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ORIGINAL ARTICLE

# ASSESSMENT OF GROUNDWATER QUALITY OF AL THIRTHAR VALLEY BASIN IN IRAQ USING GIS AND REMOTE SENSING TECHNIQUES.

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**Abstract:**

*The area of the study lies between latitudinal degrees 34° 20′ 47̋ – 36° 30′ 32̋ north and longitudinal degrees 41° 35′ 12̋ – 43° 26′ 50̋ east. The area includes the northwest parts of Iraq and the northwest parts of the Plain. The area is surrounded by Sinjar Mountain, Kolat Mountain, Zuhair Mountain, and Shaikh Ibrahim Mountain from the north; it is a series of hills which mark the border line of the water of Thirthar valley basin and Tigris. While the Eastern borders are the borders of the Tigris basin, from the south the area is surrounded by Euphrates and from the west is surrounded by the valleys of Ajeej, Ashkar and Sumbula. The study area is about 24138.259 square kms.*
*The study has been conducted to prepare a map of groundwater quality zones of al Thirthar valley. The study uses secondary data, collected from different and relevant sources. Inverse distance weighted method of the Geographical Information Systems is used to prepare the distribution map of chemical. The results of study show that the quality of groundwater varies both spatially and temporally. The results also show that the area extent of good and moderate groundwater zones decreases while poor and very poor zone areas increase.*

**KEY WORDS:**

Remote Sensing Techniques , Groundwater Quality , Geographical Information Systems (GIS).

## INTRODUCTION

It is important to know that, the chemical features of the groundwater, which has not less importance than knowing its amount and locations. Knowing the features help to determine the type of different uses, and the ways to invest them, especially in light of increasing their uses in the present time.

The increasing of population and their economic development which accompany with the development of technical search of groundwater and its extraction, all these contribute to invest groundwater in areas which lack surface water resources, as in the part which is located at Thirthar valley basin, and the areas near it.

## The Study Area

The area of the study lies between latitudinal degrees 34° 20′ 47″ – 36° 30′ 32″ north and longitudinal degrees 41° 35′ 12″ 43° 26′ 50″ east. The area includes the northwest parts of Iraq and the northwest parts of the Plain. The area is surrounded by Sinjar Mountain, Kolat Mountain, Zuhair Mountain, and Shaikh Ibrahim Mountain from the north; it is a series of hills which mark the border line of the water of Thirthar valley basin and Tigris. While the Eastern borders are the borders of the Tigris basin, from the south the area is surrounded by Euphrates and from the west is surrounded by the valleys of Ajeej, Ashkar and Sumbula. The study area is about 24138.259 square kms.

## OBJECTIVES OF THE STUDY

To assess the total of the ground water resources of Thirthar valley basin.
To understand and analyze the pattern of domestic and agricultural water resource utilization.

## METHODOLOGY AND ANALYSIS:

The study is based on secondary data, which have been collected from different sources, such as the hydro-geological maps of the study area, Samples of water wells have been analyzed and studied in the laboratory. The focus is on the most important chemical elements which are melted in the samples represented by positive ions of (Magnesium, Calcium, and Sodium) and the negative ions (Sulphates, Nitrates, Chlorides and Bicarbonates).

In order to provide clear picture of the quality of groundwater, certain of chemical elements have been adopted in the area of the study and as following:

Analyzing the spatial distribution of each parameter.
Preparation of zonation maps of the groundwater quality, using Geographical Information Systems (GIS) techniques.

Arc GIS 9.2 has been used for geo-referencing, vector layer and inverse distance weighted (IDW) analysis. The IDW generated mapping for each parameter which have then used to do overlay analysis, to create the groundwater zones.

## Hypothesis:

1.The disparity in features of water according to the disparity of the rocks in the study area.

In order to provide clear picture of the quality of groundwater, certain of chemical elements have been adopted in the area of the study and as following:

### 1. The Salinity:

The water wells of the area characterized by the concentration of melted salts in general, as well as the variance values from well to another. This is due to the existence of gypsum, limestone.

