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Evaluate Pollution in Ground Water and Mapping Utilizing GIS Techniques

A thesis

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By

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بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ

وَفَجَّرْنَا الْأَرْضَ عُيُونًا فَالْتَقَى الْمَاءُ

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Marwah sami shimal

Dedicated to

My first hero my father

My Mather

Love and loyalty

To

My brothers : Ahmed, khazwan , Haidar, Husham and Karar

My sister : Sara

Love and respect

Marwah

Abstract

The objective of this study is to evaluate and study the quality of groundwater in Salah al-Deen governorate in two different locations, Baiji and Samara, using geographic information systems (GIS) techniques.

This work begins with collecting the data about the quality of water that taken from wells of the studied areas. The samples were analyzed to achieve the concentrations of the dissolved elements in the water. The data were collected within the period of (2012-2014) and analyzed by Iraqi Ministry of Water Resources.

To achieve this goal, Baiji's samples were collected for 19 wells with the randomly of the studied area. Analysis were made with respect the following chemical pollutants (Soluble solids (TDS), Magnesium (Mg), Calcium (Ca), Potassium(k), Nitrate (NO_3), Chloride (Cl), Sodium (Na), Sulfates (SO_4)). The concentration of pollutant components was also calculated.

Similarly, samples were collected from 28 locations in Samara. The samples were analyzed for chemical pollutants (Soluble solids (TDS), Magnesium (Mg), Calcium (Ca), Potassium(k), Bicarbonate (HCO_3), Chloride (Cl), Sodium (Na), Sulfates (SO_4)). The analysis of the groundwater samples was carried out as a function of the component and pollutant of the groundwater. The structure analysis has been made by setting up maps of (Well Height, Well Depth, Static water level, and Dynamics Water level). These maps where designed by ArcGIS software (ver. 10.4). The Inverse Distance Weight interpolation method was used to establish the data map that represents the variable over the studied area. The results of the analysis of samples taken from Baiji wells showed that all wells containing NO3 did not exceed the limit and were in accordance with the

standards. It was also found that the number of wells exceeded the limit for chemical contaminants has reached the number of wells exceeded out of 19 wells

(TDS (19), K (9), Na (17), Mg (9), Ca (12), Cl (28), SO4 (16).

The results of the city of Samarra showed chemical pollutants in 28 wells studied, and it was found that the number of wells exceeds the limit allowed for each of the following pollutants: ((TDS (27), K (10), Na (24)), Mg (7), Ca (17), Cl (26), SO4 (25)). All wells containing HCO_3 were found to meet the criteria.

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Abbreviations and Acronyms

GIS	Geographic Information Systems
WHO	World Health Organization
TDS	Soluble Solids
Cl	Chloride
Na	Sodium
K	Potassium
Mg	Magnesium
Ca	Calcium
SO_4	Sulfates
HCO_3	Bicarbonate
NO_3	Nitrate
IDW	Inverse Distance Weighting
UTM	Universal Transverse Mercator
GCP	Ground Control Points
GPS	Global Positioning Systems
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
PH	potential of Hydrogen

Chapter one

Chapter One

Introduction

Water is the most important factor to preserve the life. It is used by all the living organisms for survival and it also used in agriculture, industry and other areas. Water is naturally found in different forms, such as rivers, seas or groundwater. It covers about 74% of the Earth's surface. Sea water represents the largest proportion of water on the Earth around 97%. Seawater is salty due to dissolve an enormous amount of minerals. The salinity of this water is about 35 g / L. Freshwater comprises both ice water and ice. The surface water is also a fresh water that divided into 11% swamps and 87% lakes. Rivers, are the lowest natural source of freshwater of only2%. .Groundwater is one of the most important natural sources of water in the desert, barrier and semi-barre areas, with a 30.1%. The total volume of the water on the Earth is around at 1.868 billion cubic meters (333 million cubic miles). Access to a clean source of drinking water is important. In recent decades, freshwater scarcity has been recorded in many regions of the world. One billion people on Earth still have lack in accessing a safe source of water, and about 2.5 billion do not have an adequate systems of water purification [1].

1.1. Groundwater

Groundwater is consists of soil, rocks and rainwater that seep down into the ground to form groundwater that used for drinking, irrigation of crops, industry, poultry farms ….. etc [2][3].Groundwater is defined as the water present underneath the surface of Earth in soil pore spacs and in the fractures of rock formation .It original comes from rain, surface water and or melted ice that seeps through Earth's layers to the aquifers. Groundwater can be classified based on its recharging way to renewable groundwater and non-renewable groundwater. Renewable groundwater is a type of groundwater where its aquifer always receives a new amount of water comes from annual rain, while the non- renewable groundwater was that stored over the past decades when the amount of water was more them what it is now. Recently the main problem of the groundwater is the presence of pollutants in the water wells such as chemical pollutants pesticides, fertilizers and industrial wastes. All these pollutants directly affected the quality of groundwater and become invalid for use; Therefore it very important to purify the groundwater by reducing these-types of pollutants [4][5]. The groundwater aquifer types can be classified to three layers [6].

1. Deep Sandstone Aquifer Complex: They are sandy rocks that are eligible to carry water
2. Upper Cretaceous Hydraulic Complex: This layer consists of limestone rocks, Dolomite, Merle and Chert
3. Shallow Aquifers Hydraulic Complex: This layer is a source of water collected from the rain where it stores the fallen water [2].

Although groundwater is one of the most important sources of fresh water on earth, some of these sources suffer from and they have been found a great interest from the specialists in the field of environmental protection since these aquifers are supplied by water from surface water and rain. When the surface of the earth is (contaminating with factory , residues and sewage), some of these contaminations seep down to the aquifer since, most of the groundwater wells in specific area are connected to this aquifer through a water channels, these groundwater wells will be contained either [7].

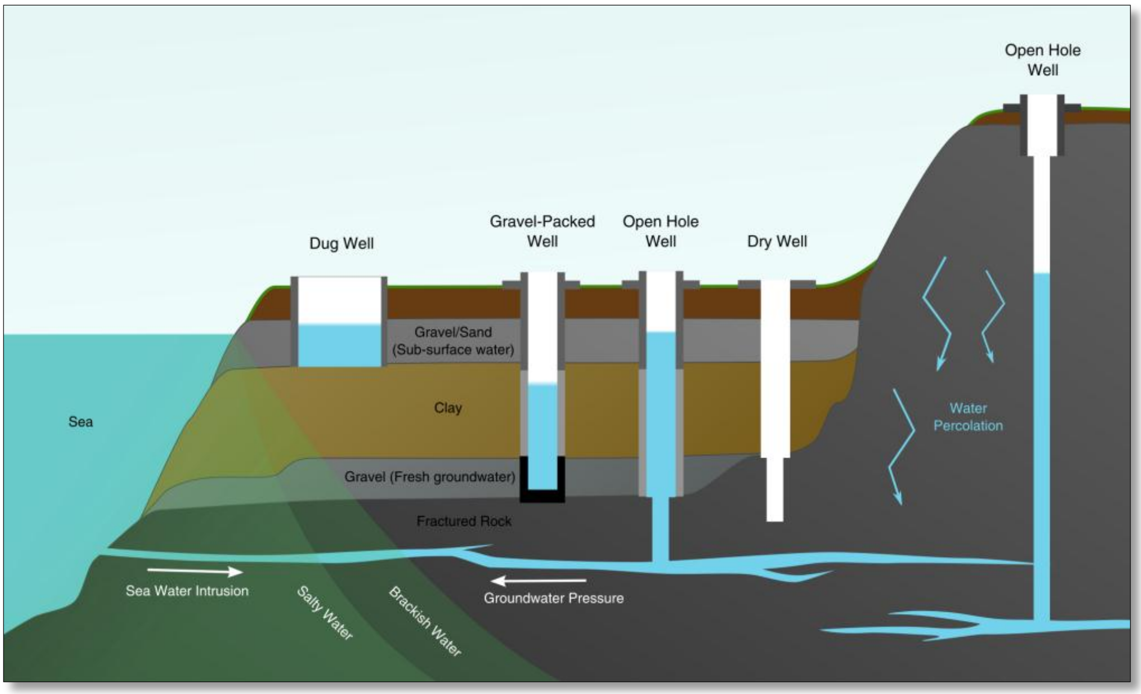

Figure 1-1. Groundwater structure [8]

The groundwater pollution is one of the most important problems facing the countries around of the world. This problem is being a serious threat to human life. The pollution is caused by an unhealthy landfill and waste complex. In addition, there are also different types of defects in water wells. Increasing the population and the consumption of water as well as and the presence of impurities in the groundwater, have directly affected its quality, and characteristics and make it for human use [9].

The study was conducted in the governorate of Salah al-Deen (Baiji and Samarra) using geographic information systems (GIS), where the province of Salah al-Deen suffers a great shortage in the water balance and also on increase in its population.

So pare GIS has been widely used because of its ability to manage accurately large amount of data in a very short and link this information with a set of data and it automatically; GIS has several definitions owing to its objectives and applications. These definitions are:

- Definition of Muller "GIS is one of the operations that deals with large scale maps that rely on large financial sources, (i.e., produced by the administrative departments, municipalities and governments). The aim is to support administrative policies to make balanced decisions regarding natural and human resources"[10].
- Definition of Doeker " A special case of information systems that contains databases based mainly on the study of the spatial distribution of phenomena and targets that can be identified in the spatial environment such as lines, spaces and points. The GIS processes a mechanism for data associated with these points and makes them recoverable for analysis Or query for specific data"[10].

1.2. GIS Components

The GIS system consists of several basic components and deliberately determines the system's success on the accuracy of the components and the processing capacity of the data [2].

1. Data.
2. User
3. computer components (Disks , Digitizer , Scanner)
4. Software to obtain maps or tables by processing data and configuring results in the form of maps, the following conditions must be met:

- Link information to its geographic location.
- Exchange of information from and to the program.
- View and output data in several ways.
- Enter data accurately and easily.
- The process of processing between the user and the computer.
- The ability to store and manage information as a database image.

The GIS technology was used in a spatial analysis to assess and identification the groundwater wells as well as prepare the database about the province of Salah al-Deen.

In this study, the research used different several water quality studies and these studies were arranged according to their importance and relation to the subject of this study.

1.3. Literature reviews

Insaf S. Babiker et al. [2005] [23]

This study is carry out in Japan in the highlands of Kakamigahara, Gifu Prefecture and the objective of the study is to assess the susceptibility of the aquifer by applying DRASTIC model and using sensitivity analyzes to determine the relative importance of the model parameters for the aquifer's susceptibility. DRASTIC it is system of calculation of the bitmap and the method of seven elements of the first letter of each of the word (Depth to water, Recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone, Hydraulic Conductivity). Another objective is to use both DRASTIC and GIS as an effective method for assessing the risk of groundwater contamination. The results showed that the concentration of nitrates is main factor of groundwater contamination.

Muheeb Awawdeh et al [2008] [21]: The objective of the study is to assess the sensitivity of groundwater surface contamination during the application of EPIK method and compare the results with the chemical data water chemistry collected from the wells; The EPIK method is based on specific geological, Geomorphological and hydrogeological factors. The acronym EPIK refers to the following four parameters:

E- Epikarst: the surface and subsurface karstic features;

P- Protective cover: the distribution of the soil thickness;

I- Infiltration condition: the relation between the slope and the different land use pattern in the watershed; and K- Karst network: the degree to which the karst network is developed. Also the use of both EPIK and GIS system as an effective method for assessing the risks of pollution underground water. By comparing the modeling results with water chemistry from wells in the studied area, the highest concentration of the anions and cations were existed in the areas with high pollution of nitrate.

Orhan Gunduz, et al [2009] [18]: The study is carry out in Kutahya, Turkey, and 27 samples are collect to determine the percentage of groundwater pollution and whether it is suitable for use or not. confirm the presence of a high percentage of arsenic around (99.1-561.5) Mg / L and other minerals (Zn, Pb and Cu) which come from that affecting water, soil and rocks Deaths due to gastrointestinal cancer drastically increased between (1995-2005)

W.Y. Wan Zuhairi, et al, [2009] [14]: Groundwater pollution in Yemen is identified in Al-Sahool area, north of Ibb City. Five wells were sampled within the studied area during the dry season due to the high leachate rate this season. The objective of the study was to determine the percentage of groundwater pollution using optical spectrum HACH, BOD Trak HACH, flame photometer (PFP 7) and Inductively Coupled Plasma of Optical Emission Spectrometry (ICP-OES) The measured parameters were (ph, EC, TDS, DO, F, Cl, SO4, NO2, NO3, NH3-N, Pb, Zn, Ni, Cr, Cd, Cu, Na, Mg, Ca, K, Fe, COD, BOD5 and coliform group bacteria). The results of this study were that the leachate in the waste dump was in the methanogic phase with a Ph ratio of 8.46. Also the percentages of the chemical elements were over that, of the global health measurements, hence the water is not suitable for use.

Baladi [2010] [9]: The study aim to determine the level of pollution indicators in the groundwater of Abi Jarash in Damascus in the time period of 2006-2007. The samples of water laboratory were mouthy collected from is well and analyzed in the validity of the water and its impact on human health and as well as its consistency with the specifications of Syrian standards of drinking water were studied. The results showed that the No3 concentration in the water is very close to the maximum allowed percentage. Other indicators were in accordance with the standard specifications, and water is also suitable for irrigation of crops.

Nosrat Aghazadeh, et al [2010] [17]:

This study is conducted in Urmia area, northwest of Iran where most of water is resulting from melting the ice. The researcher noted that the widely use of salt roads to remove the ice in winter as adversely affected the groundwater. The results showed that the chlorine ion produced by the solubility process affects groundwater quality.

El Zarka [2010] [12]: The author aim to shedding light on the reasons and the saves of the groundwater pollution that also affect the aquifers underneath the non them and central governorates of Ghaza. Also, the study includes the disease resulted from the microbiological contamination of the water and its effect on the humane life in these areas.

Nagarajan [2012] [4]: The author study the effect of the leachate percolation on the quality of groundwater at Tamil Nadu area in India. The concentration of different metals including (Cu , Cd , Fe , Cr , Pb , Zn and Ni) were estimated in the leachate samples . Near to the landfill sites, the concentration of NO_3, NH_4, Cl , SO_4 in the groundwater samples were in considerable levels. This indicates that the leachate percolation considerably affected the groundwater quality. The presence of these contaminants in the groundwater of these sites certainly will harm the associated aquifers in the specified area

Mohamed El Alfy [2012] [16]: The researcher apply GIS technique to determine the human and natural factors that may affected water quality. This study was conducted in El Arish area, north of Sina, Egypt. The study aimed to investigate the source and the percentage of pollution and assess the sources of pollution in addition to the identification of human inputs and minerals. The results showed that the potential sources of pollution that affected the water hydrochemistry are Potassium, Sulfates, phosphate, Nitrate, plasticizers, pesticides, sewage and salinization of disserved salts.

Noor Mesbah Abdullah Mahmoud [2013] [20]: This study is conducted in Khan Younis governorate in Palestine, and the samples were taken from 26 wells in (2011-2012). The results showed that the percentages of nitrates and Chloride in the groundwater were (84.6%) (76.9%) respectively, hence, the water is not suitable for use because it does not meet the standards of the World Health Organization.

Ibrahim Saud Al-Showaie, et al [2014] [15]:

The researchers present the problem and the solution of the groundwater pollution in the Kingdom of Bahrain, because it is the only natural water source; The samples were collected from 62 wells. The study aimed to calculate the percentage of groundwater pollution using DRASTIC and GIS technology. The results that the pollution is due to 5 fuel station near the wells, which poses a significant risk to human health and living organisms; Also the study showed that 37 out of 62 well were heavily consumed by Poultry farms. The research recommends the use of a water consumption planning map to maintain the level of water and protect it from pollution.

Najat Al-Bahloul [2015] [19]: The study is carry out in Tripoli, Libya, and the samples were collected from 11 wells at different regions to measure the percentages (PH, soluble salts, ammonia, nitrate, chloride, phosphates, iron, sulphates, total hardness and organic matter) in the groundwater Libya is one of the desert climate countries that rely entirely on groundwater. She studied the chemical and bacterial pollution of the water and its validity for humans and organisms. With the exceptional of chloride that exhibits high concentration in the samples, the results showed that the percentages of others element are within the limit and the water is valid for use a cording to the World Health Organization standards.

Abu Daher [2015] [11]: This study is based on an assessment of the efficiency of groundwater that used in irrigation of agricultural crops in Deir El-Balah Governorate in Palestine. The researcher selected 12 wells within the studied area, and experimentally analyzed the water in the laboratory to determine the percentage of impurities (Cl, No_3, and Ec). The results obtained from this study suggest that the water is not suitable for many crops because of it’s contain high concentrations of salt.

Emma Engström et al. [2016.] [22]:

The study is made in South Sudan, specifically in Juba, and the samples were taken from the wells of the studied area. The objective of the study was to develop a methodology for the evaluation of groundwater pollution mechanisms. The results confirmed that the residuals of traditional probit model had an important spatial correlation. The most important factor in this model (p 0.005) was the distance between the source of water and closest Tukul area.

Al-Karnaz [2017] [13]: The purpose of this thesis is to use GIS and cloud technology to create digital maps to assess the groundwater power of Gaza between 2015-2017. The study highlighted the groundwater and its exposure to a large percentage of pollution. The study also found a relationship between the increase in the population and the amount of pollution, as well as existence of a relationship between pollution of groundwater with chemical elements and compounds that lead to liver, kidney and other diseases.

1.4. Aim of the Study

The aim of this work is to study the quality groundwater in Samara and Baiji for environmental issues using GIS technique. The other approach for this study is to evaluate and estimate the quality of underground water for the studied area by using interpolations methods utilizing GIS techniques.

The pollution of groundwater with chemical elements at the studied area will be evaluate statistically for obtain the global view of the water quality. The achieved results will be illustrated as maps demonstrate the pollutant concentrations.

Thesis Layout

This thesis has organized by five chapters.

Chapter one**:** shows the general introduction of groundwater structure and Geographic Information System GIS techniques. Several published studies have been reviewed, Aim of the thesis and the description of the interest region and available data.

Chapter Two**:** includes the concept of groundwater pollutant elements and their physical characteristic as well as their impact on human's health. General concept of interpolations techniques have been reviewed.

Chapter Three**:** consists of the preface ofa groundwater analysis and GIS software (ArcGIS 10.4) and its applications. Georeferencing, rectifying, and resampling process have been detailed.

Chapter Four**:** the experimental results with its discussion are involved.

Chapter Five**:** is diverted to concluding the important obtained results, and some suggestions for future works.

Chapter Two

Chapter Two

Water Pollutions and GIS Techniques

2.1. Chemical Pollution of Groundwater

The quality of water requires a periodic monitoring and routine analysis of the quality of water. There are too many impurities that affect the quality of water, which may classified as physical pollutants (deposits dissolved in water like TDS), chemical pollutants, and biological pollutants (bactria, …).

The main threat of water pollution is the chemical one. This type of pollutant has several forms such as fertilizers, pesticides or the accumulation of waste surrounding the groundwater that may cause a water contamination with chemical elements. Increasing in the level of these pollutants in the water is very dangerous to human health beside its negative impact on the farms that used water for irrigation.

