce versa [21].The concentration of manganese in the study area is (between 0.01to0.03)m, see figure 10-, with average (0.02).

8. Boron ion B^{+3}: Boron is considered as a significant element to vegetation and animals feed, it is present in a dry soil and infiltrates to groundwater by the irrigation the surrounding farms, the concentration of boron happens with evaporation of the surface water accumulation [18]. Iron and aluminum oxides help exchanging ions for soluble boron from the clay soils[14].We can refine the boron in the natural water as salts of sodium and calcium borate.The concentration of boron in the study area is between (0.73 to 3.07) see figure 11-,with average(2.17).

Table 1- The data analysis of concentration of elements.

Well No.	**Concentration of elements**							
	Fe	**Ni**	**Co**	**Pb**	**Cd**	**Zn**	**Mn**	**B**
1	0.09	0.12	0.01	0.23	0.03	0.1	0.03	2.44
2	0.3	0.14	0.03	0.09	0.01	0.1	0.015	2,55
3	0.1	0.13	0.05	0.22	0.01	0.1	0.02	2.5
4	0.1	0.07	0.1	0.24	0.035	0.1	0.025	1.62
11	0.07	0.09	0.02	0.21	0.01	0.1	0.02	0.73
12	0.1	0.08	0.025	0.09	0.01	0.1	0.025	2.83
13	0.81	0.095	0.04	0.12	0.03	0.1	0.02	0.9
14	0.08	0.05	0.07	0.23	0.02	0.1	0.01	2.18
15	0.8	0.17	0.1	0.06	0.03	0.01	0.03	2.75
16	0.4	0.14	0.02	0.21	0.03	0.1	0.01	2.32
17	0.1	0.1	0.1	0.04	0.02	0.02	0.025	2.47
18	0.3	0.1	0.05	0.05	0.03	0.1	0.02	2.05
19	0.09	0.03	0.1	0.26	0.03	0.1	0.03	2.28
20	0.32	0.16	0.04	0.03	0.03	0.1	0.02	3.07
21	0.1	0.09	0.01	0.07	0.015	0.01	0.03	2.74
22	0.2	0.22	0.04	0.24	0.04	0.03	0.015	2.3

Disscussion:

Table 2- shows the locations and common tribesmen names of the wells, table 3- show the ranges and the average rates of heavy elements and boron in the study area. When comparing between the results of the analysis of the water of the wells and the Iraqi and international specifications of drinking water, table 4-, we can see that all water of wells are not allowable for human drinking because the concentration of heavy elements are increased in water, as a result to use fertilizers in the agricultural of surrounding the study area.

