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VARIATION OF GROUNDWATER QUALITY OF TELKAIF AREA, NORTH OF MOSUL CITY, IRAQ

Taha Hussein Al-SALIM*

ABSTRACT.- The shortage in water supply forced population to drill their private well and extract groundwater to meet their increasing needs. The area under study is a major agricultural area that supports crops such as wheat, barely, lentil and vegetable and large scale livestock operation The importance of chemical characteristics study of groundwater lies in knowing the effect between lithological unit and water flow, and naturally concentration of dissolved salts increased due to natural dissolution process. The chemical characteristics of groundwater samples in Telkaif area north of Mosul City have been studied through the chemical analysis of (14) water samples to evaluate the quality of groundwater for determining its suitability for domestic and agricultural uses. Physical and chemical parameters of groundwater samples such as electrical conductivity (Ec), pH, Total Dissolved Solids (TDS), Na^+, K^+, Ca^{+2}, Mg^{+2}, HCO_3^{-1}, SO_4^{-2}, NO_3^{-1},Cl^{-1} and Total Hardness (TH) were determined. Hydrochemical parameters are analyzed graphically by using Piper diagram to show the suitability, type and the geochemical evolution of the groundwater. Richard (1954) and Wilcox (1955) classifications are also used to show the suitability of groundwater for irrigation. Lithological unit of Al-Fatha, Injana and Quaternary aquifers were identified and examined from the wells distributed over the area of study. Groundwater of the study area is replenished from rainfall and valleys draining water to the catchment. Groundwater chemistry of the study area indicates that most groundwater samples are of $CaHCO_3$ and $CaSO_4$ water type, hawing high total hardness (TH) and Total Dissolved Solids (TDS), and generally low alkaline in nature.

Key Word: Iraq, Telkaif area, groundwater, hydrochemistry

INTRODUCTION

Water quality analysis is an important issue in groundwater studies and is equally important to its quantity owing to the suitability of water for various purposes. The study area is a major agricultural that supports crops such as wheat, barely and lentil and a large scale livestock operation. The present work in this paper outlines a geochemical and hydrogeological investigation of Telkaif area. Major ion chemistry is identified and the graphical representation of the hydrochemistry is used to identify the type of water and the distribution of major ion concentration of the area under research. The present study describes and show the variation in chemical characters of ground water samples of north and south of the study area and is found to be directly related to geologic formations.

People and farm owners in this area resorted to drill their private wells and extract groundwater to meet their domestic, agricultural and industrial needs .The future agricultural development in this area will be accompanied by increased demands for water which must come from local groundwater resources , therefore it is essential to asses the suitability of groundwater for drinking and agricultural uses.

LOCATION AND DESCRIPTION OF STUDY AREA

The study area is located at NE of Mosul city (Figure 1), and approximately between latitudes (36° 23' 42" – 36° 35' 41")and longitudes (42° 56' 04" – 43° 18' 24"). It covers an area of about 120 Km^2, and fall under semi-arid climatic type. The average minimum temperature during December-February is 18°C. The average max-