The definition of water pollutions refers to an elements dissolved in water and make it questionable for life activities. The dissolved elements could be a group of chemical elements, compounds or salts that affect quality and characteristic of water. (WHO) set a standards for drinking, irrigations and farming activities. These standards show the limit of each pollutant elements to be acceptable in its category of use. The chemical contaminants that may affected groundwater at the studied area will be illustrated as follows:

2.1.1. Soluble Solids (TDS):

A group of soluble salts used to describe inorganic salts and low amounts of organic matter in water. TDS is formed in water due to several factors like interaction with surrounding rocks, agriculture, industry, and wastewater. The (WHO) has identified the permissible TDS concentration in the water is (1000) ppm, and above this concentration TDS may change the taste of water [24].

2.1.2. Chloride (Cl):

Chloride is one of the most common elements in the nature. It is formed in groundwater because of human's general waste, waste, and when ground water surrounds by sedimentary rocks. The high concentration of Cl in water makes it tasteless for human use .The allowed level of Cl concentration in the water is limited by the World Health Organization to be 250 ppm. However animals can drink water containing chloride concentration up to 400 mg/L [25].

2.1.3. Sodium(Na):

It is one of the most abundant elements in the nature and it exists in groundwater. Due to surrounding the source of water with feldspar and mineral rocks. This element belongs to the alkaline group. Alkaline is a set of elements that fall into the first group of the periodic table such as sodium and potassium. The replacement of salt water to fresh water due to excessive water pumping and the presence of rocks containing sodium ion such as feldspar, increase sodium concentration in water. According to the WHO standards, allowed concentration of sodium in water is 200 ppm, and above this limit may causes leads to high blood pressure for people [6].

2.1.4. Potassium(K):

It is a chemical element also belongs to alkaline, potassium exists in the groundwater because of the presence of Feldspar mineral [26]. The more the water stagnates the higher the concentration of potassium in water. The limit for potassium concentration in water is 12 mg/L. Despite this limit leads to high blood pressure for humans but it is useful for plants since it is considered an excellent fertilizer [5].

2.1.5. Magnesium(Mg):

Magnesium is seldom exist in the groundwater. It is usually found due to amphibole and dolomite rocks near the water [5]. The (WHO) has reported that the limit for magnesium concentration in water is 50 ppm, and above this limit the water's hardness is increased [27].

2.1.6. Calcium (Ca):

Calcium is another chemical element that belong to alkenes group. Alkenes are a group of elements in the second group of the periodic table such as calcium and magnesium. It exists in groundwater surrounded by limestone rocks, limestone and dolomite and gypsum. The permissible concentration of calcium in the water according to (WHO) standards is 250 ppm. Above thin limit, the water's hardness is increased the resulting in increasing concentration in water than the permissible limit causes water hardness in addition to the accumulation rate in the water pipes [26].

2.1.7. Sulfates (SO4):

Alkaline salts naturally form in different minerals, such as barite and gypsum. The World Health Organization has determined that the limit for the concentration of sulphate in water is 200 ppm. This limit cannot be exceeded because increasing the concentration of sulphates makes the taste of water bitter [2].

2.1.8. Bicarbonate (HCO3):

A salt of carbonic acid can be obtained from the acid equation of one of the rules as in the following reaction:

$CaCo_3 + H_2O + CO_2 = Ca(HCO_3)_2$ …………….(2-1)

CO_2 can be dissolved in water comprising lines ton since a major component in water. The basis for the presence of HCO_3 in water is the result of water interaction with limestone and dolomite. The WHO-approved HCO_3 concentration is 500 ppm and an increase of HCO_3 from the allowable limit increases the hardness of water [28].

2.1.9. Nitrate (NO3):

It is a multi-atom ion and an inorganic fertilizer as used for plants. Due to its easily dissolved, in water the concentration of nitrates increases in the water hence widely absorbed plants through irrigation and rain, on the other hand animal residue, which is used as fertilizer also increases the concentration of nitrate in water . According to the standards of the World Health Organization the limit of nitrate concentration in the water is 45 ppm. Above this ratio can cause what it is called a blue baby syndrome due to formation of nitrate thud affect the efficiency of hemoglobin to carry oxygen [2].

2.2. Spatial calculations

A process of predicting an unknown value between two known points measured during a geographical. The distance between known points and the unknown values are contribute to the prediction process. The distribution of the known points affects the methods which will be used for interpolated the area. In addition, the size of the sample is an important element in the interpolation process. As the sample size increases, the accuracy of the prediction increases. spatial interpolation methods are fall into two categories[29]:

1) non-geostatistical methods.

2) geostatistical methods.

2.2.1. Non-Geostatistical Methods:

This group includes some interpolation methods that will be described.[29]

2.2.1.1. Inverse Distance Weighting (IDW):

The Inverse Distance Weighting method is used when the scale of the values or the points of prediction is increased or decreased by distance under the principle of the objects closest to them, which is greater than the distance between them. The measured values take the nearest to the site because their effect is greater on the expected value than the remote values. The effect of any relationship is positive. IDW uses nearby points to find unknown points and interpolation works more precisely if there is an equal distribution where unequal distribution leads to inaccuracy of interpolation and lack of obtaining desired predictions[30]. The IDW method is used because it is efficient and efficient when the sample points are distributed evenly and are used on surfaces associated with distances. This method takes into account the distance opposite the rest of the other methods. This method works very efficiently when there are a large number of sample points. This method can be mathematically expressed as follows:

$$\lambda_i = \frac{1/d_i^p}{\sum_{i=1}^{n} 1/d_i^p} \text{ ....(2-2)}$$

Where d_i = distance between (x_o - x_i), x_i = power parameter, n = number of sample point, p = power, **λ** = the weight of point.

Limiting the points used for interpolation:

The properties of the surface can be controlled by controlling the input points used and calculating each value alone, as the process of determining the number of input points improves the processing speed. Figure (2-1) shows the IDW method [31].

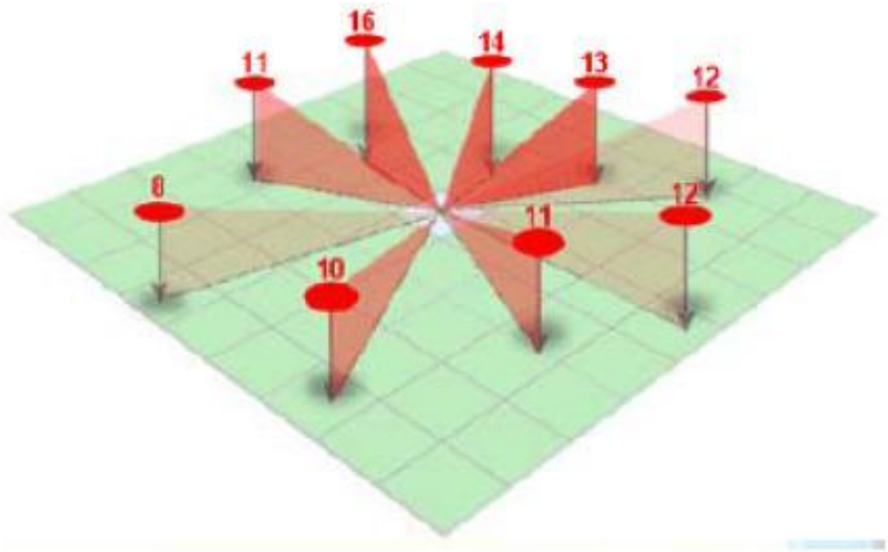

Figure 2-1. IDW interpolation [31]

2.2.1.2. Spline:

This method works opposite to the work of IDW. It does not need an arithmetic mean to find the unknown value. You only need to predict a value higher than the existing values and less value than the existing values. It is the best method to be used in the case of using random data or points [32]. Where the rest of the methods give expected values that are not equal to the real values and are the best methods used to calculate precipitation rates. But this method has some disadvantage. When the contiguous points are significantly different, the surface of the spline does not work efficiently [33]. Figure (2-2) show the spline method.

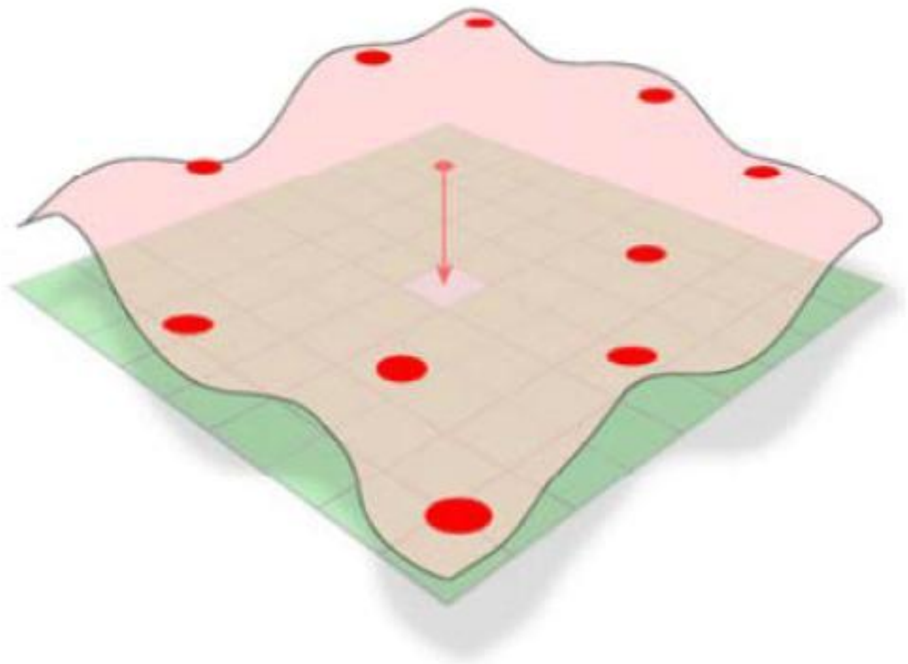

Figure 2-2. Spline Interpolation[33]

2.2.1.3. Natural Neighbor:

The natural neighbor method is one of the simplest methods of interpolation. This method simply determines the nearest pixel adjacent to the average calculation and then enters the calculated average value in a pixel that has not yet been allocated[34]. This method uses this approach instead of calculating the average value by weighting criteria, The greater the number of pixels adjacent to the calculation of the value allocated, the greater the accuracy of the resulting data [35]. Figure (2-3) show the natural neighbor method.

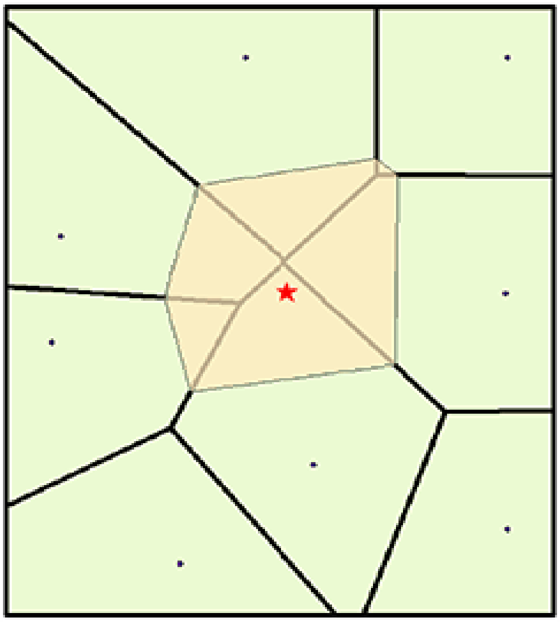

Figure 2-3. Natural neighbor Interpolation[35]

2.2.1.4. Trend:

Is one of the interpolation methods called interpolation trend because it represents a continuous change in a particular direction and is used to determine the direction of the appearance of the graph when the fall of the points received with the synchronization with the display period, for example, samples were taken in a certain direction six times between the update of the trend graph where only one value can be displayed for each update A single value representing the six samples should be used appropriately and can be higher, average, or smaller. Trend is used as a global function to create a smooth surface by a specific mathematical function [29].

Trend is interpolation is resulting in a smooth surface represents gradual trends in the surface of interesting area, and this type is used for:

- Fitting the sample points to the surface when it varies from site to another, for example pollution over an industrial area.
- Testing or removing the effects of long-term trends.

The higher number of borders, lead to more difficult to deal with the data, since dealing with data with a few borders creates a smooth surface gradually different. There are two types of trend interpolation Linear and Logistic.

1. Linear trend: This type of trend creates a surface with floating bitmap lines. This multi-border type is used to fit the surface of the lower squares with the insertion points. It can control the polynomial arrangement to fit the surface. It also creates smooth surfaces when passing through the original dots. It works better on the entire surface.

2. Logistic trend: This type of trend creates a continuous probability network for values (1, 0) and creates appropriate surfaces for predicting the presence or absence of certain phenomena, for example, the presence of a species that is threatened with extinction or lack thereof [36]. Figure (2-4) show the trend method.

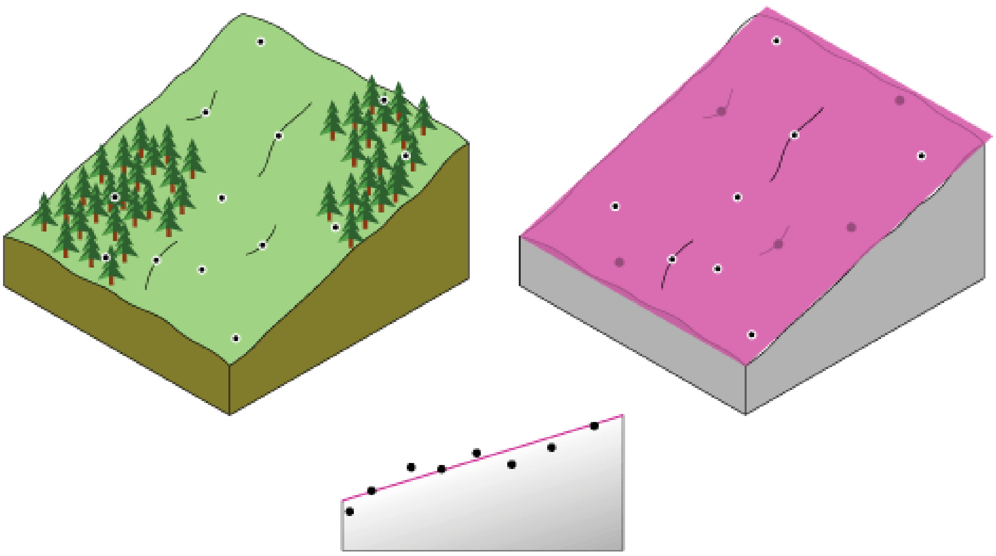

Figure 2-4. Trend Interpolation [36]

2.2.2. Geostatistical Methods:

Geographical statistics have been created by work in geology and mining, such as agricultural engineering and meteorology. This phenomenon can be described by spatial distribution in space and includes variable distribution.

The algorithms are used to predict continuous characteristics, The following methods belong to this group:[29]

2.2.2.1. Kriging:

It is a mathematical or geo-statistical procedure submitted to create a surface from a set of random points and depends on the presence of predictors or differences in the expected values. Kriging is similar to IDW but the difference is that IDW has the arithmetic mean of values while Kriging uses the arithmetic average in the prediction process but more complexly as all the points are included in the calculation of the mean in a grid mode [37]. In this way, values can be obtained higher than the existing value. Less than the lowest value exists, the following relationship represents kriging formula:

$$\hat{Z}(s_o) = \sum_{i=1}^{N} \lambda_i Z(s_i) \text{ ....(2-3)}$$

Where:

$Z(s_i)$ = measured value

λ_i = the unknown weight of measured value.

s_0 = the prediction location.

N = the number of measured values.[38]

Kriging's prediction surface map can be created with two important factors:

- Disclosure of dependency rules .
- . Making predictions.[39]

The Kriging method provides some functions in which the semi-empirical crescent model (circular, spherical, exponential, camouflage, linear).

Kriging has several hypotheses:

1. **Normalized data**: This hypothesis requires that the distributed data be a natural distribution to explore the spatial characteristics. If all values are naturally distributed, the data is collected in a straight line.
2. **Assuming that the data constant:** It is assumed that the points are fixed and do not change in different areas on the map, for example, the difference between two points of data distance between them 6 meters, it is

required that all other different values are similar to the value measured, that is, Different areas on the map and this hypothesis is not quite good for the possibility of sudden changes or cutting lines.

3. **Data assumption does not contain directions**: directions are systematic change in data across the whole study area [40]. Figure (2-5) show the kriging method.

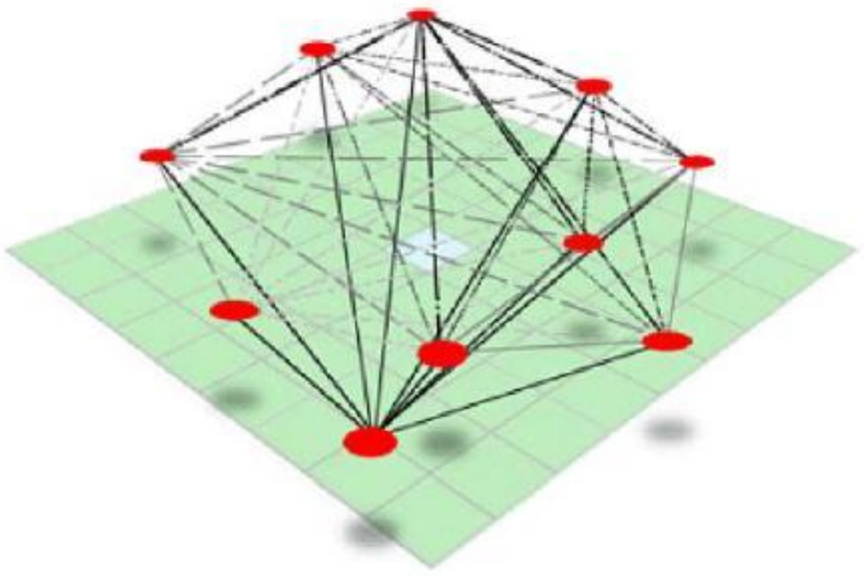

Figure 2-5. Kriging Interpolation [38]

2.2.2.2. Global Interpolation:

The global method is used on all known points to predict an unknown value. The closest neighbors are selected to estimate the unknown value. Global fits the polynomials on the first-class surface. Global is an inaccurate method, but touches the exact details. In other words, Global does not take all points taken Which means that it applies a single calculation on all sample points to form a smooth surface where the difference of the value of one entry affects the entire map where one curve is used to interpolation all the control points and the advantages of the gobal method it is simple and contains one curve or the disadvantages of probability of obtaining Tend Unwanted sweeteners [40].

Global is used when:

- The surface is installed on the sample points taken when the surface slowly changes from place to place.
- Test or remove the effects of long-range trends This method is called surface-direction analysis.

In theory, global is like taking a piece of paper and sticking it between the points of the sample (being raised to the highest value), using the term mathematical formula to reach a similar result where the many borders of the second degree have a single curve while the many borders of the third degree have two curves The global method is the only method used for geographic statistics [41]. Figure (2-6) show the global method.