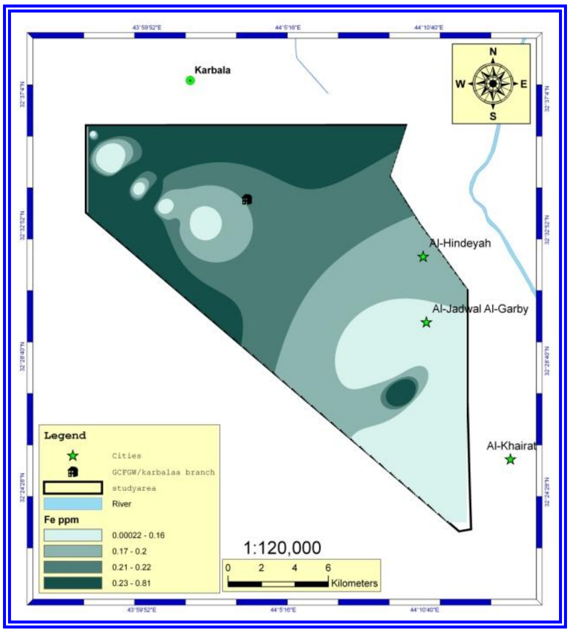


Figure 4- Distrbution of concentration of Fe

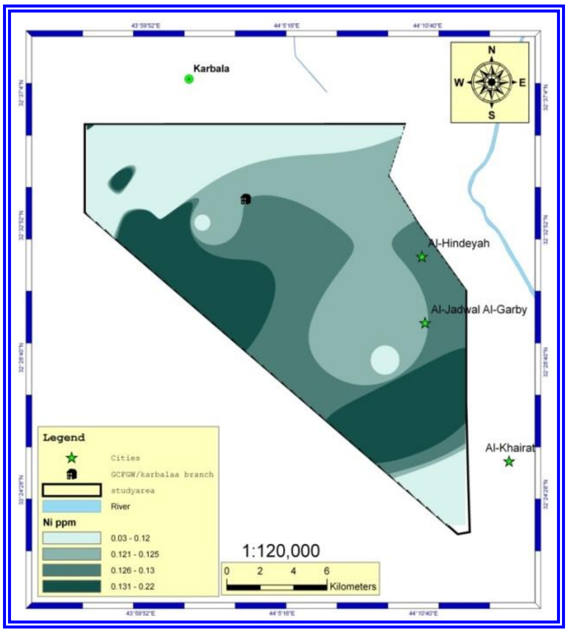


Figure 5- Distrbution of concentration of Ni

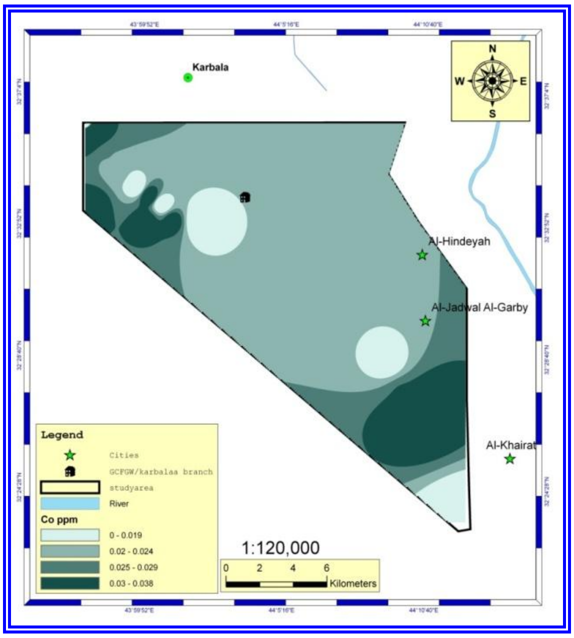


Figure 6- Distrbution of concentration of Co

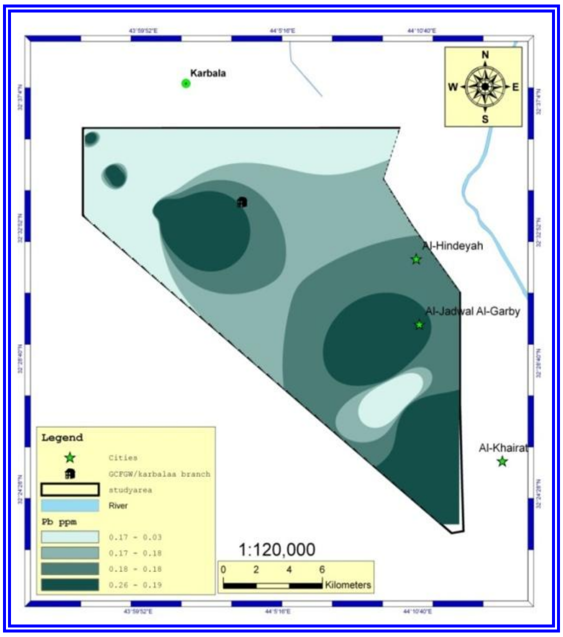


Figure 7- Distrbution of concentration of Pb.