* Remote Sensing Center University of Mosul
tahahusseinsalim@yahoo.com

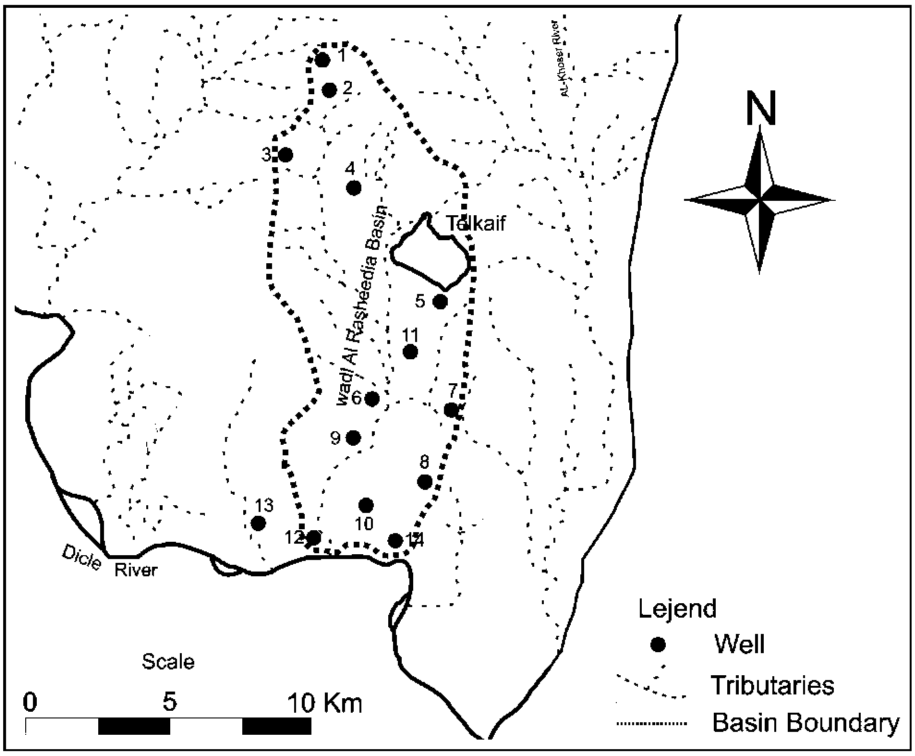

Figure 1- Location map of the study area

imum temperature during March-May is about 23°C while during June-August is about 42-46°C. Rainfall is the primary source of water in the study area which receives an average annual precippitationof about 430 mm.

The area is characterized by well-developed dendritic type of drainage system. Tributaries are ephemeral, as it carries water during rainy period between November-March only. Coarse textured patterns present in the plains indicate high rainfall infiltflouringration. The regional slope of the studied area is from north to south where the Tigris River is.

GEOLOGICAL SETTING

Stratigraphically, the area under research is dominated by geological formations ranging from Middle Miocene to Quaternary as shown in figure 2, and as follows:

1- Middle Miocene Al Fatha Formation. This formation crops out at the southern part of the study area and composed of gypsum, anhydrite, marl, clay, green marl and limestone (Buday and Jassim, 1984 ; Mohi -Alddin et al., 1977). The thickness is about (50-75) m on the average.

2- Upper Miocene Injana Formation. This formation crop out at the North East of the study area, composed of sandstone, marl, limestone and thick beds of red to brown sandstone(Buday and Jassim, 1984).

3-Quaternary sediments. The Quaternary sediments are mostly covering the area completely under the study. This sediments include residual soil (sandy and loamy soil) and flood plain deposits which consist of sand, silt and clay, and slope deposits which consist of rock fragments, sand and silt which is slightly cemented. The thickness varies greatly from less than 2 m to greater than 5 m.

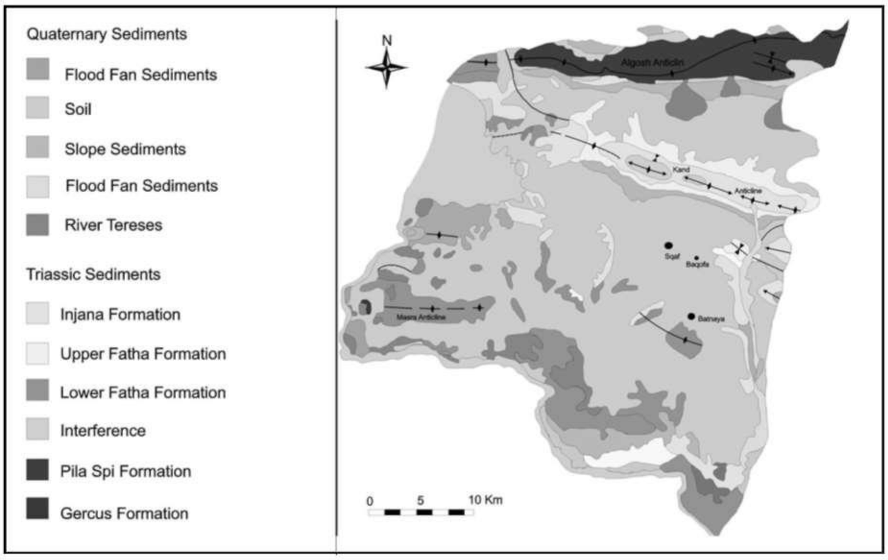

Figure 2- Geology of the study area

HYDROGEOLOGICAL SETTING

According to the geological formation, two types of aquifers are present in the study area;