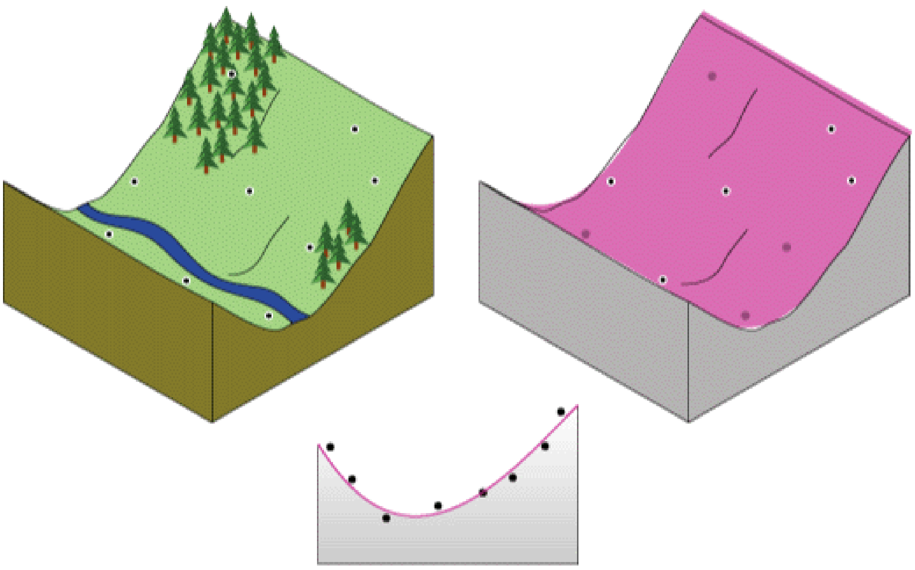

Figure 2-6. Global Interpolation [41]

2.2.2.3. Local Interpolation:

Are local techniques that do the same work as global, but on small areas where they calculate the predictions of the measured points. One calculation is repeated in small areas within large areas. These surfaces are connected to form a composite surface covering the whole study area. The curve has several points where a mix of many multi-degree boundaries is inserted where the size, number of neighbors and shape are searched [42]. Figure (2-7) show the local method.

Local depends on several factors:

- The samples shall be taken in a grid or even equal length.
- Distribution of data values within the study area [42].

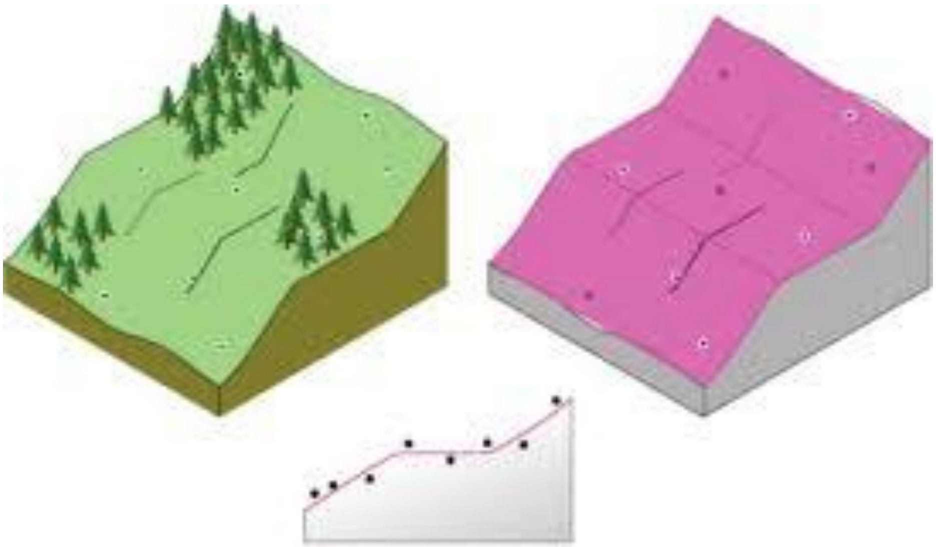

Figure 2-7. Local Interpolation [42]

Chapter three

Chapter three

Methodology

3.1. Introduction

This chapter is a summary of the process of collecting primary and secondary information as well as data and the mechanism of the action related to the subject of the study. The work went through several stages.

3.2. Studied Region

Province of Salah al-Deen / Iraqi is the target area to be studied, and this research focused on two specific locations (Baiji and Samara). The first area (Baiji) shown in figure (3-3), is about 210 km north of Baghdad with a semi-arid area. The Universal Transverse Mercator (UTM) projection was used and Iraq lies at zone38N. The studied area located between (342075.162 – 371962.555) m in the east and (3844995.575 – 3874120.697) m in the north. The area of the city of Baiji (871454) Km2. Figure (3-1) show the geographical location of Studied wells for Baiji city.

Samara is an Iraqi city lies east of Tigris River in the north of Baghdad. Samara is 125km from the capital, as show in the figure (3-3). UTM projection shows make sure it is located in area 38 N. The surveyed area is between (389123.3-420358.219) m east and (3772801.369-3799246.483) m north. This site has an area of (825731) Km2 and Samara is also an ancient cultural heritage city. Figure (3-2) show the geographical location of studied wells for Samara city.

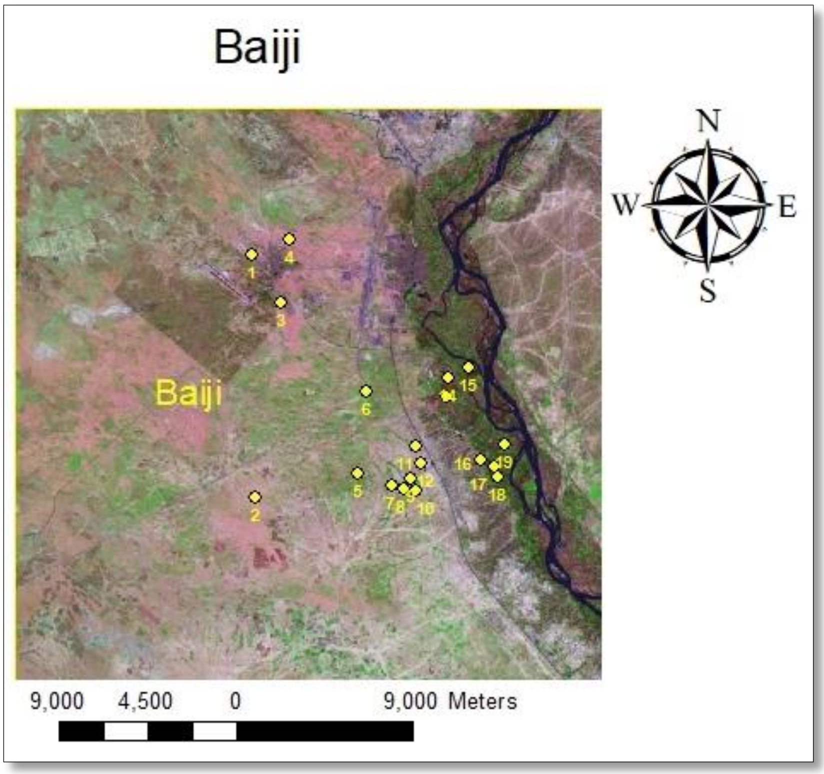

Figure 3-1. Studied area and wells for Baiji city.

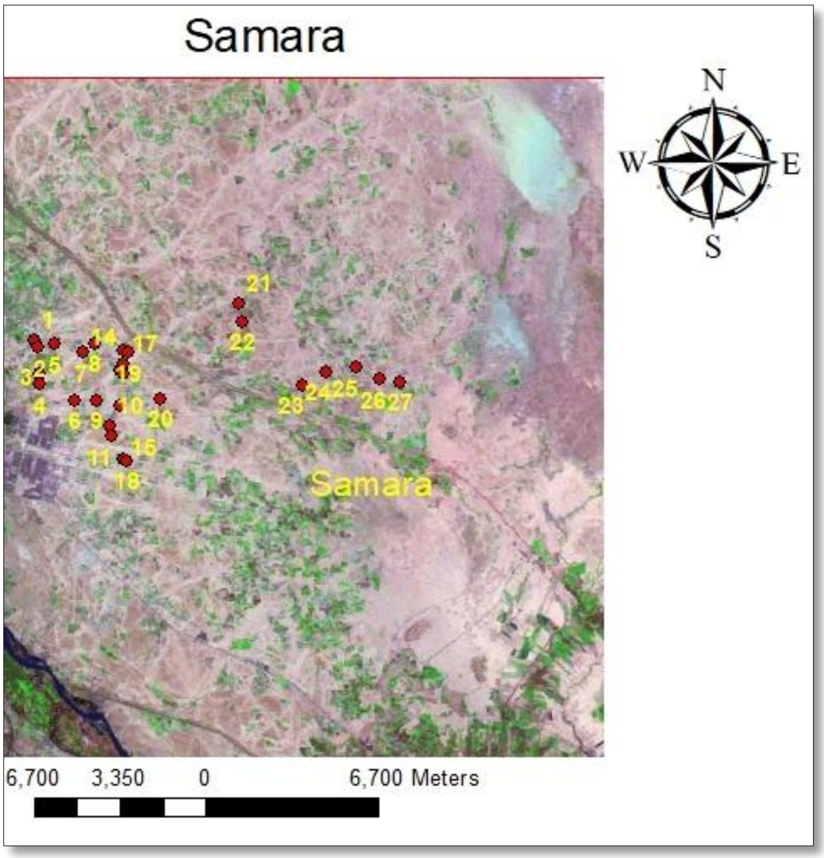

Figure 3-2. Studied area and wells for Samara city.

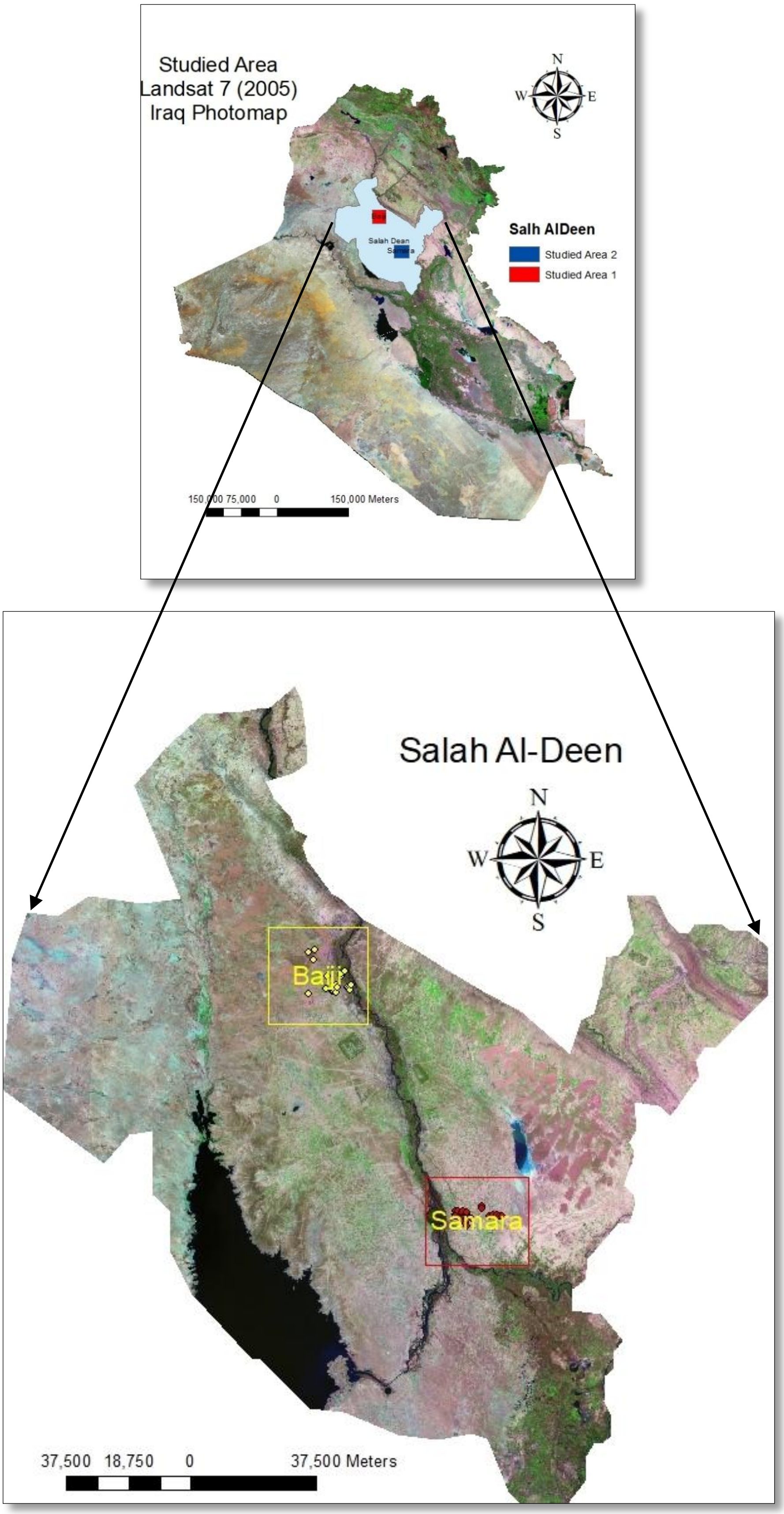

Figure 3-3. Studied Area at Salah al-Deen Province – Iraq.

3.3. Processing steps

The methodology of this work were established by two approaches:

1- Field work for gathering information of well's water.

2- Calculations approach for estimations of the pollutions rate.

3.4. Field work

The field work of this research can be summarized in the following steps:

1. **First step:** is the collection and processing of the data and the information. The database for the map was a satellite image taken from LandSat 7 in (2005). The geological information about groundwater formations was studied and prepared for the next steps. This information's consists of soil structure, groundwater layers and water quality.

2. **Second step**: Field work where samples were collected from water wells within the studied areas. 19 wells were selected from Baiji and 28 wells from Samara area. The data covers the period of (2012-2014). Samples were collected randomly with the help of a specialist team from Iraqi Ministry of Water Resources. The geographical coordinates of the wells were selected, using the Global Positioning Systems (GPS) technique. The wells locations are treated as Ground Control Points GCP which they use UTM projection in this research.

3. **Third Step**: The laboratory work stage. In this stage, the samples were analyzed to determine the percentage of pollutants present in groundwater extracted from the wells of the studied areas. These samples were analyzed in the laboratories of Iraqi Ministry of Water Resources. The following instruments were used for sample analysis:

Spectrophotometer: is used to analyze nitrate ion and measure the degree of the chemical contamination in the water Figure(3- 4).

Optical Flame Device: This device is used to determine the concentration of sodium ions and potassium ions in the water Fig (3-5) . Other of ions such as (Ca ,Mg , Cl , SO_4 , HCO_3) were analyzed by correction method.

The TDS method uses a long method of analysis using weight and evaporation.

Figure 3-4. Spectrophotometer

Figure 3-5. Optical Flame Device

The work base was created using the available data taken from the study areas and also using a satellite image of the Republic of Iraq, which was captured by satellite Lansat-7 in 2005, where Figure(3- 3) show the locations of study areas on the map of Iraq.

3.5. Calculations work

The Calculation were made by using ArcGIS (10.4) software.

3.5.1 Step 1: Create a map

Data used for mapping and their chemical characteristics were taken from Iraqi Ministry of Water Resources. The data of this study belongs to the results of the fieldwork for groundwater samples. The output maps were generated from the collected data using ArcGIS software. These maps illustrated the pollutants elements concentration in the studied area. The quality of groundwater that depends on the concentrations of these elements is extracted from the pollutant maps. Spatial analysis methods were used to analyze and process the data.

3.5.2 Step 2: Projection data

The spatial reference is a system of coordinates and projections aims to unify this coordinate system for all data and layers. There are several kinds of references depend on different methods. The coordinate system been used in this study is UTM. The UTM projection is divided the global area to 60 zones, and separated it to north and south hemispheres. GIS manipulates the data as layers and should be well referenced through georeference command which is a part of ArcGIS-tool box. The desirable global position system to specify the data to be displayed is the most accurate one could find.

3.5.3 Step 3: GCP projetion

The Ground Control Positions (GCP) refer to the wells locations. The wells positions are given by the Iraqi Ministry of Water Resources. These coordinates are matched with the real ones by taking the coordinates of each well. The GCP coordinates were converted to be identical to the UTM system.

3.5.4 Step 4: Data processing

The data used by ArcGIS and spatial analysis techniques were from available (IDW, Spline, Natural neighborhood, Trend, Kriging, Global, Local) methods. The most convenient method that gives the best results is the IDW. IDW gives more accurate results closer to the reality than other methods. Therefore, IDW method was adopted in processing the data.

3.5.5 Step 5: Production maps

Generate maps by means of a set of data stored in points were used to obtain unknown values and to find results for the unmeasured areas. The maps were produced for each variable and each map consists of information (title, legend, scale bar, and north arrow). These maps represent a set of data within the studied area and can be read by ArcGIS software.

3.6. WHO standards:

The World Health Organization has the guide and coordinating authority within the United Nations System in the field of health. It is responsible for playing a leading role in addressing global health issues, designing a health research program, setting norms and standards, clarifying evidence-based policy options, providing technical support to countries and monitoring and evaluating health trends. It is one of several United Nations agencies specialized in the field of health. It was established on April 7, 1948. Its current headquarters is in Geneva, Switzerland, and now is running by the organization Margaret Chan. This organization roles identified 62 criteria, such as physical, chemical and microbiological for the quality of water. Table(3-1) present the standardized limits for human uses which was based on in this research:

Table 3-1. World Health Organization (WHO) standardization [1]

Symbol	**Material**	**ppm**
SO_4	sulfate	400
Cl	Chlorides	250
Mg	Magnesium	150
Ca	Calcium	200
NO_3	Nitrates	45
TDS	Soluble solids	1000
Na	Sodium	200
K	Potassium	12
HCO3	Bicarbonate	500

3.7. Baiji city test elements

The first location is Baiji city which represent the first studied area with 23 GCP, represents the number of wells. These wells have been used for testing the water in the laboratories of the Iraqi Ministry of Water Resources, in the period (2012-2014). The following pollutants test were adopted for this site:

1. **Nitrate (NO_3).**
2. **Chloride (Cl).**
3. **Sodium (Na).**
4. **Potassium (K).**
5. **Magnesium** (Mg).
6. **Calcium (Ca).**
7. **Soluble solids (TDS).**
8. **Sulphate (SO_4)** .