The results of table (1) show the existence of clear difference in the values of melted salts in the groundwater, within the wells of the study area of which range between 2000-2900 Mg/liter. The area has divided into four levels which consistent with the requirements of the study. (Map-1)

**Table No: 1 Selected Water Wells of Chemical Properties of the Al Thirthar Valley Basin**

| Valley No | Total Salts (Mg / L) | Electrical Conductivity Dc Siemens/ M | PH | Mg Eq/L | Calcium Eq/L | Sodium Eq/L | Sulphates Eq/L | Chloride Eq/L | Nitrates Eq/L | Bicarbonates Eq/L |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2100 | 3.1 | 7.3 | 5 | 12 | 8 | 10 | 12 | 9 | 6 |
| 2 | 2900 | 4.7 | 7.8 | 9 | 24 | 12 | 13 | 23 | 7 | 5 |
| 3 | 2300 | 3.6 | 7.1 | 8 | 19 | 8 | 12 | 17 | 5 | 4 |
| 4 | 2600 | 4.3 | 7.3 | 11 | 10 | 22 | 10 | 21 | 9 | 3 |
| 5 | 2800 | 4.5 | 7.5 | 10 | 23 | 11 | 13 | 22 | 6 | 6 |
| 6 | 2600 | 4.2 | 7.2 | 9 | 12 | 18 | 10 | 20 | 5 | 4 |
| 7 | 2400 | 3.8 | 8 | 10 | 21 | 8 | 11 | 19 | 4 | 7 |
| 8 | 2700 | 4.5 | 7.2 | 8 | 17 | 11 | 10 | 20 | 7 | 5 |
| 9 | 2200 | 5 | 7.6 | 13 | 29 | 12 | 14 | 21 | 4 | 8 |
| 10 | 2300 | 5.2 | 7 | 9 | 16 | 22 | 12 | 24 | 6 | 6 |
| 11 | 2400 | 6.3 | 8 | 11 | 22 | 25 | 10 | 37 | 15 | 7 |
| 12 | 2900 | 4.4 | 7.6 | 6 | 30 | 8 | 13 | 18 | 4 | 6 |
| 13 | 2000 | 3.2 | 7 | 14 | 18 | 13 | 9 | 33 | 0.9 | 3 |
| 14 | 2800 | 5.7 | 6.8 | 14 | 21 | 29 | 10 | 38 | 0.8 | 7 |

**A.The first level:**

The amount of salts vary at the area of the study between high and low (1999)Mg/L., this level represented in different parts of the area of the study, as in the northern and eastern parts. The reason of existence little salts in the water of the other wells is due to their location near feeding sources, and the existence of cracks help in increasing the speed reaching of water to the location of the wells, and also, the limited time of ion exchange among the rocks and the water which pass above them and these what make them acquire less concentrations.

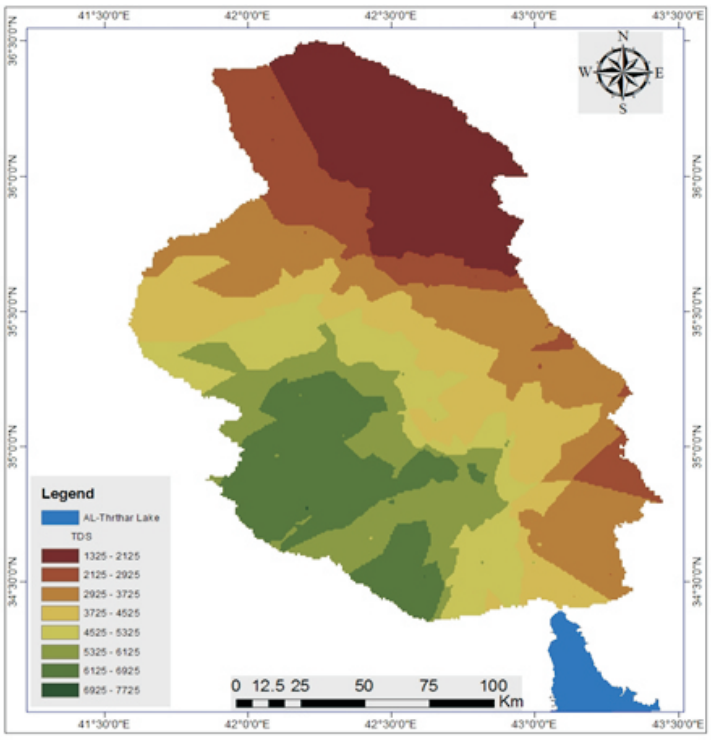
**B.The second level (2000-2549 Mg/L):**

The salts concentration in the water ranged between 2000-2549 mg/L. This level extend in the eastern and western parts, this level is considered the beginning of the gradient in the ratio of salts concentration of the area, which increase generally as we progress from north toward south and south-east with the general regression of the area of the study. This is due to the flow of water among the pores of the rocks that work on melting the components of the rocks and concentrating the salts.