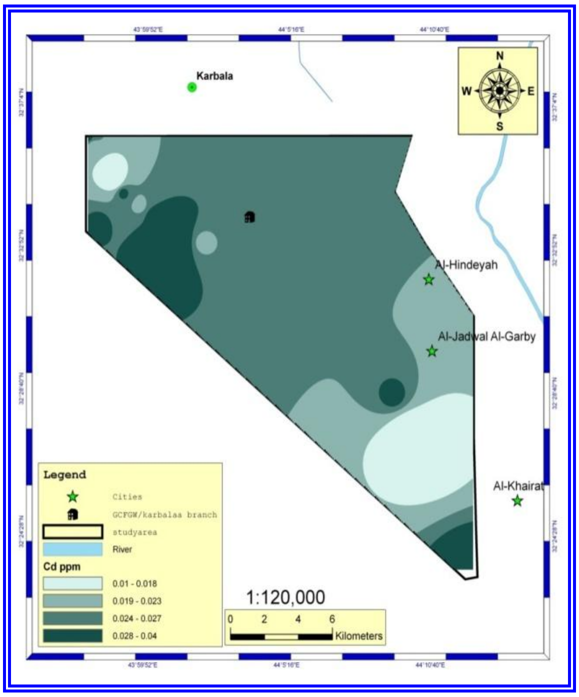


Figure 8- Distrbution of concentration of Cd

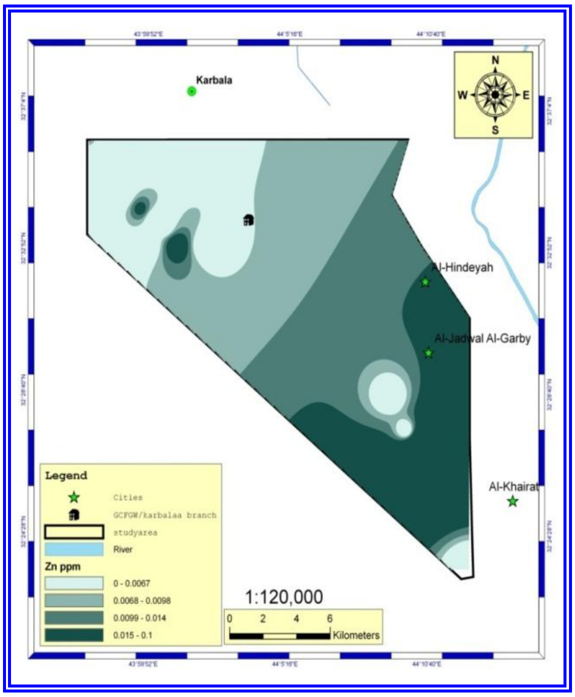


Figure 9- Distrbution of concentration of Zn

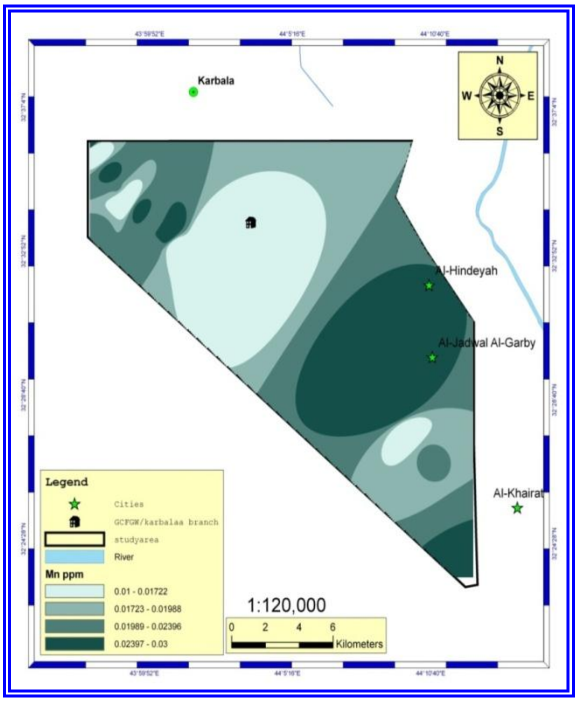


Figure 10- Distrbution of concentration of Mn

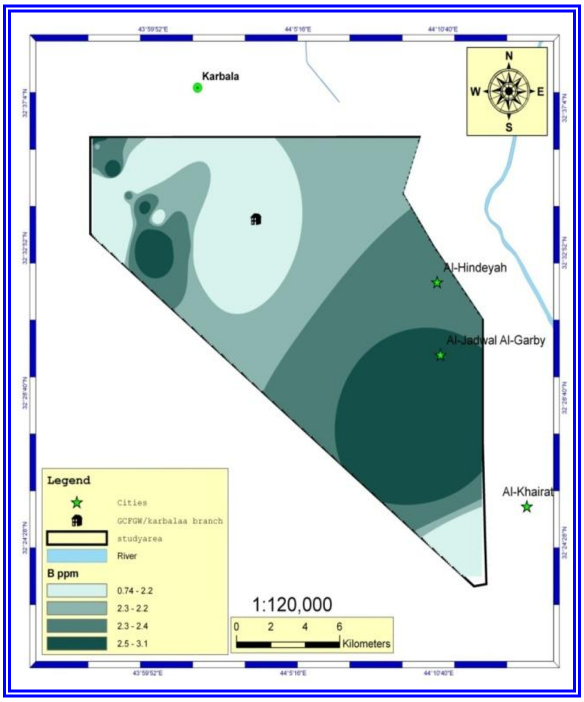


Figure 11- Distrbution of concentration of B

Table2- The numbers and the names and locations of the wells.

Number of well	Locations of the well Northing	Easting	Common name of the wells
1	32° 28′ 32″	44° 09′ 13″	Hussain15
2	32° 27′ 35″	44° 09′ 47″	Hussain12
3	32° 26′ 96″	44° 10′ 29″	Hussain11
4	32° 23′ 29″	44° 12′ 13″	Hussain8
11	32° 35′ 5″	43° 58′ 28″	Green belt24
12	32° 33′ 32″	43° 58′ 3″	Green belt26
13	32° 35′ 50″	43° 57′ 48″	Green belt28

14	32° 33′ 46″	44° 00′ 6″	Green belt30
15	32° 33′ 31″	44° 00′ 33″	Green belt31
16	32° 33′ 40″	44° 00′ 30″	Green belt22
17	32° 38′ 20″	43° 56′ 30″	Green belt20
18	32° 33′ 50″	44° 01′ 50″	Green belt18
19	32° 33′ 10″	43° 02′ 30″	Green belt16
20	32° 33′ 40″	44° 00′ 30″	Green belt1
21	32° 38′ 20″	43° 56′ 30″	Green belt14
22	32° 33′ 50″	44° 01′ 50″	Green belt46

Table3- The concentrations of elements in water of wells.

Minerals	**Ranges(ppm)**	**Average(ppm)**
Fe	0.07 - 0.81	0.247
Ni	0.03 - 0.22	0.111
Co	0.01- 0.1	0.05
Pb	0.03 - 0.26	0.149
Cd	0.01 - 0.04	0.023
Zn	0.01 - 0.1	0.079
Mn	0.01 - 0.03	0.021
B	0.73 - 3.07	2.233

Table 4- Water s contemenated of the wells of study area.

Min.	**IraqiSpecif(IDWS)2001[22]**	**International specif.(HWO) 2007[23]**	**Water of wells with Impermissible limit**	**Water of wells with Permissible limit**
Fe	0.3	0.3	Wells,13,15,16,20	All wells
Ni	0.02	0.07	All wells	----