1-Unconfined aquifer is mainly the Quaternary sediments which have wide geographical distribution and thickness in ranges of 3 - 6 m . This aquifer is underlained by the Pliocene clay which acted as impermeable confining bed between Quaternary and Injana formation. The recharge to this aquifer takes place from direct rainfall and runoff.

2-Injana and Al-Fatha formations are considered to be a semiconfined aquifers. Bore hole lithology records as shown in figure 3 reveal that both formations are separated from Quaternary sediments by an aquiclude of clay sediments in some places and are hydraulically connected to Quaternary sediments in others. These aquifers consist mainly of variable lithological units of permeable and impermeable beds and receives its water mainly by underflow and leakage from upper regional aquifer. These aquifers are well jointed and fissured and in local scale exhibits solution channels.

Rainfall is the main source of aquifer recharge. It occurs along Quaternary sediments. In addition, infiltration from intermittent tributaries that drain water during period of heavy precipitation.

HYDROCHEMISTRY

SAMPLE COLLECTION AND ANALYSIS

Groundwater samples were collected from (14) deep wells during March, 2006. The chemical analysis were carried out in the laboratories of the Department of Geology, Mosul University according to the methods adopted by the U. S. Geol. Survey, (Rainwater and Thatcher, 1960). Electrical conductivity (Ec) and pH were measured immediately after sampling. Water samples collected in the field were analyzed for major cations (Ca^{+2}, Mg^{+2},Na^{+}, and K^{+},) and major anions (HCO_3^{-1}, SO_4^{-2},Cl^{-1}, and NO_3^{-1}), total hardness (TH), and total dissolved solids (TDS). All measurements and major ion analysis are presented in table 1.