**C.The Third level (2550-2849 Mg/L):**

The salts ratio increase in this level which less its validity of investment. The high total of salts is concentrated in the water wells of quartet sediments; because their groundwater reservoirs consist of layers which are rich in salts.

**Map No: 1 The Salinity of Al Thirthar Valley in Iraq**




**D.The Fourth level (more than 2900 Mg/L):**

The salinity concentration increases in some wells of the area of the study due to their components which are rich with salts, as well as the little feeding source. The highest values of salt concentration were recorded in the southern parts of the basin and near Thirthar Lake. The concentration of salts is due to their location within sediments rocks, and gain groundwater feeding which is derived from salt water which comes from lake in original like Thirthar Lake.

**2. Electrical Conductivity:**

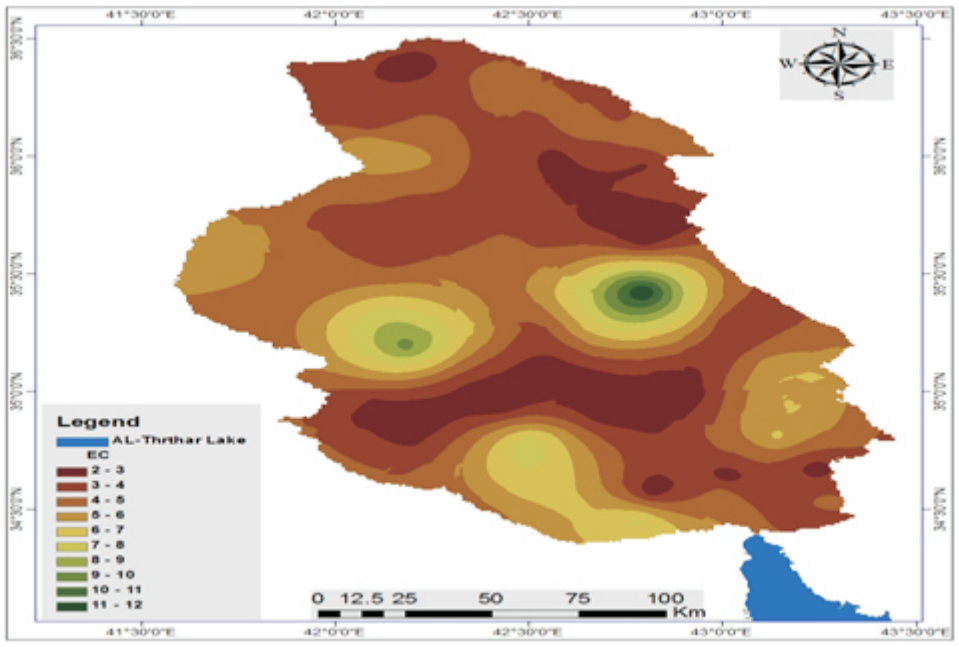
The water wells at Thirthar valley characterize with high electrical conductivity which range between 3.1-6.3 Dc Siemens/M, table no (1) map no (2). This express the concentration of slats in the water, as well as the less of spatial differences of the value of electrical conductivity in the water of aquifer aperture which range between 2.6 to 6.4 Dc Siemens/m.

The values of conductivity in the middle and southern parts increase to reach maximum 6.3Dc Siemens /m, due to the increasing of the concentration of mineral elements melted in them.