Co	---	0.05	Wells4,14,1517,19	All Well
Pb	0.01	0.01	All wells	----
Cd	0.003	0.003	All wells	----
Zn	3	3	----	All wells
Mn	0.1	0.1	----	All wells
B	0.5	0.5	All wells	----

Conclusions:

1.All the wells of the area are dugs in the Dibdiba basin,with depth about 10 to 50 meters.

2.All the farmars are used the fertilizers to them vegetations because the top soil(Transported soil) of the area have no or a few amount of organic matters with it materials.

3.One of the reasons are the heavy elements reachs to the wells by the water of irrigations.

4.From the maps of concentrations of the heavy elements and boron of the 16 wells of the area of study, we can seen the concentrations increase toward south and southern east of the area, the direction of the movement of groundwater.

5.From the samples of the groundwater of the study area we are seen Ni,Pb,B elements are out of permissible, while Zn,Mn,Cd with the limit of premissble and Co with permissible except well number 14,while Fe is with premissible except well 13,15,16,20.

6.when compare the results of analysis of water of wells of study area with Iraqi and International standers for drinking water for human we are shows all the water of wells are not used for human drinking because the water of wells are polluted by heavy minerals.

Recommendations:

1-The water of wells which are dugs in West and Northren-West areas of the basin was a good water quality than the area of study.

2-We must analized the water of wells of the area evry period to prove there are no organic and bacteriological pollutants,in addition to the heavy metals.

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