Table 3-2. Reference table for Baiji city zone 38 [43]

Well number	Well name	UTM-X East	UTM-Y North
1.	Hatem Ali Hussein	354184	3866525
2.	Monitoring Well/14	354338	3854199
3.	Abdul Wahid Bara	355672	3864104
4.	Abdullah Ali Hussein	356096	3867313
5.	Jassim Mohammed Ali	359560	3855447
6.	Mahmoud Abdullah Hussein / 2	359978	3859576
7.	Hammadi Abdullah Saleh / 1	361270	3854848
8.	Muhannad Mohammed	361935	3854682
9.	Mohamed Hassan Attieh /2	362244	3855191
10.	Khaled Thamer Jadaan	362501	3854567
11.	Fattah Ghayeb Hassan	362514	3856797
12.	Jassim Mohammed Bakr	362743	3855933
13.	Abdullah Ali Hassan	364070	3859391
14.	Ahmed Hussein Ammar	364190	3860262
15.	Juma Matar Hamad / 2	365191	3860788
16.	Saleh Hamid Ali / 1	365811	3856143
17.	Saleh Khalil	366502	3855809
18.	Ziad Khalaf Aukba	366713	3855221
19.	Hassan Mohamed Khalif / 1	367040	3856886

3.8. Samara City Test Elements

The 28 GCP, which represents the number of wells in Samara city, has been used for testing the water of these wells in the laboratories of the Iraqi Ministry of Water Resources in the period (2012-2014). The following pollutants were tested:

1. **Chloride (Cl).**
2. **Sodium (Na).**
3. **Potassium (K).**
4. **Magnesium (Mg).**
5. **Calcium (Ca).**
6. **Soluble solids (TDS).**
7. **Sulphate (SO_4).**
8. **Bicarbonate (HCO_3).**

Figure (3-5) illustrates the flowchart diagram of the methodology used in this work. This diagram summarizes the steps been done through the research to achieve the final goal. The final goal of this work is to calculate the ratio of pollutants elements dissolved in groundwater.

Table 3-3. Reference table for Samara city zone 38 [43]

Well number	Well name	UTM-X East	UTM-Y North
1	Thamer Ammash Hussein	398425	3787731
2	Duean muslah	398425	3787317
3	Ahmed Latif	399776	3786715
4	Ayoub Taher	400620	3786690
5	Ahmed Mahmoud	401581	3786465
6	Abdul Ibrahim	401131	3785742
7	Mahmoud Majid	401219	3785292
8	Rashid Latif	401783	3784361
9	latif behind	401662	3784429
10	Sajid Abdul / 2	403144	3786755
11	Behind Abed / 1	401562	3787877
12	Majid Al-Fazaa	401664	3787740
13	Behind Aabed / 2	401704	3788153
14	Alaa Hassan	401860	3788568
15	Mahmoud Hassan Khalaf	401660	3788620
16	Hamad Mahmoud Hafez	400595	3788902
17	Mahmoud Khalaf	400107	3788352
18	Mahmoud Khalaf \ 2	400109	3788561
19	Saleh Abdul Qader	399024	3788879
20	Falah Al Zamil	398326	3788748
21	Wael Mishal	398250	3789035
22	Taha Hamid Hassan	408659	3787270
23	Sikban Majeed	409591	3787805
24	Kamel Abdel Sattar	410748	3787980
25	Sabaar Mohammed Ahmed / 2	411649	3787518
26	Attallah Mohammed Saleh	412432	3787411
27	Saleh Hussein Abdul	406295	3789764
28	Jabbar Mahdi Saleh	406165	3790470

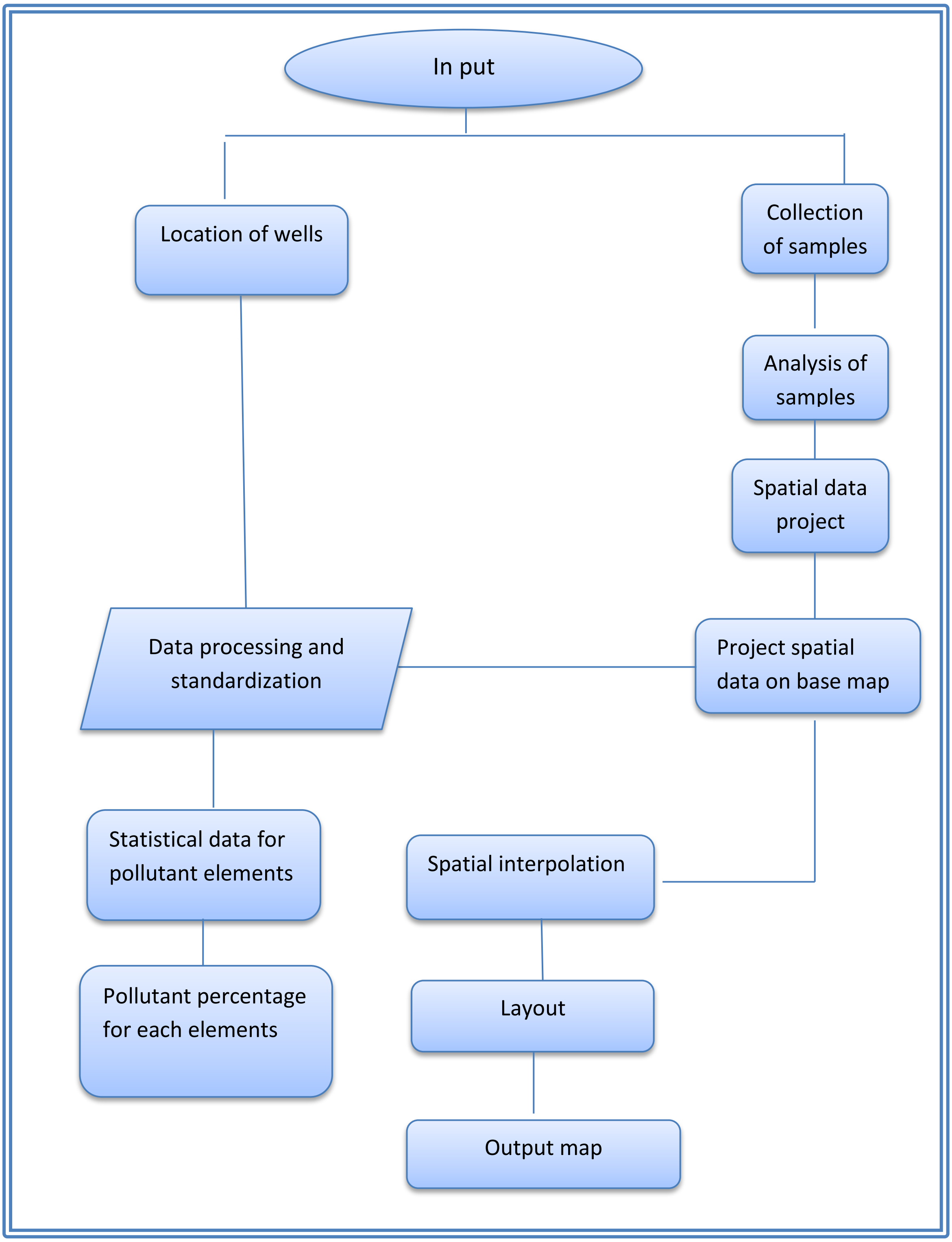

Figure 3-6. Methodology Diagram

Chapter four

Chapter four

Results and Discussions

4.1 Introduction

The main purpose of this research is to illustrate the pollution factors in the groundwater. The real data collected from the existing wells were manipulated and projected to a base map for the studied area. The tested samples of water's well as mentioned in chapter three, were processed and calculated for the entire area.

GIS technique is used to estimate certain values. This technique has many advantages including short-time, low cost and high accuracy. The results obtained from the available data presented as Iraqi map by arcGIS 10.4 starting from drawing the contour lines of the IDW method.

There are two approaches for study the areas with respect to the data manipulation. The firs one is illustrated the structure of water's table at each studied areas. The structure was illustrated by the well depth, elevation, static water level, and dynamic water level.

The second approach is the pollution factors that been tested and estimated for the entire studied area.

4.2. Baiji city results.

In order to understand the nature of groundwater in Baiji, different properties have been studied .this study was divided in two approaches. First, deals with the compound of the groundwater, and second deals with the pollution rate at this area.

4.2.1. Structure and morphology of Baiji Groundwater

The compound of the groundwater studies by means of water by wells depth ranging from (7 - 108) m. Figure (4-1) represents the wells depth and table (4-1) shows estimated groundwater depth for Baiji city (area1). Well heights, also and they varied within the range of (72-168) m. Figure (4-2) shows the variation of the well high. From the result of well depth and heights, the morphology and roughness of the studied area were estimated by subtracting the former results and analyzing the resultant.

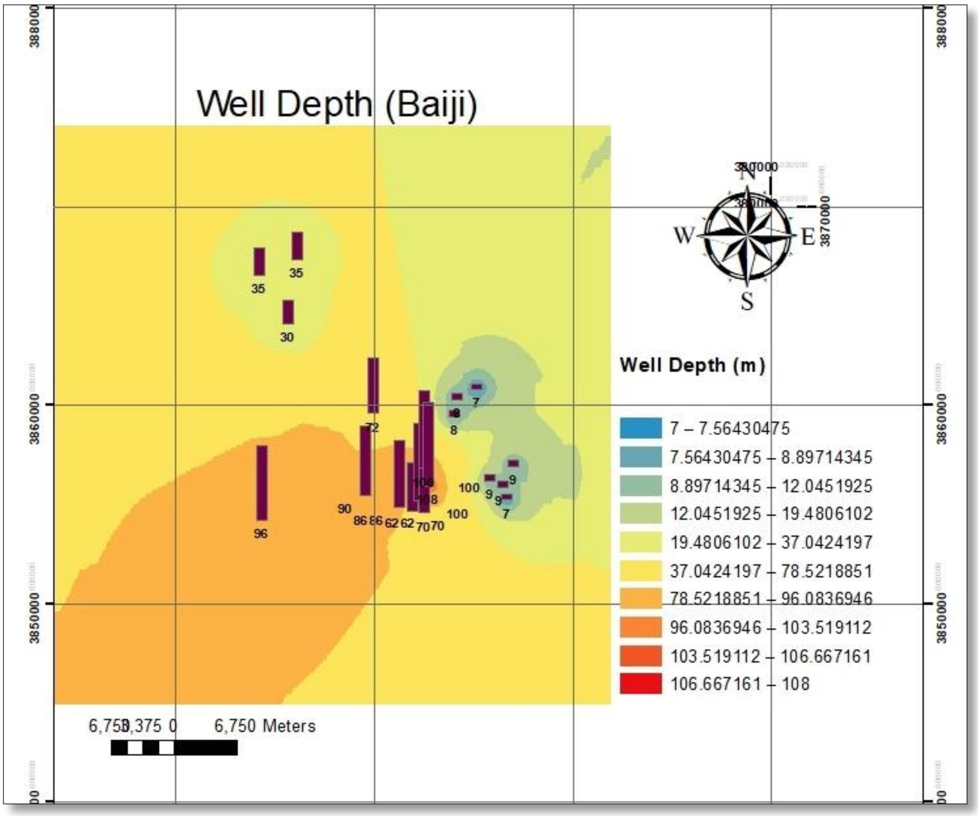

Figure 4-1. Well Depth

Table 4-1. The area classified with respect to groundwater depth

Classes	Value_Min of depth(m)	Value_Max	Area (m^2)
1	7	7.56	226047
2	7.56	8.89	1079430
3	8.89	12.04	7317500
4	12.04	19.48	32692000
5	19.48	37.042	205733000
6	37.04	78.52	433310000
7	78.52	96.08	190011000
8	96.08	103.51	934135
9	103.51	106.66	118360
10	106.66	108.00	33273.7

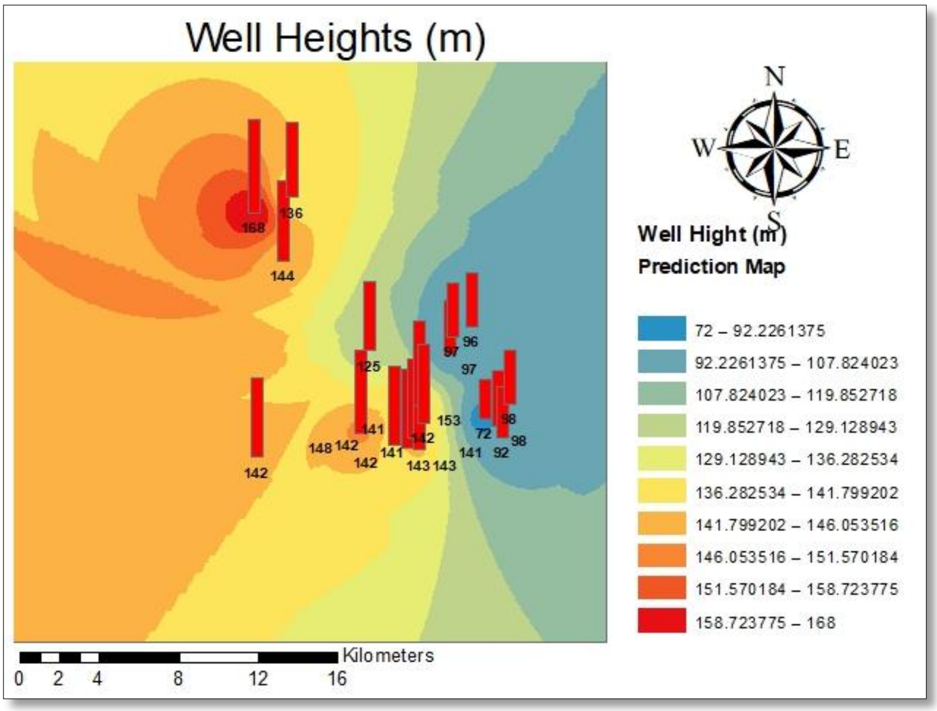

Figure 4-2.Well Height

Table 4-2. The area classified with respect to their elevations

Classes	Value_Min of height (m)	Value_Max	Area (m^2)
1	72.0	92.22	1686630
2	92.22	107.82	126951000
3	107.82	119.85	94691800
4	119.85	129.12	67104600
5	129.12	136.28	70680500
6	136.28	141.79	163594000
7	141.79	146.05	287063000
8	146.05	151.57	47145200
9	151.57	158.72	8828030
10	158.72	168.00	3709240

The physical properties of the groundwater at area1 can be understand by studying the static and dynamic water level. Figure (4-3) shows the static water level in the range of (3-30) m. Table (4-3) shows the value of each class of static water level, which refers to the height of water in the well without any interference by pumping. The dynamics water level gives the amount of pumped water per square meter, which is represents a pumping rate at stable level of the water in the well. Figure (4-4) represents the dynamics water level, ranging from (6-59) m in the studied area and table (4-4) shows the value of each class of dynamic water level.

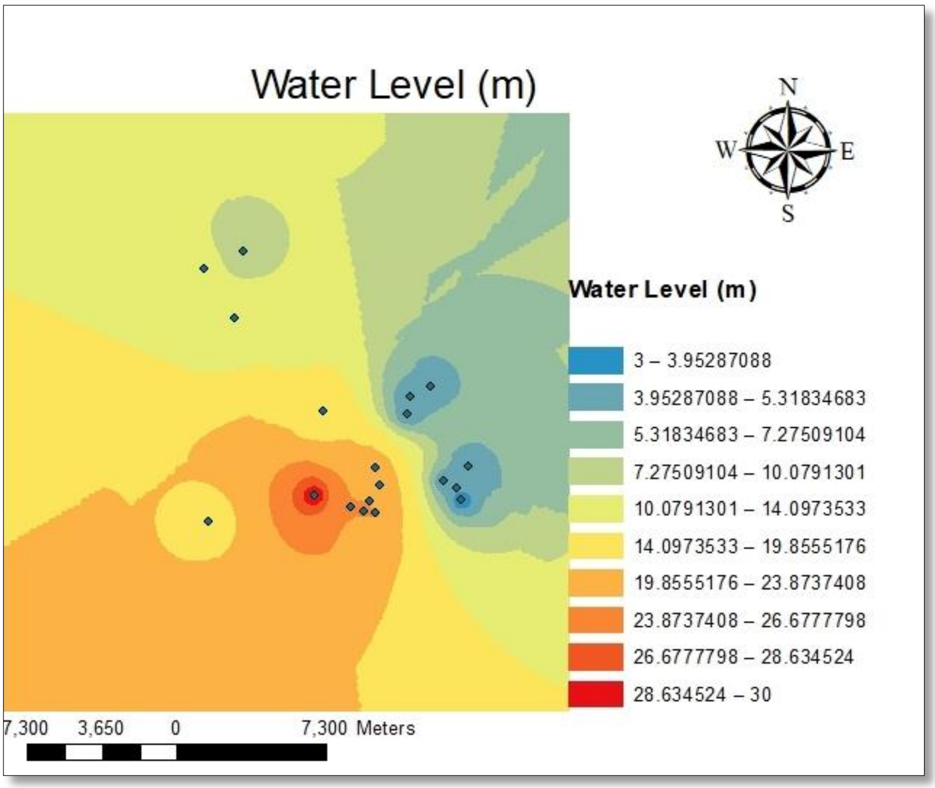

Figure 4-3. Static water level

Table 4-3. The value of each Water level class

Classes	Value_Min of Water level(m)	Value_Max	Area (m^2)
1	3.00	3.95	562173
2	3.95	5.31	14931100
3	5.31	7.27	95187400
4	7.27	10.07	98632700
5	10.07	14.09	239872000
6	14.09	19.85	196291000
7	19.85	23.87	210797000
8	23.87	26.67	12525000
9	26.67	28.63	1952760
10	28.63	30.00	703715

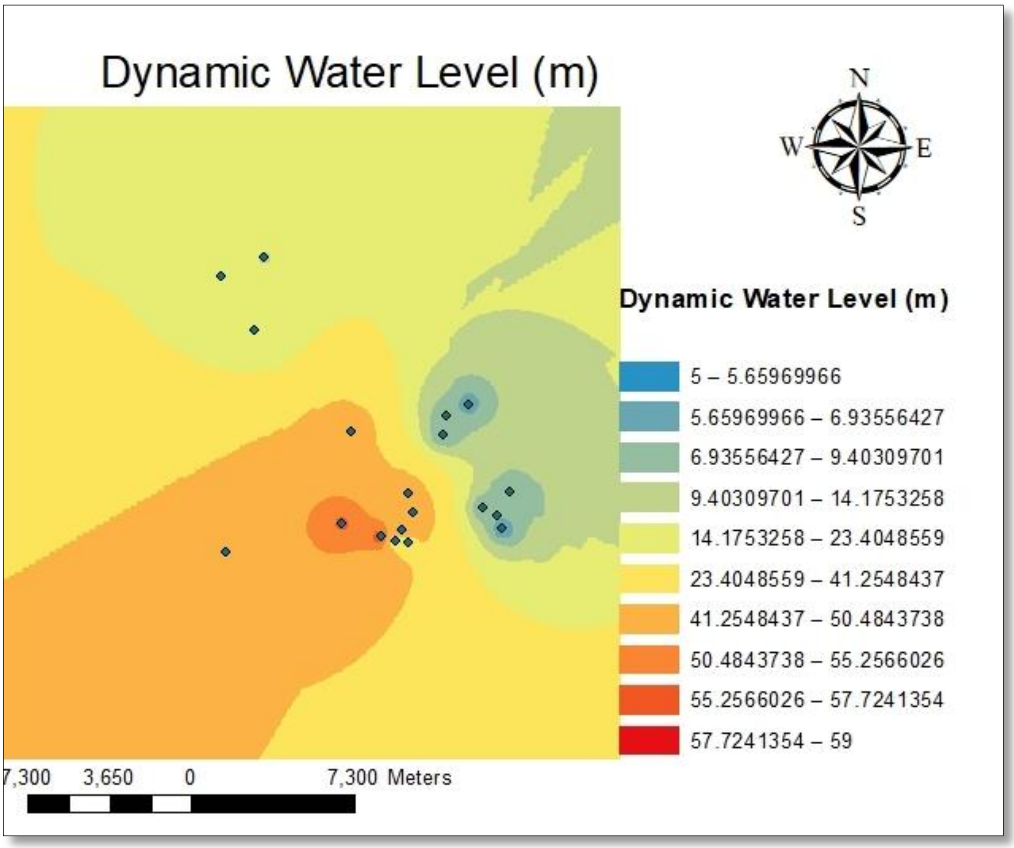

Figure 4-4. Dynamic Water level

Table 4-4. The value of each dynamic Water level class

Classes	Value_Min of water level(m)	Value_Max	Area (m^2)
1	5.00	5.65	0
2	5.65	6.93	1262800
3	6.93	9.40	12951700
4	9.40	14.17	86939500
5	14.17	23.40	262840000
6	23.40	41.25	285487000
7	41.25	50.48	215086000
8	50.48	55.25	6401600
9	55.25	57.72	455295
10	57.72	59.00	29544