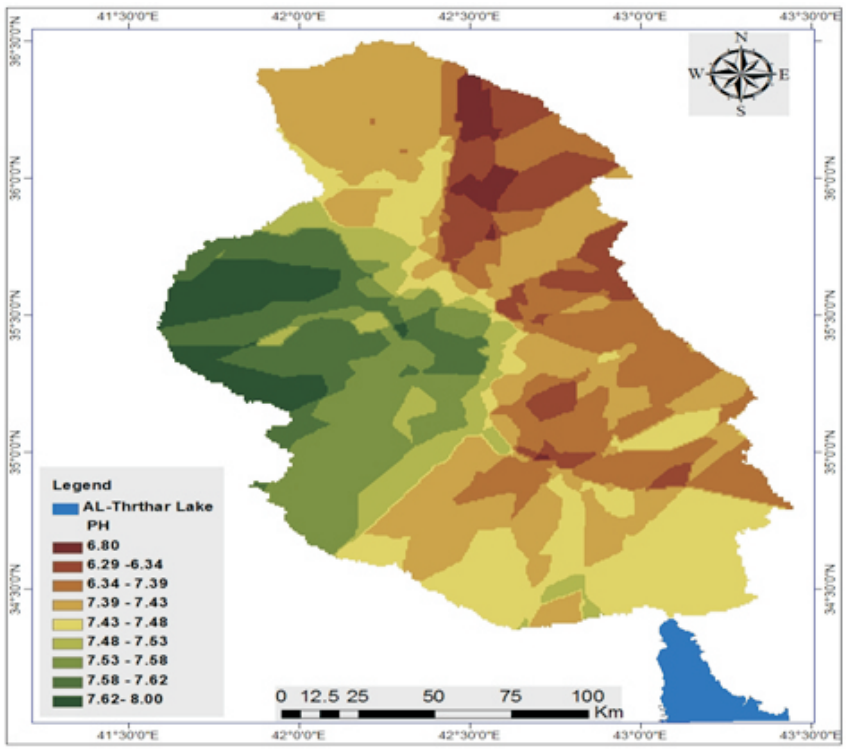
**3. PH (Acidic and Alkaline)**

The Ph is considered a measurement of ion hydrogen activity, whether the water is acidic or alkaline. Thus, it gives an indicator of the water validity for drinking. Out of field measurements of these wells, it has discovered the differences of the value of this element in the water wells from light acid to light alkaline ranged between 7-8 as shown in Table (1) map no(3). This indicates that the groundwater reservoirs have affected by the water which filtrated from rain and the surface sources. In order to determine the features of chemical groundwater of the wells of the study, their water validity has been studied to specify the kind of uses and as following:

**Map No: 2 Electrical Conductivity of Al Thirthar Valley in Iraq**




**Map No: 3 The Acidic and Alkaline of Al Thirthar Valley in Iraq**



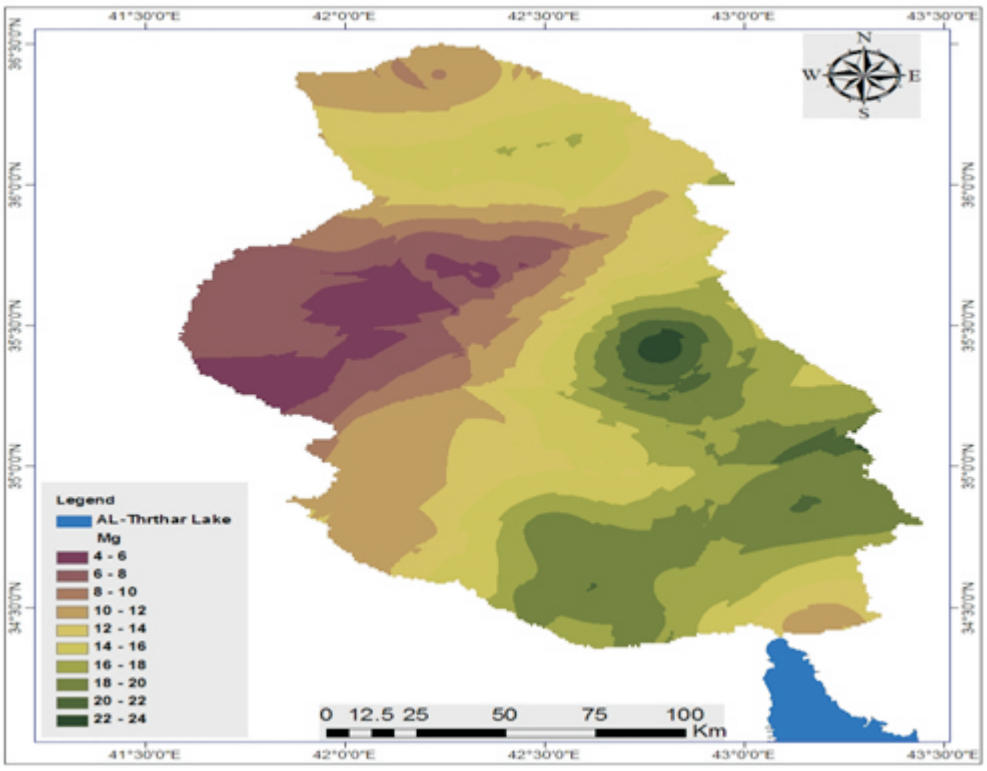

**A.The Magnesium:**

The magnesium is one of the ions which scattered in the water wells of the area of the study due to spread of gypsum and dolomite rocks within their configuration. This rocks have the ability of melting in water forming salts which the ions ones one of them.

The previous Table revealed that, existence of variation in the values of magnesium ion from one

well to another. The lowest concentration is 5 Mg Eq/L, whereas the highest concentration is 14 Mg Eq/L, and between these two values located the other values, as shown in table (1) map no (4). The reason of concentrating the magnesium in some wells is due of the flow of their groundwater for rocks which rich in magnesium such as limestone rocks. The concentration becomes less in other layers reservoirs. The highest values were recorded of this ion in some wells of Euphrates aquifer and quartet sediment, particularly the deep wells due to the existence of muddy stone, and parasites in the lower layers which are rich in magnesium element.

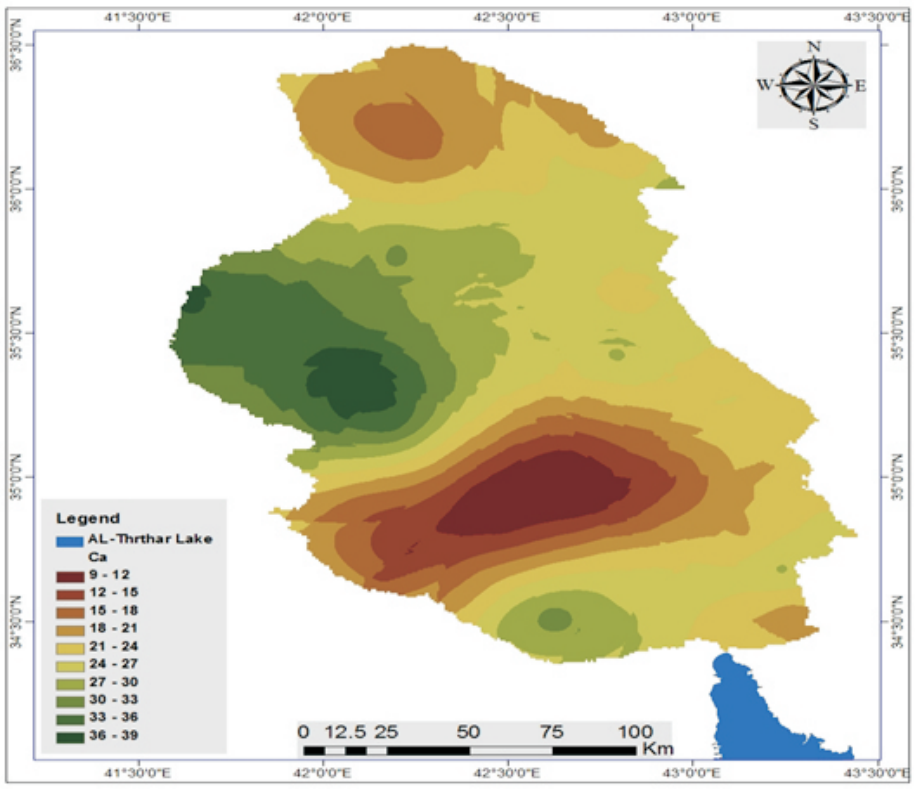
**Map No: 4 The Magnesium of Al Thirthar Valley in Iraq**




**B.Calcium:**

The calcium ratio which is melted in water wells increase generally. This increasing is due to the chemical weathering of sedimentary rocks as in gypsum, dolomite, and halite rocks which recognize by their super usability to decomposition and melting in water. The values of calcium element concentration are varied from one aquifer to another. This varying is existed within geological configuration. The values varied between 10-30 Mg Eq/L, table (1) map no (5). The results of the table refer to the increasing of the ratio of this ion in most wells of quartet sediments aquifer, because its groundwater contains sediments on the secondary gypsum, and the hemihydrates, as well as gaining its reservoirs rich groundwater with calcium.