4.2.2. Pollution analysis for Baiji groundwater

The second approach to this study is the pollution factors of the groundwater that have been tested and evaluated in the entire studied area. The main steps for this purpose including; creating a map, projection the GCP point along with their data and processing these data using IDW method. These maps represent a set of data for each point within the studied area and can be read and manipulate by ArcGIS software. Table (4-5) show the results of the pollutants elements:

Table 4-5. Chemical elements of a sample of groundwater wells (Baiji)[43]

Well number	NO_3 (ppm)	Cl (ppm)	Na (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	TDS (ppm)	SO_4 (ppm)
1.	9	530	553	5	71	190	3400	860
2.	1.2	780	255	14	158	290	2628	670
3.	5.4	519	410	75	123	257	2790	980
4.		487	32	7.4	371	530	4090	452
5.		391	205	71	201	349	1610	331
6.	3	389	236	7	91	160	1813	572
7.	6	550	380	3.5	108	228	2502	773
8.	2	388	376	2.3	105	223	2658	570
9.	5	531	376	2.1	105	223	2470	772
10.	1.4	442	305	15	74	120	1826	551
11.	2	313	245	4	53	170	2121	530
12.	1	412	280	5	72	190	2003	581
13.	2	659	539	81	165	335	4940	1270
14.	3.8	275	183	14	99	146	1830	643
15.	3	651	530	89	139	283	3404	1182
16.	9	1060	803	19	249	459	5700	1750
17.	2	648	530	90	137	285	3674	117
18.	4	533	374	3	102	225	2684	775
19.	9	190	204	4	43	95	1550	390

- **Nitrate:**

Nitrate is an inorganic fertilizer for plants due to its solubility in water. Increasing its concentration in water is dangerous to human life. Analysis shows that the concentration of nitrates in the groundwater Baiji ranging from (1-9) ppm. Figure (4-5) displays the nitrate concentrations and table (4.6) shows the value of each class for nitrate.

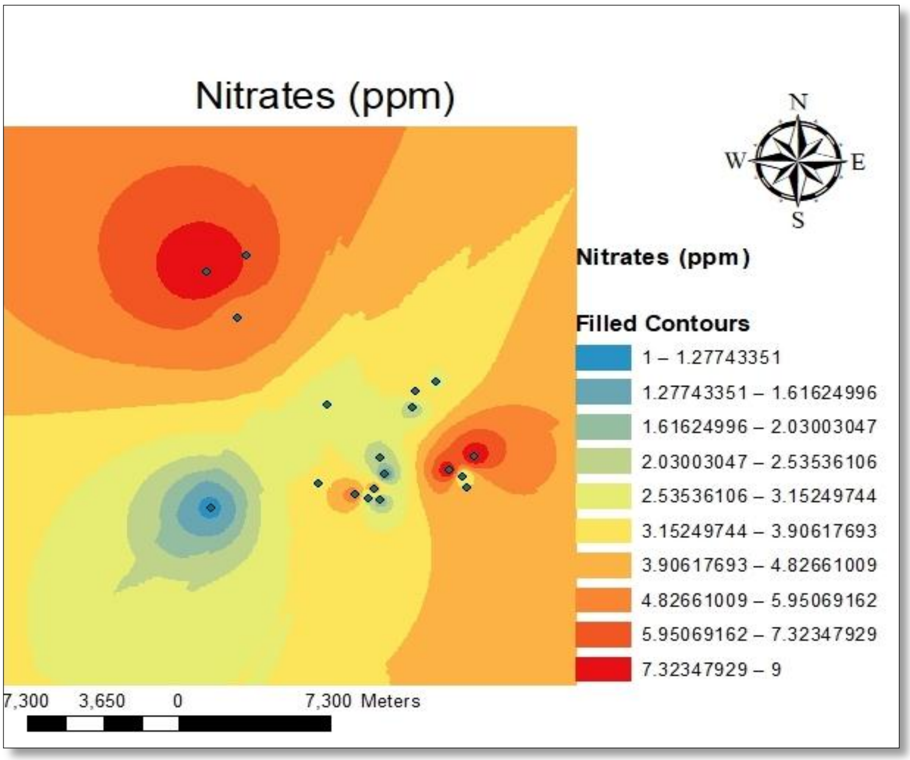

Figure 4-5. Nitrate concentrations

Table 4-6. The value Nitrate concentration classes

Classes	Value_Min of NO_3 (ppm)	Value_Max	Area (m^2)
1	1.00	1.27	944931
2	1.27	1.61	5544120
3	1.61	2.03	10058500
4	2.03	2.53	25071800
5	2.53	3.15	139446000
6	3.15	3.90	205916000
7	3.90	4.82	254650000
8	4.82	5.95	166871000
9	5.95	7.32	48213600
10	7.32	9.00	14738200

- **Chloride**:

Figure (4-6.) show the chloride concentrations in the studied area. The results indicate that the percentage of chloride in water ranging from (190 -1060) ppm.. The chloride concentration is very high and some samples approach to three times the acceptable limit of WHO. Table (4-7) display the chloride concentrations of different area.

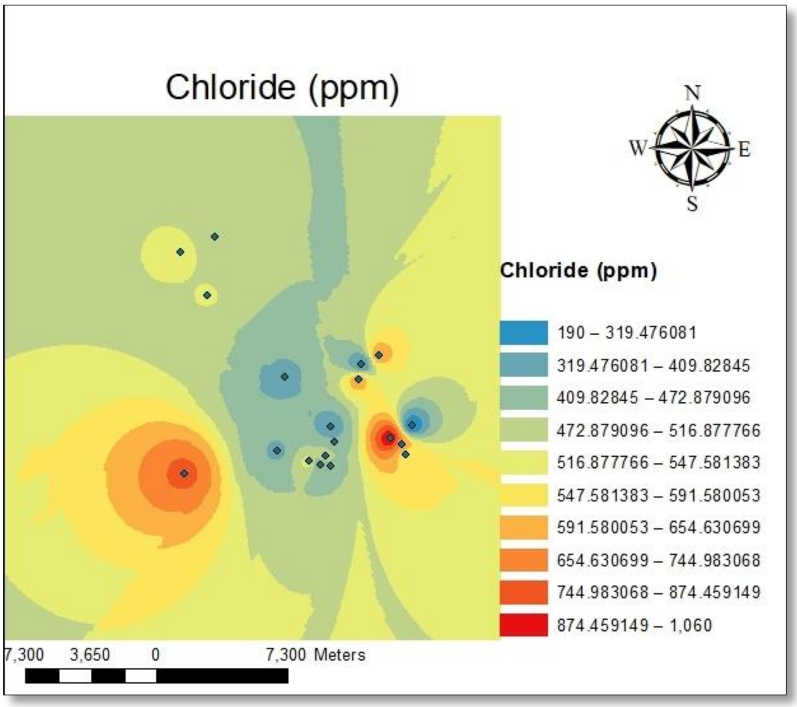

Figure 4-6. Chloride concentrations

Table 4-7. Chloride concentrations and estimated area.

Classes	Value_Min of Cl (ppm)	Value_Max	Area (m^2)
1	190.00	319.47	640971
2	319.47	409.82	9169230
3	409.82	472.87	73737600
4	472.87	516.87	372269000
5	516.87	547.58	295430000
6	547.58	591.58	78798200
7	591.58	654.63	25379800
8	654.63	744.98	12324000
9	744.98	874.45	3191230
10	874.45	1060.00	514291

- **Sodium**:

The results show that the sodium percentage in the water ranging between (32 - 803) ppm and the number of wells that exceeded the standards is 15 out of 19. Figure (4-7) shows sodium concentrations in the studied area. Table (4-8) illustrats the concentration level and their estimated area with respect to 10 classes of sodium concentration.

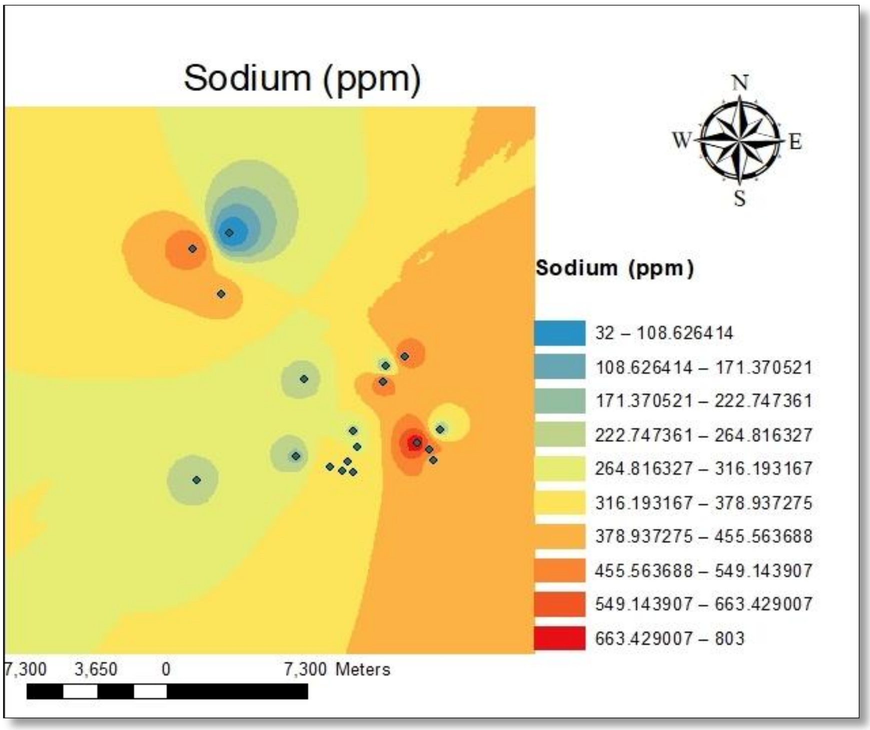

Figure 4-7. Sodium concentrations

Table 4-8 the value of each . Sodium class

Classes	Value_Min of Na (ppm)	Value_Max	Area (m^2)
1	32.00	108.62	1876590
2	108.62	171.37	3042580
3	171.37	222.74	5799030
4	222.74	264.81	23989500
5	264.81	316.19	283887000
6	316.19	378.93	335018000
7	378.93	455.56	205788000
8	455.56	549.14	10215600
9	549.14	663.42	1286240
10	663.42	803.00	551975

- **Potassium:**

Figure (4-8) shows the potassium concentrations, in the water pollution in is rangeing from (2.1 - 90) ppm and found the number of wells that exceeded the limit of WHO is 9out of 19. Table (4-9) shows the area of each class for potassium concentrations at different areas.

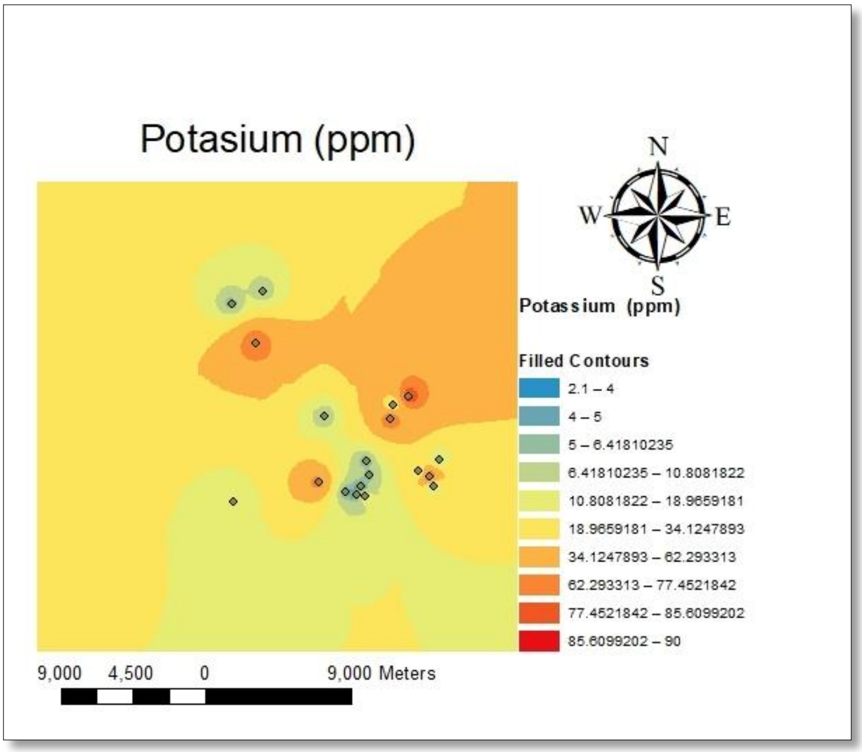

Figure 4-8. Potassium concentrations

Table 4-9. Concentrations values for Potassium.

Classes	Value_Min of K (ppm)	Value_Max	Area (m^2)
1	2.10	4	34810
2	4	5	949852
3	5	6.41	1895277
4	6.41	10.80	10446140
5	10.80	18.96	200848000
6	18.96	34.12	486189000
7	34.12	62.29	163731000
8	62.29	77.45	6659660
9	77.45	85.60	580162
10	85.60	90.00	120614

- **Magnesium:**

The results show that the percentage of magnesium in the water is between (43 to 371) ppm and the number of wells that exceeded the standards of WHO are 4 of 19. Figure (4-9) shows Magnesium concentrations and their estimated area and table (4-10) presents the area of each class of magnesium.

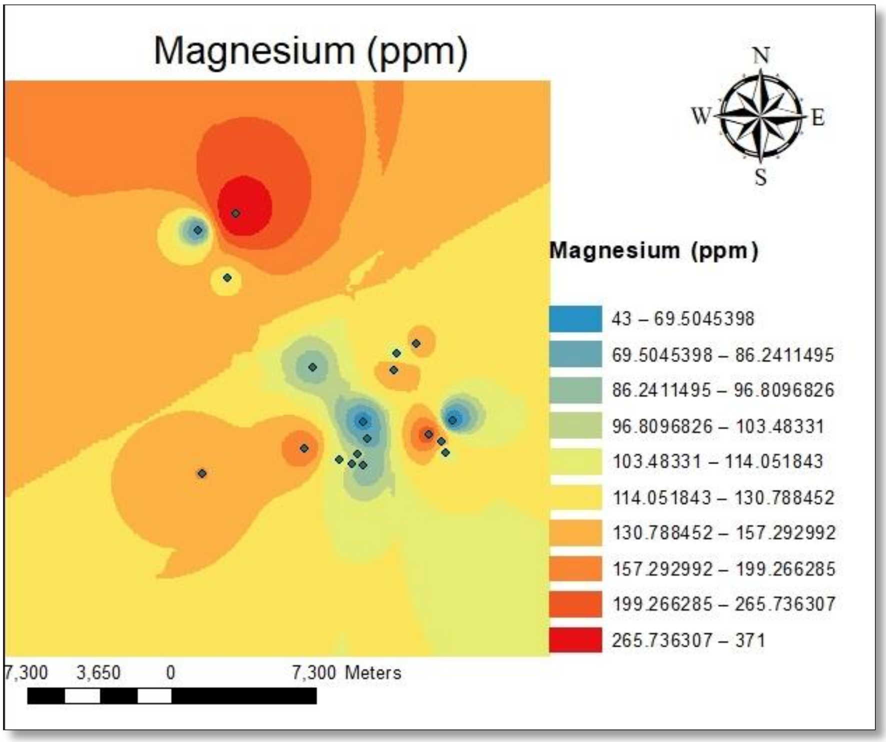

Figure 4-9. Magnesium concentrations

Table 4-10. Magnesium concentration classes

Classes	Value_Min of Mg (ppm)	Value_Max	Area (m^2)
1	43.00	69.50	1215370
2	69.50	86.24	3820300
3	86.24	96.80	8889520
4	96.80	103.48	12783100
5	103.48	114.05	90769100
6	114.05	130.78	287119000
7	130.78	157.29	326177000
8	157.29	199.26	109517000
9	199.26	265.73	24515600
10	265.73	371.0	6648360

- **Calcium:**

The results indicate that the calcium concentration within the range of (95 – 530) ppm and the number of wells that exceeded the standards of WHO was 12out of 19 wells. Figure (4-10) displays estimated calcium concentration areas and the highest concentration areas located at the east north of the studied area. Table (4-11) presents the area of each class of calcium concentrations.

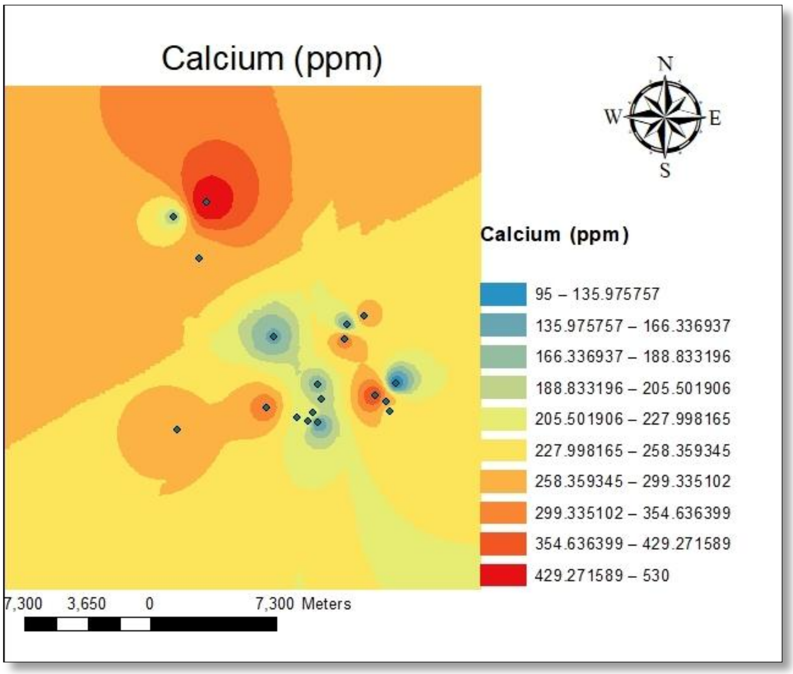

Figure 4-10. Calcium concentrations

Table 4-11. Calcium concentration classes

Classes	Value_Min of Ca (ppm)	Value_Max	Area (m^2)
1	95.00	135.97	422187
2	135.97	166.33	1708560
3	166.33	188.83	6843040
4	188.83	205.50	13032100
5	205.50	227.99	67608600
6	227.99	258.35	349249000
7	258.35	299.33	354010000
8	299.33	354.63	59184900
9	354.63	429.27	14659200
10	429.27	530.00	4736740

- **TDS:**

Figure (4-11) shows TDS concentrations. The results showed that the percentage of water pollution by soluble solids is ranging from (1550 to 5700) ppm and results found that all the wells exceeded the standards of WHO. Table (4-12) shows the distribution of TDS concentration.

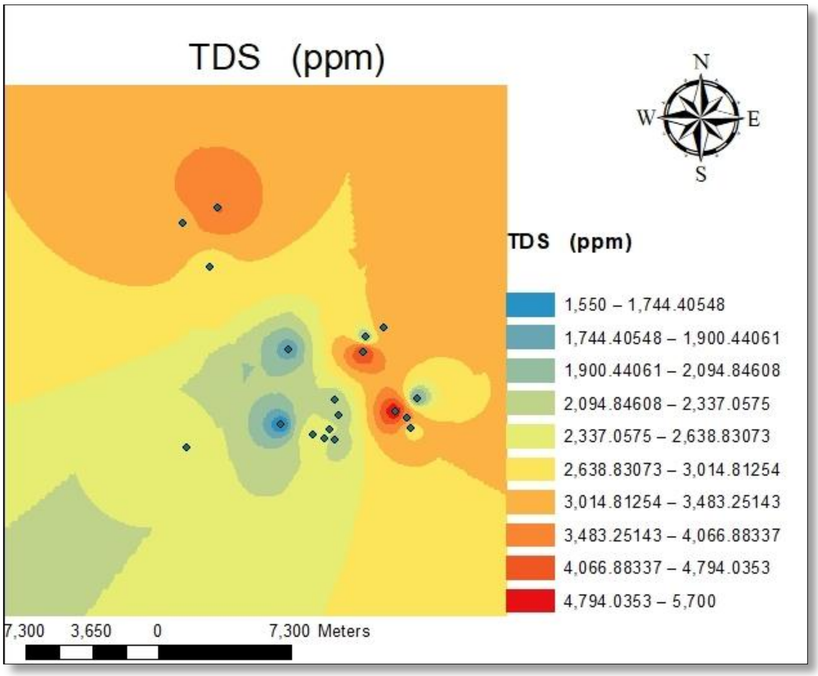

Figure 4-11 TDS concentrations.

Table 4-12. TDS concentration classes

Classes	Value_Min of TDS (ppm)	Value_Max	Area (m^2)
1	1550.00	1744.40	635698
2	1744.40	1900.44	2291590
3	1900.44	2094.84	9627230
4	2094.84	2337.05	88908000
5	2337.05	2638.83	207455000
6	2638.83	3014.81	221821000
7	3014.81	3483.25	316029000
8	3483.25	4066.88	22175300
9	4066.88	4794.03	2029210
10	4794.03	5700.00	482672

- **Sulphate:**

The results show that the percentage of in sulphate in the water is ranges from (117 to 1750) ppm. Overflow wells were monitored and the number of wells that exceeded the standards of WHO 16 out of 19. Figure (4-12) shows sulfates concentrations. Table (4-13) presents the value of each class of sulfates.

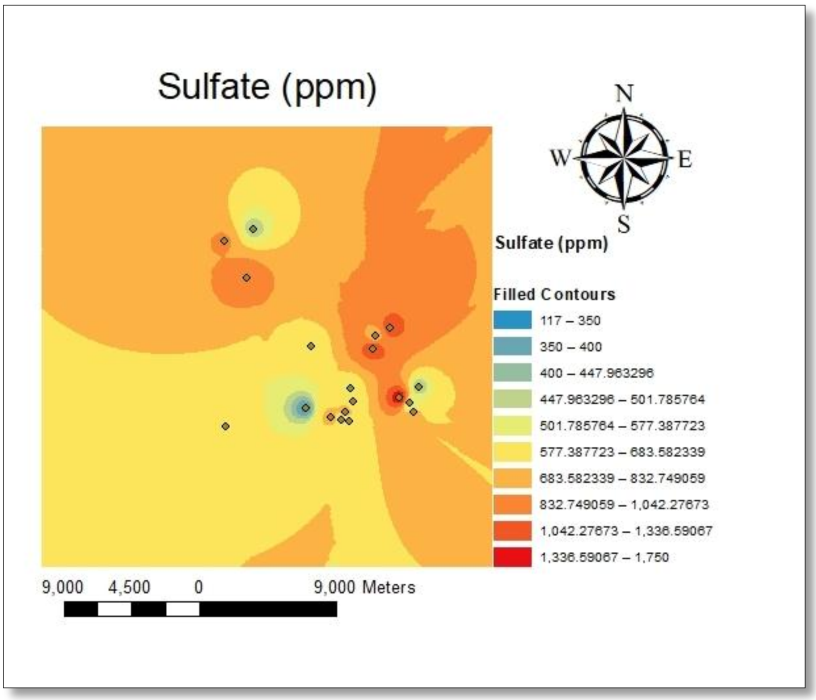

Figure 4-12. Sulfates concentrations

Table 4-13. Sulfates concentration classes

Classes	Value_Min of SO_4 (ppm)	Value_Max	Area (m^2)
1	117.00	350	153206
2	350	400	640713
3	400	447.96	941681
4	447.96	501.78	3780417
5	501.78	577.38	14716800
6	577.38	683.58	3325221000
7	683.58	832.74	4001071000
8	832.74	1042.27	114057066
9	1042.27	1336.59	4076170
10	1336.59	1750.00	459001

4.3 Results of Samara City

The main approach for studying the groundwater pollution in samara city areas with respect to the data manipulation is to illustrate the compound of the studied areas. Represented by well depth, well height, static water level, and dynamic water level.

4.3.1. compound and morphology of Samara Groundwater

The wells depth was calculated as a function of the ground level (8- 75) m. Figure (4-13) shows the variation of well depth and table (4-14) shows estimated depth. Figure (4-14) represent the height of the surface area in Samara with respect to the to sea level. Table (4-15) shows the surface roughness of the area. The height of the surface of Samara city is within the range of (51-80)m.

The water level was calculated with respect to the sea level. Figure (4-15) shows the static water level of the wells within the studied area is in the range between (3-20) m. Table (4-16) shows the estimated value of each class of static water level. The dynamic water level is ranging between (6-20) m as shows figure (4-16). Table (4-17) shows the estimated area for each class of dynamic water level.

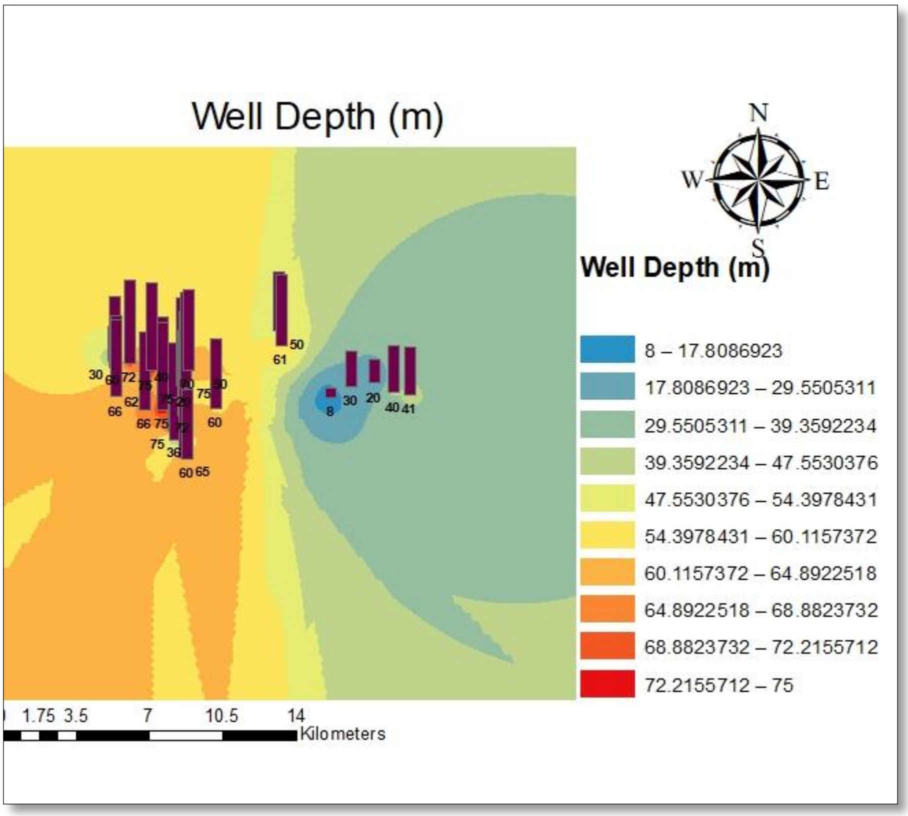

Figure 4-13. Well Depth

Table 4-14. The value of wells depth levels

Classes	Value_Min of depth(m)	Value_Max	Area(m^2)
1	8	17.80	1366300
2	17.8	29.55	10753100
3	29.55	39.35	206688000
4	39.35	47.55	134280000
5	47.55	54.39	40232700
6	54.39	60.11	233418000
7	60.11	64.89	194254000
8	64.89	68.88	3621630
9	68.88	72.21	961169
10	72.21	75	157038

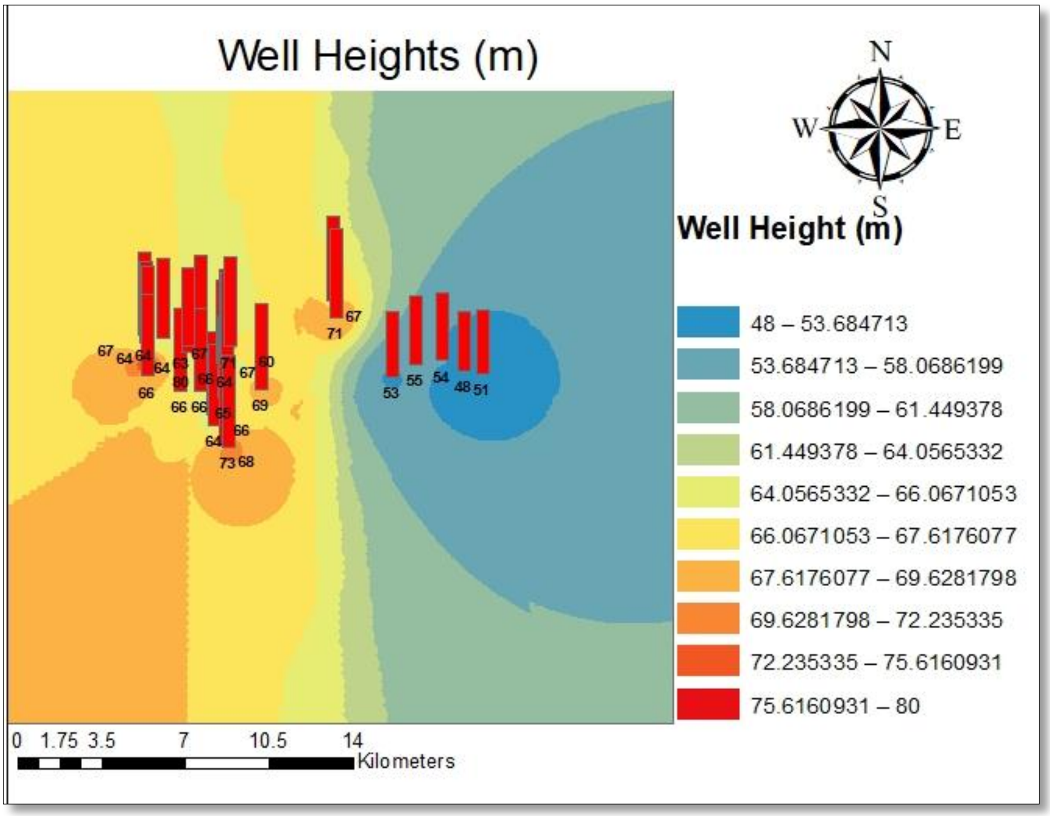

Figure 4-14.Location Height

Table 4-15. The value of morphological height areas

classes	Value_Min of height (m)	Value_Max	Area m^2
1	48.00	53.68	23278000
2	53.68	58.07	184638000
3	58.07	61.45	126814000
4	61.45	64.06	27804600
5	64.06	66.07	69251600
6	66.07	67.62	255423000
7	67.62	69.63	136736000
8	69.63	72.24	1377670
9	72.24	75.62	286818
10	75.62	80.00	121440

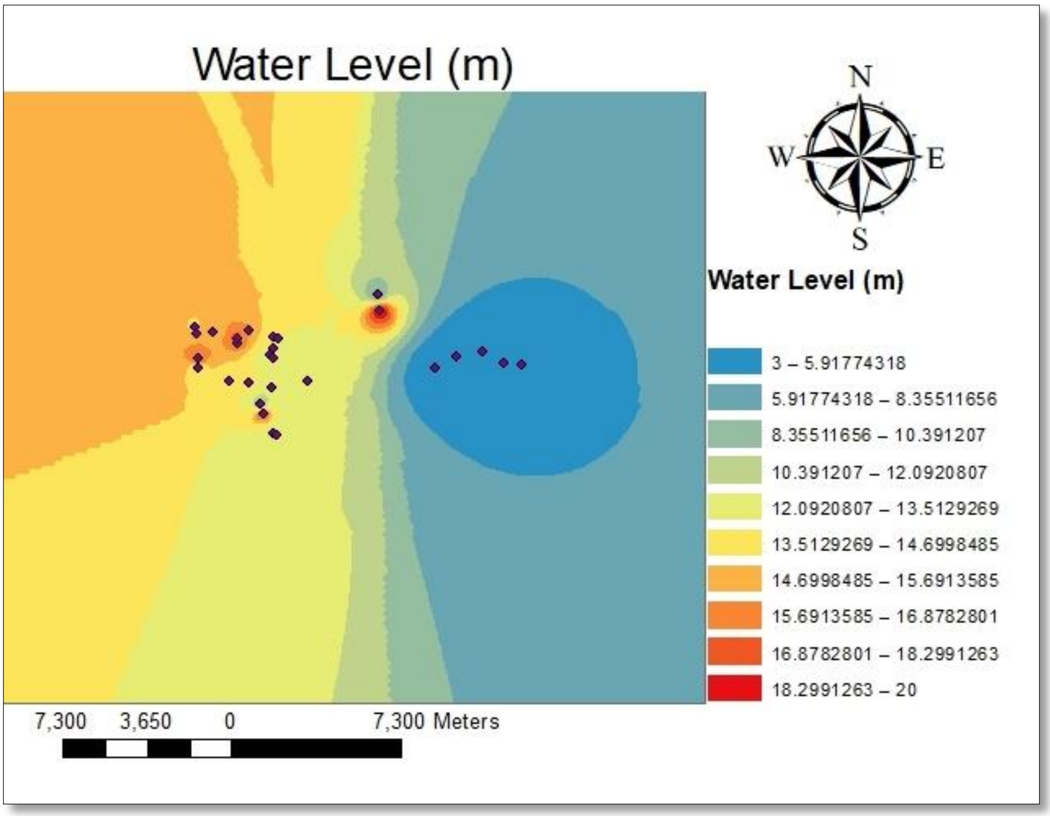

Figure 4-15. Water level

Table 4-16. The value of groundwater level class

Classes	Value_Min of Water level(m)	Value_Max	Area(m^2)
1	3	5.91	66243600
2	5.91	8.35	243841000
3	8.35	10.39	49669700
4	10.39	12.09	39028000
5	12.09	13.51	118475000
6	13.51	14.69	139952000
7	14.69	15.69	165250000
8	15.69	16.87	2424290
9	16.87	18.29	620136
10	18.29	20	227467

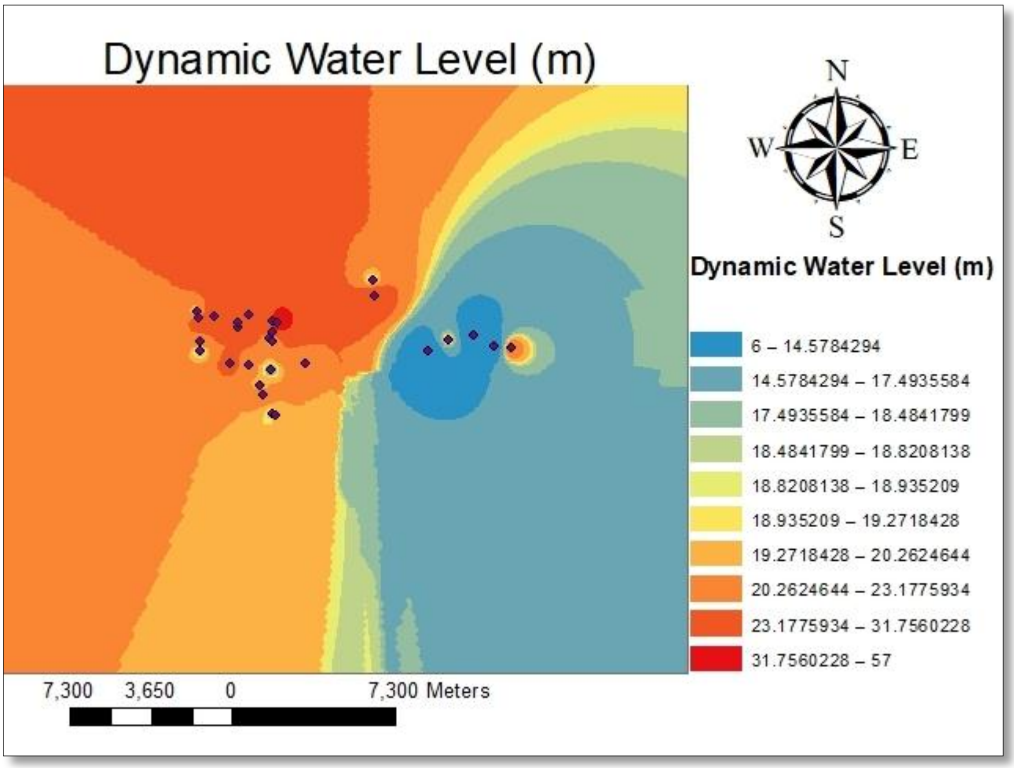

Figure 4-16. DynamicWell level

Table 4-17. The value of dynamic Water level class

Classes	Value_Min of dynamic Water level(m)	Value_Max	Area (m^2)
1	6	14.57	18018500
2	14.57	17.49	220175000
3	17.49	18.48	61778200
4	18.48	18.82	25572800
5	18.82	18.93	9617330
6	18.93	19.27	15982600
7	19.27	20.26	102559000
8	20.26	23.17	220164000
9	23.177	31.75	151088000
10	31.75	57	775489

4.3.2. Pollution analysis for Samara groundwater

Another approach of this work is studying the pollution factors that have been tested and evaluated for the entire studying area. The main steps for this purpose including: creating a map, projection the GCP points along with their data and processing these data using the IDW method. The map represent a set of data for each point within the studied area and can be read by ArcGIS software. The aim of this process is to study the quality of and study the groundwater and its validity for irrigation and human use. The concentration of the elements in the water refers to the quality of water according to WHO limits. The following specific results were obtained for these pollutants:

Table 4-18. Chemical elements concentration for Samara groundwater [43]

Well number	TDS (ppm)	K (ppm)	Na (ppm)	Mg (ppm)	Ca (ppm)	Cl (ppm)	SO_4 (ppm)	HCO3 (ppm)
1	2180	61	366	105	153	509	787	100
2	2200	6	360	93	145	467	680	349
3	1831	7	236	91	160	389	572	210
4	1850	15	3.5	74	120	442	551	92
5	4250	31	524	162	389	683	1408	487
6	2390	22	371	109	157	521	845	109
7	2012	5	280	74	188	408	885	247
8	2490	3	375	105	224	532	772	309
9	3996	81	541	142	300	660	1270	481
10	3830	113	521	151	321	696	1241	495
11	2230	13	270	120	185	610	840	165
12	3056	11	512	141	312	681	1180	484
13	1953	12	251	116	180	567	519	165
14	1400	7	184	32	72	310	212	70
15	550	9.3	54	106.6	420	190	346.35	168
16	2160	2.7	86	163.8	370.4	390	461.19	315

17	1740	12	308	55	126	239	721	177
18	2410	5.9	284	163.8	405.2	365	550.095	312
19	2627	2	360	20	210	500	730	280
20	2740	3.2	219	212	419.16	458	599.148	352
21	2480	4.9	250	163.8	410	368	371.2	346
22	3780	3.62	662	234.4	375	700.8	673.7	416.5
23	3380	4.2	609	230.5	344	693	405.9	436
24	2810	7	491	181.6	339	427	599.4	427
25	1830	15	305	74	120	442	551	92
26	3210	3.7	481	202.2	380.8	521.5	497.07	397
27	3835	116	538	158	329	715	1286	510
28	3550	95	456	146	307	638	1149	456

- **TDS:**

The results of TDS showed that the rate of which is high then the water pollution due to the dissolving the solids is ranging from (550-4250) ppm the maximum allowed concentration of TDS of 1000 ppm. Figure (4-17) shows TDS concentrations. Table (4.19) shows the surface values of each class for TDS.