**Map No: 5 The Calcium of Al Thirthar Valley in Iraq**




**C.Sodium:**

The melted Sodium salts form high ratio in the water wells of the area of the study, because the rocks contain high ratios of minerals which reacts with water to configure these salts. The most importance of these salts is the gypsum, the hemihydrates, and the muddy rocks . The outcomes of table (1) map no (6) show that the concentrations of sodium in water wells range between 8-29 Mg Eq/L.

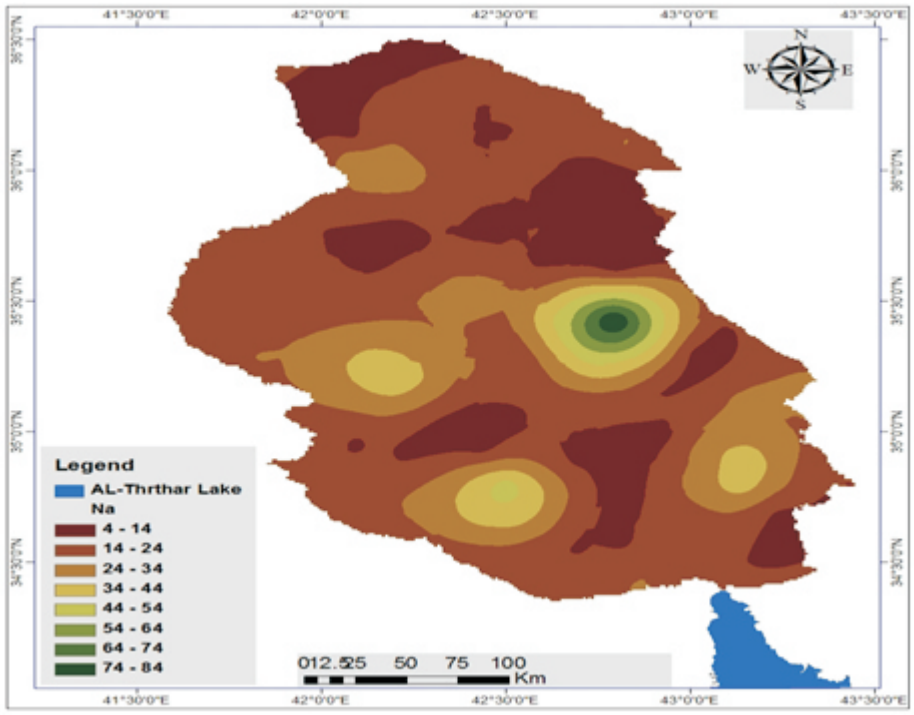
This is due to existence of cracks (caves) and big channels in the rocks, as well as the continuous pumping process from these wells. This process reduce melting and decomposition processes due to the lack time of water contacting with rocks which reduce the concentration of salts in general and sodium slat in specific. The Sodium concentration increases in the eastern parts due to the availability of essential minerals of sodium in the region's rocks, that the most important is halite mineral which soluble in water.