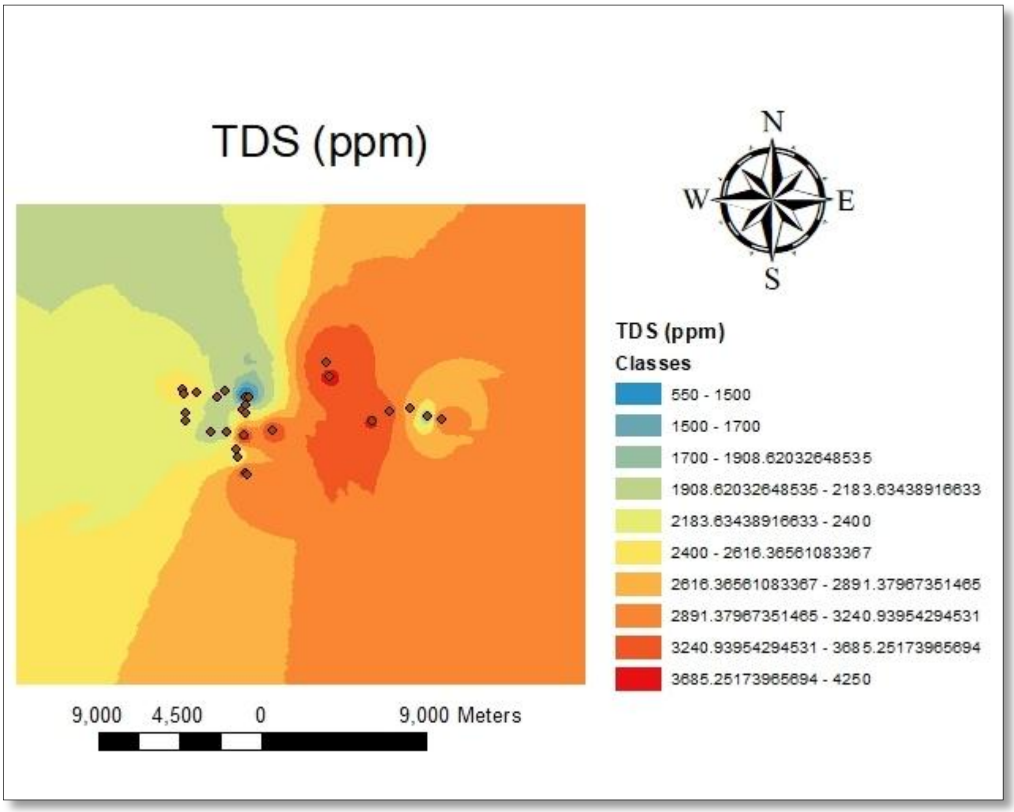

Figure 4-17.TDS concentrations

Table 4-19. The value of TDS concentration

Classes	Value_Min of TDS	Value_Max	Area (m^2)
1	550	1500	507418
2	1500	1700	626961
3	1700	1908.62	1823870
4	1908	2183.63	87133400
5	2183.63	2400	129470000
6	2400	2616.36	93918900
7	2616.36	2891.37	119393000
8	2891.37	3240.93	357119000
9	3240.93	3685.25	34467000
10	3685.25	4250	1272110

- **Potassium:**

The results indicate that the percentage of potassium in water between (2-116) ppm and the number of wells that exceeded the criteria is 7 out of 28 wells. Figure (4-18) shows Potassium concentrations and table (4-20) present the area of each class for potassium concentrations.

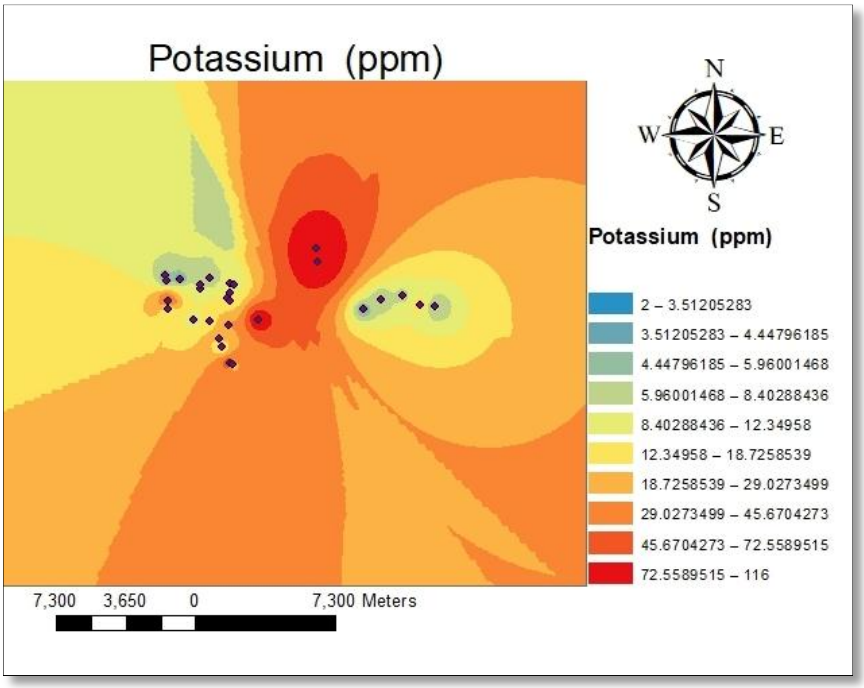

Figure 4-18. Potassium concentrations

Table 4-20. The value of Potassium concentration classes

Classes	Value_Min of K (ppm)	Value_Max	Area (m^2)
1	2	3.51	69788
2	3.51	4.44	94589
3	4.44	5.96	1087160
4	5.96	8.40	15939700
5	8.40	12.34	112097000
6	12.34	18.72	101080000
7	18.72	29.02	267318000
8	29.02	45.67	285315000
9	45.67	72.55	31818300
10	72.55	116	10911500

- **Sodium:**

The results show that the percentage of sodium in the water is the range (3.5 to 662) ppm and the number of wells that have been tested were 28. The number of wells that exceeded the allowed limit is 24 out of 28. Figure (4-19) shows Sodium concentrations and table (4-21) shows the calculated area of each class of sodium

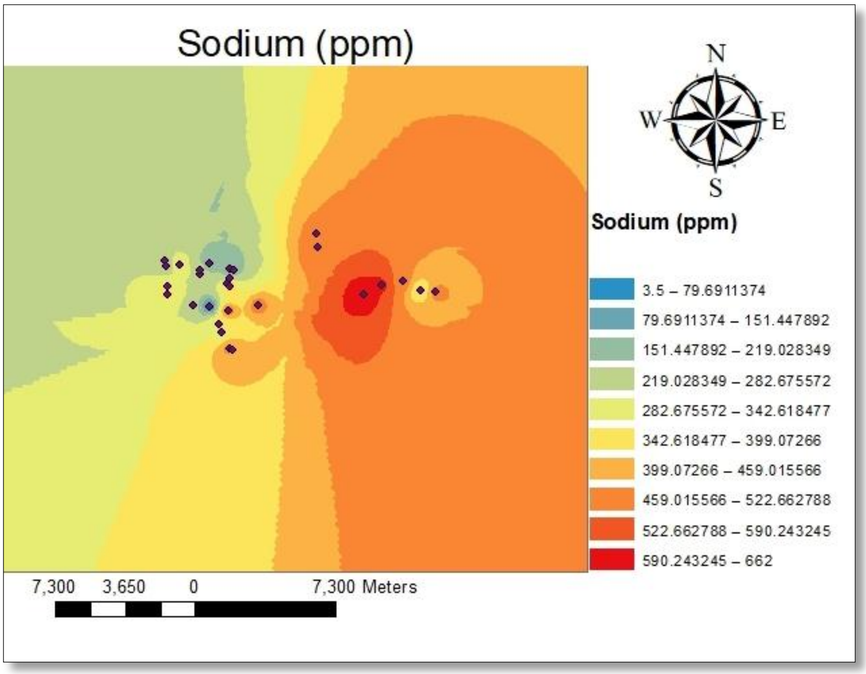

Figure 4-19. Sodium concentrations

Table 4-21. The value of Sodium concentration classes

Classes	Value_Min of Na (ppm)	Value_Max	Area (m^2)
1	3.5	79.69	118666
2	79.69	151.44	244837
3	151.44	219.02	4469880
4	219.02	282.67	179104000
5	282.67	342.61	124841000
6	342.61	399.07	102069000
7	399.07	459.01	110981000
8	459.01	522.66	285438000
9	522.66	590.24	14901200
10	590.24	662	3563940

- **Magnesium:**

The results indicate that the percentage of magnesium in the water of Samara is within the range of (20 - 234.4) ppm 28 wells are monitored and the number of wells exceeded the acceptable limits are 5. Figure (4-20) shows magnesium concentrations and table (4-22) presents the area of each class of magnesium concentration.

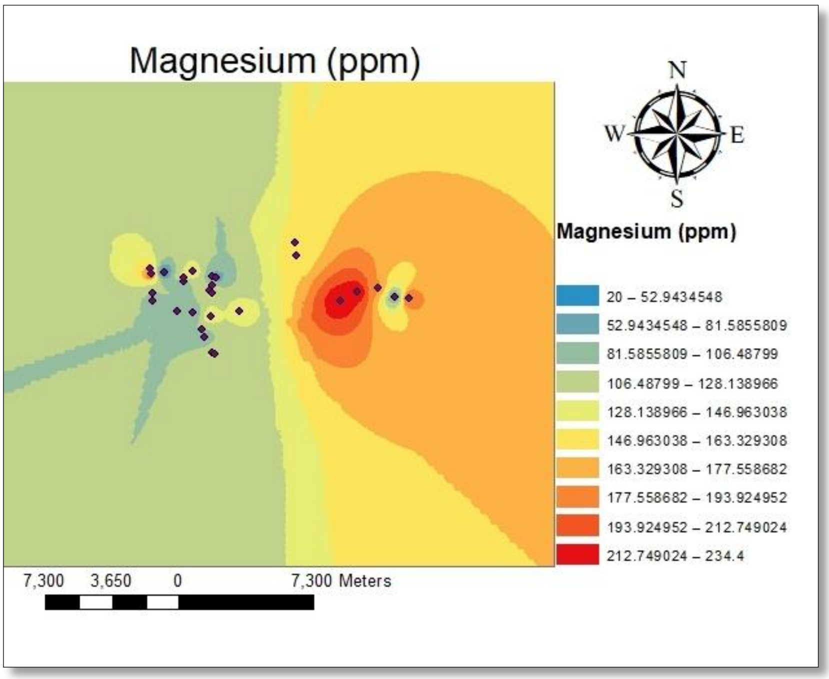

Figure.4-20. Magnesium concentrations

Table 4-22. The value of Magnesium concentration classes

Classes	Value_Min of Mg (ppm)	Value_Max	Area (m^2)
1	20	52.94	125398
2	52.94	81.58	684023
3	81.58	106.48	28992600
4	106.48	128.13	380516000
5	128.13	146.96	48515400
6	146.96	163.32	164524000
7	163.32	177.55	180468000
8	177.55	193.92	13162100
9	193.92	212.74	5508880
10	212.74	234.4	3234700

- **Calcium:**

The results show that the percentage of calcium in the water (72 - 420) ppm and the number of the wells exceeded the standards of WHO is 17 wells out of 28. Figure (4 -21) display the calcium concentrations. Table (4.23) presents the area of each class of calcium.

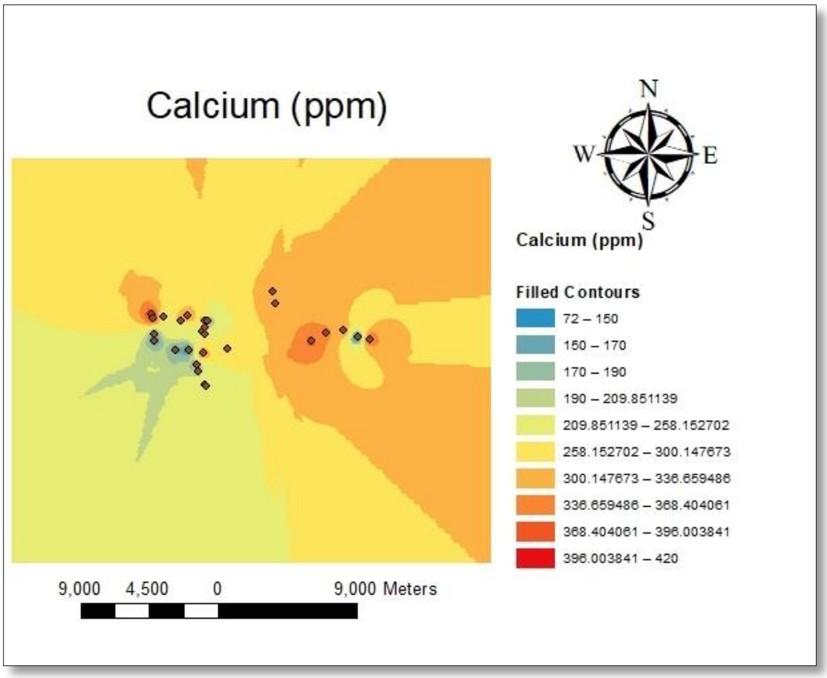

Figure 4 -21. Calcium concentrations

Table 4-23. The value of Calcium concentration classes

Classes	Value_Min of Ca (ppm)	Value_Max	Area (m^2)
1	72	150	179835
2	150	170	1276140
3	170	190	2654290
4	190	209.851	15511500
5	209.85	258.15	232906000
6	258.15	300.14	324409000
7	300.14	336.65	240957000
8	336.65	368.40	7041090
9	368.40	396.003	660450
10	396.003	420	136683

- **Chloride:**

The chloride concentration in the water is within the range of (190 - 715) ppm which is out of the standards of the World Health Organization. The number of wells exceeded the standards is 27 out of 28. Figure (4-22) shows the chloride concentrations and table (4-24) shows the value of chloride concentration and the estimated area for each class.

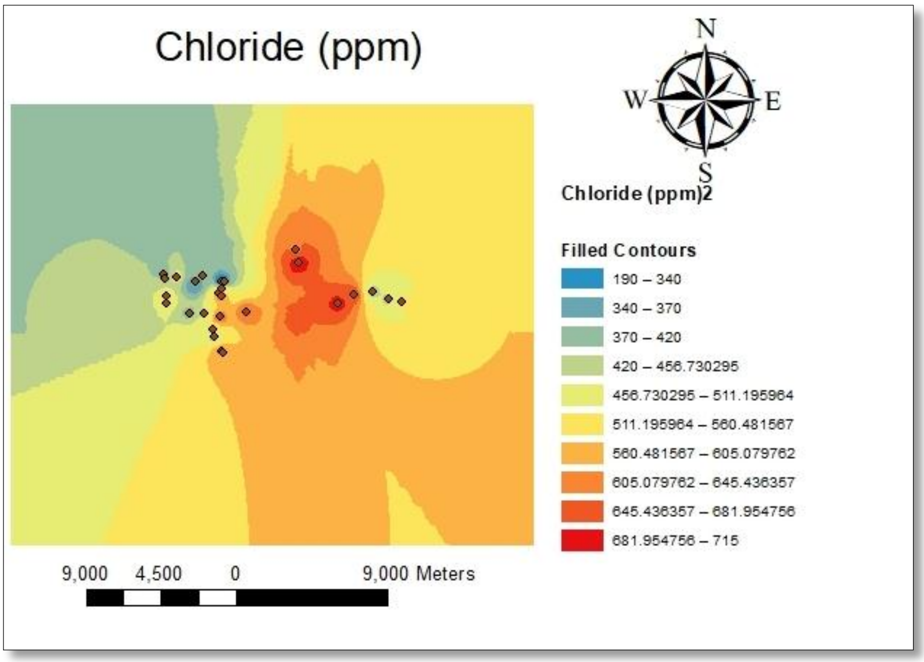

Figure4 -22. Chloride concentrations

Table 4-24. The value of Chloride concentration classes

Classes	Value_Min of Cl (ppm)	Value_Max	Area (m^2)
1	190	340	363918
2	340	370	1167300
3	370	420	124827000
4	420	456.73	71586700
5	456.73	511.19	114950000
6	511.19	560.48	244188000
7	560.48	605.07	227842000
8	605.07	645.43	26687300
9	645.43	681.95	12575100
10	681.95	715	1544820

- **Sulfates:**

The analysis shows that the percentage of sulfate in the water ranging from (212 – 1408) ppm and it is out of the standards of the World Health Organization since 24 out of 28 wells exceeding the limit.. Figure (4-23) shows the sulfates concentrations. Table (4-25) presents the value of each class of sulfates

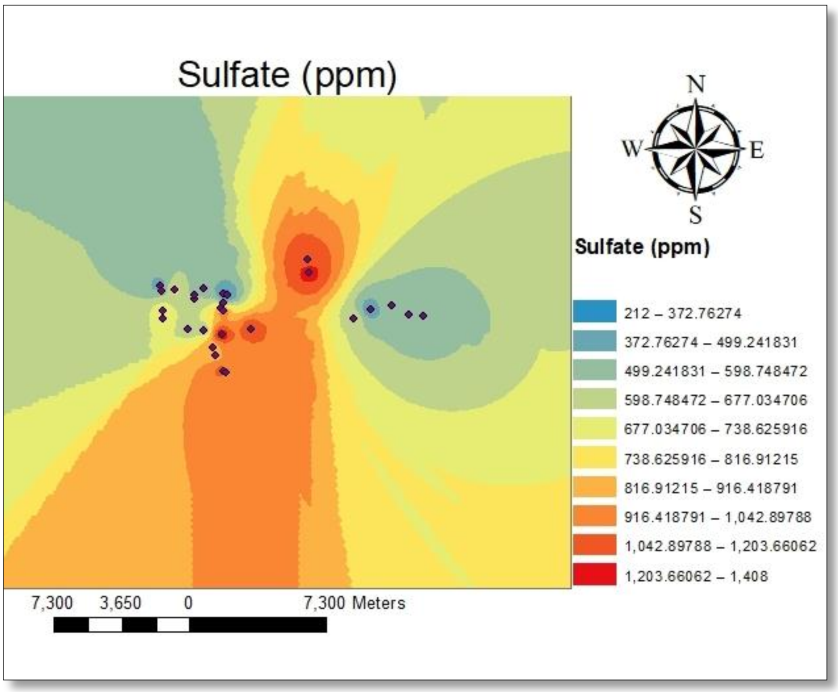

Figure4-23. Sulfates concentrations

Table 4-25. The value of Sulfates concentrations classes

Classes	Value_Min of SO_4 (ppm)	Value_Max	Area (m^2)
1	212	372.76	186715
2	372.76	499.24	2003730
3	499.24	598.74	135636000
4	598.74	677.03	177386000
5	677.03	738.62	163181000
6	738.62	816.91	123739000
7	816.91	916.41	116952000
8	916.41	1042.89	97549900
9	1042.89	1203.66	8169950
10	1203.66	1408	926570

- **Bicarbonate:**

The concentration of bicarbonates in the groundwater in the studied area is within the permissible limit and does not exceed the standard value. The percentage of Bicarbonate (72-510) ppm. Figure (4-24) show the bicarbonate concentrations in the groundwater at Samara city. Table (4-26) presents the bicarbonate concentrations and the estimated area of each class.

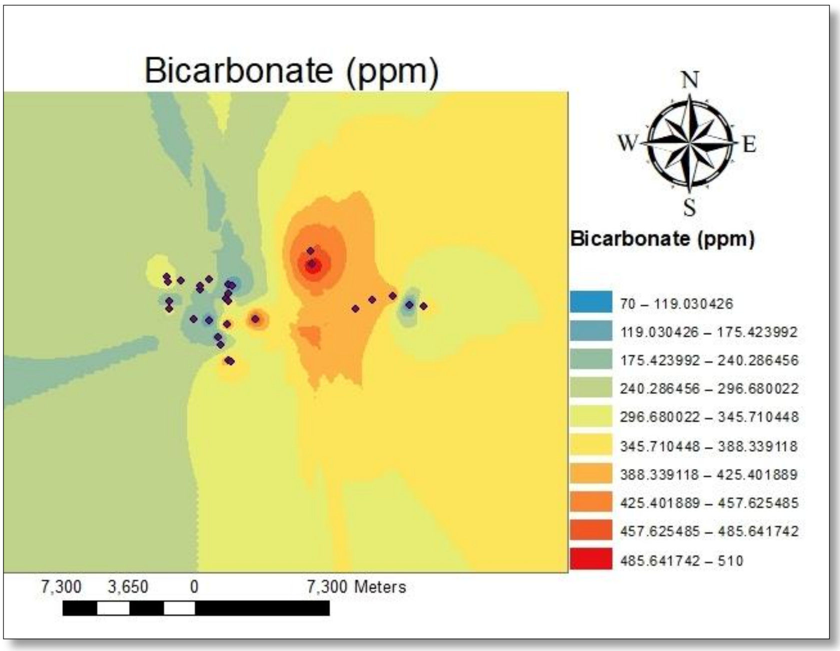

Figure4-24. Bicarbonate concentrations

Table 4-26. The value of bicarbonates concentrations classes

Classes	Value_Min of HCO_3 (ppm)	Value_Max	Area (m^2)
1	70	119.03	122385
2	119.03	175.42	1469310
3	175.42	240.28	33553600
4	240.28	296.68	295535000
5	296.68	345.71	167315000
6	345.710	388.33	280814000
7	388.33	425.40	35816600
8	425.40	457.62	8198200
9	457.62	485.64	2263660
10	485.64	510	643103

Chapter five

Chapter five

Conclusions and Recommendations

In this section, the conclusion of the study will demonstrated in two parts; one for Baiji city, and the other for Samara city.

The results of the wells studied in the city of Baiji shows that the concentration of nitrate in groundwater in this region was within the limits of the World Health Organization, where it was found that not all wells exceeded the limit. The concentration of chloride in groundwater exceeded the limit, the number of wells exceeded 18 out of 19 wells. By analyzing samples of sodium concentrations exceeded the limit and the number of wells exceeded 17 out of 19. The number of wells exceeded by the concentration of potassium is 9 out of 19, and for magnesium found a few wells that exceeded the number of only 6 wells. The results showed that the percentage of dissolved solids in the groundwater exceeded the standards. It was found that all wells exceeded the limit, while for calcium was found that the number of wells exceeded is 12 wells. The concentration of sulphates in groundwater exceeded the standards. The number of wells exceeded 16 out of 19.

The results of the city of Samara shows the chemical elements of the 28 wells that been studied, it was found that the number of wells exceeded the limit allowed for each of the following pollutants: (TDS exceeds at (27) wells, K exceeds at (10) wells, Na exceeds at (24) wells, Mg exceeds at (7) wells, Ca exceeds at (17) wells, Cl exceeds at (26) wells, SO_4 exceeds at (25) wells. Table (5-1) illustrated the Statistic table for pollutant area for(Baiji city and Samara city)

There are many pollutants that have directly affected the quality of groundwater in the city of Baiji. It is an industrial zone containing oil refineries (Baiji refinery), thermal and chemical plants, strategic pipelines, fertilizer plant and power plant. In addition to the fact that it is a semi-arid city. All these pollutants directly affected the quality of water and make it unsuitable for human use according to the standards of the World Health Organization, while the city of Samara also contains other pollutants that have affected the quality of groundwater, where the city of Samara contains factories and of these factories there is a pharmaceutical factory in Samarra. All above these pollutants have directly affected the water quality, and characteristics, making unsuitable for human, but can be used for other purposes.

Table (5-1) Statistic table for pollutant area

elements	Baiji	Samara
NO_3	0%	-
Na	60%	99%
K	70%	40%
Mg	10%	24%
Ca	90%	90%
SO_4	90%	99%
Cl	90%	100%
TDS	100%	100%
HCO_3	-	0%

Recommendation for future work

1. Consider seasonal measurements to identify changes in groundwater quality.
2. Study other areas nearby Salah al-Deen governorates to link the results to a wider area.
3. Study other contaminants such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and potential of Hydrogen (PH), to link the obtained results to the sources of pollution in the studied area.
4. Study the relation between the quality of groundwater and the upper soil layers, to determine the source of pollution whether it is by direct absorption or contaminants from the water cavity.

References

1. Reisner, Marc; Cadillac Desert: The American West and its Disappearing Water; pp. 438-442. ISBN 0-14-017824-4.1993.
2. Ibrahim Hamdan" Investigating Groundwater Quality in the Azraq Oasis Area Using GIS and Remote Sensing" Thesis Al - Bayt University• November 2006.
3. Kamel Salem Abu Daher, "Assessment of Groundwater Efficiency for Crop Irrigation In Deir Al-Balah Governorate ") Master Thesis, Islamic University-Gaza, 2015.
4. Rajkumar Nagarajan1*, Subramani Thirumalaisamy2 and Elango Lakshumanan2"Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of erode city, Tamil Nadu, India" Rajkumar et al. Iranian Journal of Environmental Health Sciences & Engineering 2012, 9:35
5. Al-Adamat, R.A.N and Foster, I.D.L and Baban, S.M.J; Groundwater vulnerability and risk mapping for the Basaltic aquifer of the Azraq basin of Jordan using GIS, Remote Sensing and DRASTIC; Applied Geography; volume23; pp 303 – 324;2003
6. Al-yasiri, Kifaya Hassan, " Contamination of groundwater for some areas between the Kefal and Shatt al-Hindi" Babylon University / Faculty of Basic Education.
7. Davis FW, simonett DS) GIS and remote sensing. In: Maguire DJ, Godchild MF, Rhind DW (eds) Information Systems “Principles and Applications”; London; Longman. 1991.pp.191-213,Vol1.
8. https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwjr6LatsMvlAhUSExQKHTxnD8sQjRx6BAgBEAQ&url=%2Furl%3Fsa%3Di%26source%3Dimages%26cd%3D%26ved%3D%26url%3Dhttps%253A%252F%252Far.wikipedia.org%252Fwiki%252F%2525D9%252585%2525D9%25258A%2525D8%2525A7%2525D9%252587_%2525D8%2525AC%2525D9%252588%2525D9%252581%2525D9%25258A%2525D8%2525A9%26psig%3DAOvVaw3phRTgPJbijI1QuzOa0sGG%26ust%3D1572778920814888&psig=AOvVaw3phRTgPJbijI1QuzOa0sGG&ust=1572778920814888.

9. Riad Baladi"Study of Groundwater Pollution within Abu Jerash Area"(Damascus University for Agricultural Sciences _2010.
10. Muller, J; Generalization of Spatial Databases In Geographic.1998.
11. Kamel Salem Abu Daher, "Assessment of Groundwater Efficiency for Crop Irrigation In Deir Al-Balah Governorate ") Master Thesis, Islamic University-Gaza, (2015).
12. Mohamed Abdel-Nasser El-Zarka, "Water Pollution in the Northern and Central Governorates and their Impact on human health "(Master Thesis, Islamic University - Gaza, 2010).
13. Sami Ahmed Suleiman Al – Karnaz, "Using GIS Cloud Technology in Establishing a DataBase of Groundwater Quality Monitoring in the Gaza Strip""(Master Thesis, Islamic University - Gaza, 2017).
14. 1W.Y. Wan Zuhairi, Fadhl Al Nozaily and 2Fares Alshaebi, "The Characteristics of Leachate and GroundwaterPollution at Municipal Solid Waste Landfill of IbbCity, Yemen" American Journal of Environmental Sciences, 2009.
15. Ibrahim Saud Al-Showaie, Asma Ali Abahsen, Walid Khalil Zabari " Assessment of the groundwater potential of the Dammam reservoir for pollution resulting from surface activities in the Kingdom of Bahrain Using your study method and GIS techniques" emirates Research Journal- (2014).
16. Mohamed M. El Alfy "Integrated Geostatistics and GIS techniques for assessing groundwater contamination in Al Arish area, Sinai, Egypt" 2012.
17. Nosrat Aghazadeh, Majid Nojavan, Asghar Asghari Mogaddam, "Effects of road-deicing salt (NaCl) and saline water on water quality in the Urmia area, northwest of Iran"2010.
18. Orhan Gunduz, Celalettin Simsek, Altug Hasozbek, "Arsenic Pollution in the Groundwater of Simav Plain, Turkey: Its Impact on Water Quality and Human Health"Springer Science + Business Media B.V. 2009.
19. Najat Al Bahloul almabruk Salem"Study on the quality of groundwater in the Tripoli area of Libya"University of Tripoli, 2015.

20. Nour Mesbah Abdullah Mahmoud, "Water Assessment of Water Quality of Drinking Wells in Governorate"2012) Master Thesis, Islamic University, Gaza, Khan Younis, 2000(2013).
21. Muheeb Awawdeh [1)] and Awad Nawafleh [2]), "A GIS-based EPIK Model for Assessing Aquifer Vulnerability in Irbid Governorate, North Jordan" Jordan Journal of Civil Engineering, Volume 2, No. 3, 2008
22. Emma Engström[1,2] & Ulla Mörtberg[1] & Anders Karlström[2] & Mikael Mangold[3,4], "Applying spatial regression to evaluate risk factors for microbiological contamination of urban groundwater sources in Juba, South Sudan "2016.
23. Insaf S. Babiker*, Mohamed A.A. Mohamed, Tetsuya Hiyama, Kikuo Kato, "A GIS-based DRASTIC model for assessing aquifer vulnerability in Kakamigahara Heights, Gifu Prefecture, central Japan" Science of the Total Environment 345 (2005).
24. WHO; Guidelines for Drinking Water Quality; Second Edition; Volume 2; Geneva; 1996.
25. P. Balakrishnan1*, Abdul Saleem2 and N. D. Mallikarjun2" Groundwater quality mapping using geographic information system (GIS): A case study of Gulbarga City, Karnataka, India" African Journal of Environmental Science and Technology Vol. 5(12), pp. 1069-1084, December 2011.
26. Minessota Pollution Control Agency; Barium, Beryllium, Calcium, Magnesium and Strontium in Minnesota's Ground Water; 1999.
27. Heine, G. W. "A Controlled Study of Some Two-Dimensional Interpolation Methods." COGS Computer Contributions 3 (no. 2): 60–72. 1986.
28. Todd, David Keith; Groundwater Hydrlogy; Second edition; John Wiley and sons; New York; 1980.
29. Jin Li and Andrew D. Heap" A Review of Spatial Interpolation Methods for Environmental Scientists" Record 2008/23.
30. Philip, G. M., and D. F. Watson. "A Precise Method for Determining Contoured Surfaces." Australian Petroleum Exploration Association Journal 22: 205–212. 1982.
31. Watson, D. F., and G. M. Philip. "A Refinement of Inverse Distance Weighted Interpolation." Geoprocessing 2:315–327. 1985.

32.Franke, R. Smooth Interpolation of Scattered Data by Local Thin Plate Splines. Computer and Mathematics with Applications. 1982. Vol. 8. No. 4. pp. 273–281. Great Britain

33.Anat Thapinta, B.S., M.S." Use of Geographic Information Systems for Assessing Groundwater Pollution Potential by Pesticides in Central Thailand" Dissertation Prepared For The Degree Of Doctor Of Philosophy, University Of North Texas August 2002

34.Sibson, R. "A Brief Description of Natural Neighbor Interpolation," Chapter 2 in Interpolating Multivariate Data, 21–36. John Wiley & Sons: New York, 1981

35.Watson, D.Contouring: A Guide to the Analysis and Display of Spatial Data. Pergamon Press: London, 1992.

36.Buhmann, MartinD ,"Radial Basis Function: Theory and Implementations" Cambridge University Press Pdf,2003.

37.Oliver, M. A. "Kriging: A Method of Interpolation for Geographical Information Systems." International Journal of Geographic Information Systems 4: 313–332. 1990

38.Royle, A. G., F. L. Clausen, and P. Frederiksen. "Practical Universal Kriging and Automatic Contouring." Geoprocessing 1: 377–394. 1981.

39.Heine, G. W. "A Controlled Study of Some Two-Dimensional Interpolation Methods." COGS Computer Contributions 3 (no. 2): 60–72. 1986.

40.Kouri,et al "Method for performing DAF data filtering and padding", United States Patent,January 25,2005.

41.Halit Apaydin,F.Kemal Sonmez,Y.Ersoy Yildirim,"Spatial interpolation techniques for climate data in the GAP region in Turkey",Climate Research,Vol. 28:31-40,2004.

42.Michael J. de Smith,Michael F. Goodchild and Paul A. Longley,"Geospatial Analysis 3rd edition",Trobaor Publishing UK,2012.

43.Iraqi Ministry of Water Resources,2012-2014.

الخلاصة

تهدف هذه الدراسة إلى تقييم ودراسة نوعية المياه الجوفية في محافظة صلاح الدين في موقعين ، بيجي وسامراء ، باستخدام تقنيات نظم المعلومات الجغرافية.

يبدأ هذا العمل بجمع البيانات حول نوعية المياه المأخوذة من الآبار في المناطق التي شملتها الدراسة. تم تحليل العينات لتحقيق تركيزات العناصر المذيبة في الماء. تم جمع البيانات خلال الفترة (2012-2014) وتحليلها من قبل وزارة الموارد المائية العراقية.

لتحقيق هذا الهدف ، تم أخذ عينات من بيجي لـ 19 بئراً داخل منطقة الدراسة و الموزعة عشوائياً في المنطقة التي شملتها الدراسة. تم إجراء تحليلات لكل من الملوثات الكيميائية التالية TDS (،Mg ،Ca ، k، NO_3 ، Cl، Na، SO_4) في عينات المياه من مدينة بيجي حيث تم حساب تراكيز الملوث للمنطقة بأكملها.

تم أخذ عينات من الآبار من 28 موقعاً داخل مدينة سامراء. تم تحليل العينات للملوثات الكيميائية (TDS، Mg، Ca، K، HCO_3 ، Cl، Na، و SO_4.) وتم حساب تراكيز الملوث للمنطقة بأكملها. لتحليل المياه الجوفية في منطقة معينة يجب اتباع طريقتين هما: هيكلية المياه الجوفية، ومقدار ونوع التلوث في المياه الجوفية. تم إعداد التحليل الهيكلي لخرائط (ارتفاع البئر وعمق البئر ومستوى الماء الثابت ومستوى المياه الديناميكي). هذه الخرائط حيث صممها برنامج ArcGIS الاصدار 10.4.

تم استخدام طريقة الاستكمال العكسي للوزن العكسي لإنشاء خريطة بيانات تمثل المتغير في جميع أنحاء المنطقة المدروسة. أظهرت نتائج تحليل العينات المأخوذة من آبار بيجي أن جميع الآبار التي تحتوي على NO3 لم تتجاوز الحد المسموح و كانت مطابقة للمعايير . كذلك تبين ان عدد الآبار التي تجاوزت الحد المسموح بالنسبة للملوثات الكيميائية فقد بلغ عدد الآبار المتجاوزة من اصل 19 بئر

((TDS (19) , K (9) ,Na (17) , Mg (9) ,Ca (12) , Cl (28) , SO_4 (16)).

أظهرت نتائج مدينة سامراء الملوثات الكيميائية في 28 بئرا التي تمت دراستها ، وقد وجد أن عدد الآبار يتجاوز الحد المسموح به لكل من الملوثات التالية:((TDS (27)، K (10)، Na (24) (، Mg (7)، Ca (17)، Cl (26)، SO4 (25)). بينما وجد ان جميع الآبار التي تحتوي على HCO_3 مطابقة للمعايير .

جمهورية العراق

وزارة التعليم العالي والبحث العلمي
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تقييم التلوث في المياه الجوفية و رسم الخرائط لها باستعمال نظم المعلومات الجغرافية

رسالة مقدمة إلى
مجلس كلية التربية للعلوم الصرفة / ابن الهيثم - جامعة بغداد
وهي جزء من متطلبات نيل درجة ماجستير
في علوم الفيزياء

من قبل
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