**D.The Sulphates:**

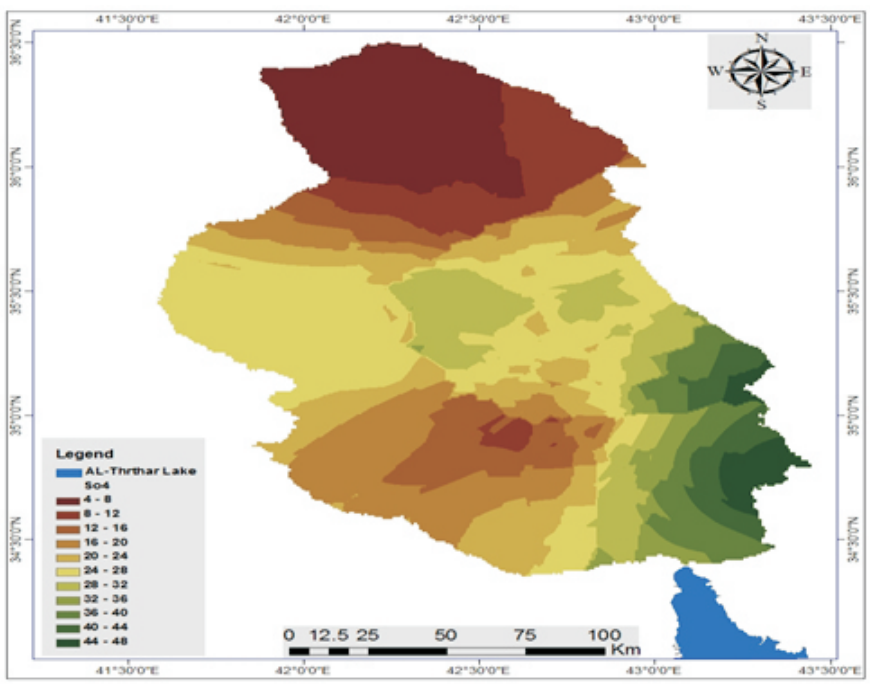
Ttable (1) shows that the sulfate salts spread dramatically in the area of the study which makes water with bitter test. The reason of concentrating the sulfate is due to soluble the gypsum and hemihydrates which located within the configuration of the area. The Table shows the concentration of sulfates in water wells that varies between 9-14 Mg Eq/L, map -7.

The reason for increasing the sulfate in this aquifer is its location in the area of drainage underground water which comes from the northern parts and rich with sulfur. As a results of flowing between prose and cracks of rocks, this lead to increase the time of ion exchange with long distance, that make them gain more salts from aquifer aperture.

**Map No: 6 The Sodium of Al Thirthar Valley in Iraq**




**Map No: 7 The Sulphates of Al Thirthar Valley in Iraq**




**E.Chloride:**

Chloride is the most ions concentrated in groundwater of wells of the area of the study. The reason of concentrating this ion is the presence of halite mineral, which is one of evaporates marine rocks in their geological configuration. Halite rock is recognized by its quick melting and dissolution in water, to

configure molten salts.

The chloride salt represents 60% of the Halite rock. Through the results of chemical analysis for the water wells, we recognize table (1) map no (8) the minimum variation and maximum values for chloride ion between 17-38 Mg Eq/L. This is closely with differences of ground water aquifers which feed the wells. The reason of this increase is attributed to the slow movement of water in these two aquifers, particularly in the deep wells. This lead to activate the process of dissolution and increase of this ion, besides gaining their groundwater aquifer rich feeding of chloride ion.

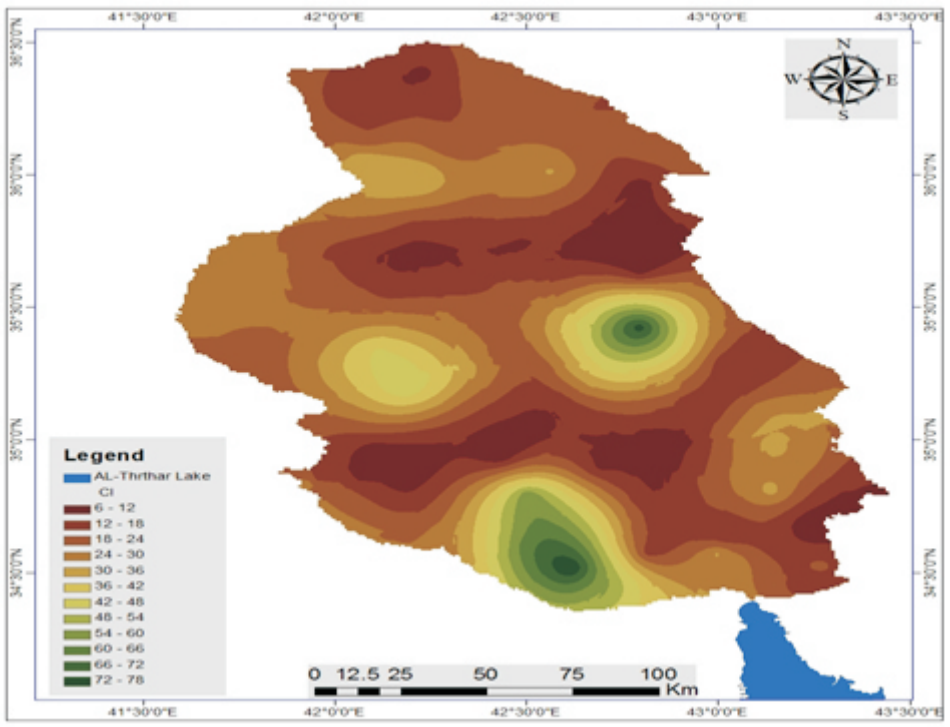
**F.Nitrates:**

Nitrates differ from other mineral salt dissolved in the groundwater in terms of being a source resulting from the decomposition of waste, human waste, agricultural and animal waste, as well as chemical fertilizers which are leaked to the shallow reservoirs. The results of the chemical analysis of the wells of the study, show the differences of nitrates concentration between 0.8 mm Eq/L to 15mm Eq/L., map -9 and the nitrates are concentrated in the southern parts more than others.

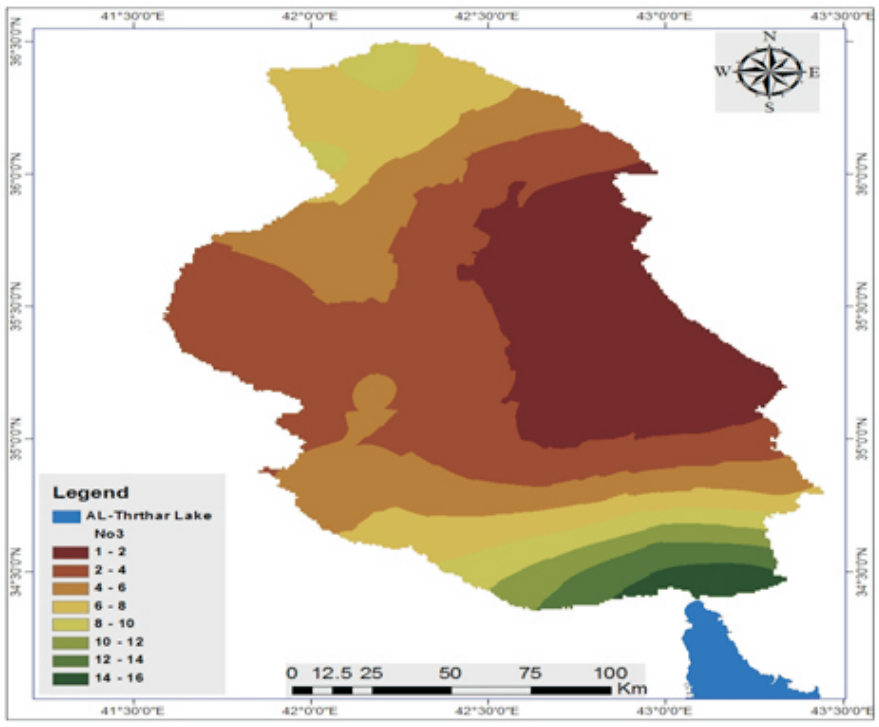
The cause of concentration the nitrate in the southern parts is attributed to the shallow depth of aquifers of the wells of the study. Also, due to the concentration of agricultural and animal investment and what filtrate from water which is rich with chemical fertilizers into underground aquifers for these parts.

Also, the northern parts areas are considered good pastures for animals, particularly at rainy years. The intensive networks of the valleys worked on transforming of such waste, whether they are plant or animal west in the rainy season to the underground reservoirs of these wells, and the accumulation of waste and converts it to nitrate over time. The low of nitrates in other parts indicate the depth of the wells and the limited investment.

**Map No: 8 The Chloride of Al Thirthar Valley in Iraq**




**Map No: 9 The Nitrates of Al Thirthar Valley in Iraq**




**G.The Bicarbonates:**

The presence of bicarbonates rocks in the area of the study represented by limestone and dolomite rocks have helped the existence of dissolved bicarbonates in underground water. The concentration of this ion and the raise of its ration depend on the existence of dioxide carbon and the high temperature of water, which works together to activate the processes of melting the rocks and transforming the carbonate to dissolved bicarbonate.

The results of chemical analysis of the water wells of the study reveal the differences in the bicarbonate values between 3 mm Eq/L to 8 mm Eq/L., and what ells between these two values, range the other values, as show in table-1.

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