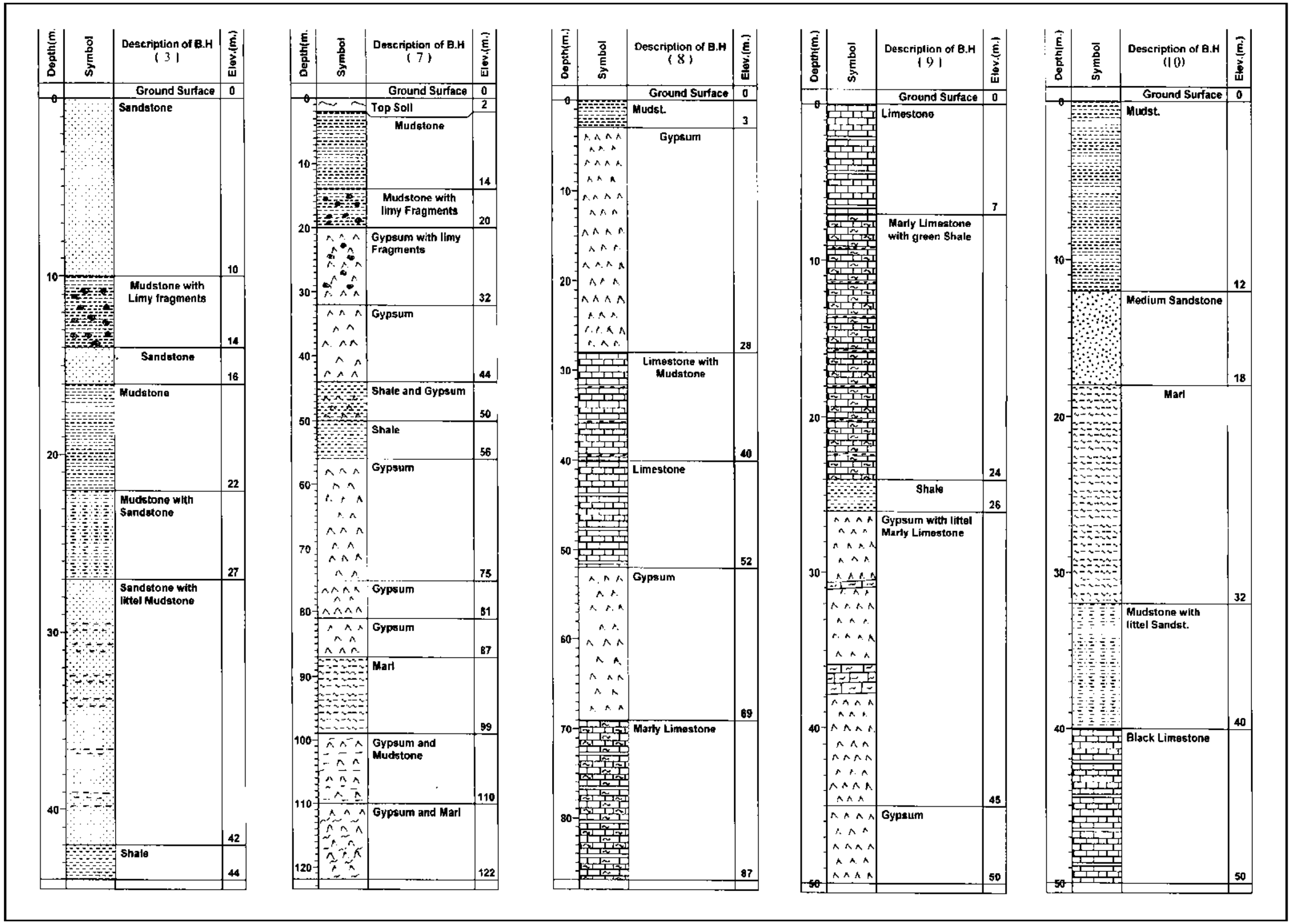

Figure 3a- Bore hole lithological unit

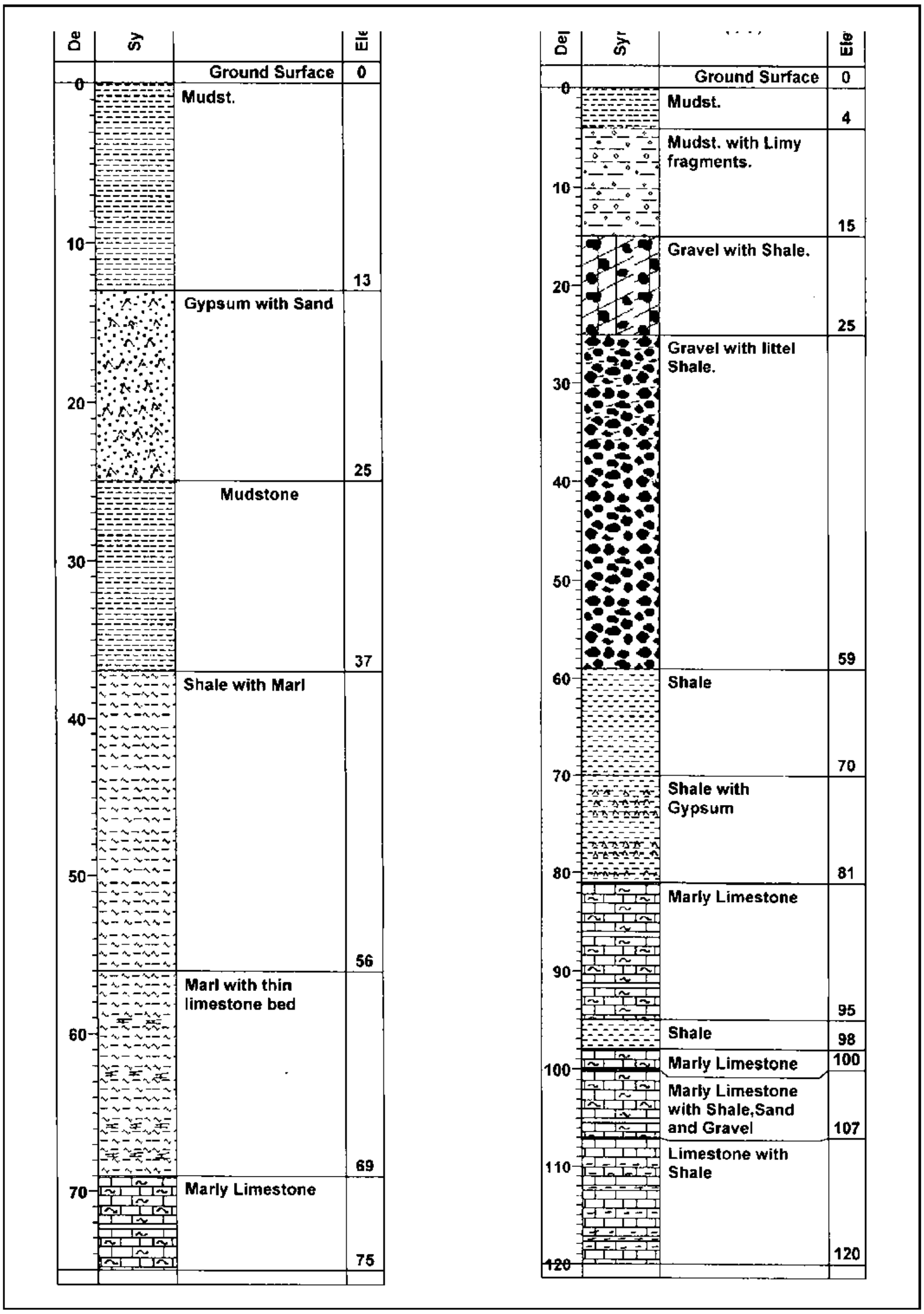

Figure 3b- Bore hole lithological unit

Table 1- Ion concentration of groundwater samples of the study area (ppm) March, 2006

Sample No.	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	TDS	Ec	pH	TH	SAR	Na%
1	166.7	95.5	87.3	3.1	435.0	200.5	85	3.5	1700	1660	7.42	809.2	1.89	19.4
2	154.3	104.5	72.8	1.8	470.0	218.3	68	2.8	1560	1620	7.4	815.3	1.57	16.5
3	172.3	98.2	79.4	2.1	445.8	208.5	72	3.1	1450	1500	7.38	834.3	1.69	17.4
4	184.7	112.8	85.2	2.0	474.3	226.0	78	3.2	1680	1540	7.42	925.3	1.72	16.9
5	158.2	88.0	72.0	3.6	380.0	1660.0	87	3.7	2400	2300	7.21	757.1	1.61	17.6
6	228.7	82.3	75.0	3.2	680.0	1340.0	94	3.4	2550	2400	7.28	909.7	1.53	15.56
7	284.6	152.3	87.0	2.9	372.0	1420.0	84	2.1	2180	2350	7.36	1337.3	1.46	12.67
8	278.8	149.4	77.3	3.2	480.0	1620.6	78	2.6	2820	2520	7.28	1310.9	1.31	11.65
9	275.3	158.7	73.0	3.8	775.0	750.8	88	3.8	2500	2270	7.41	1340.4	1.22	10.90
10	262.0	152.3	88.4	3.6	640.3	520.6	80	3.2	2000	1900	7.22	1280.9	1.52	13.36
11	290.0	107.3	89.1	3.4	340.0	2130.0	110	4.2	3000	2650	7.30	1165.6	1.60	14.60
12	266.7	152.5	77.0	2.8	690.0	712.0	82	2.8	2170	1900	7.42	1293.4	1.31	11.75
13	278.6	168.4	82.0	3.1	575.0	680.7	84	2.4	2050	1950	7.38	1388.6	1.35	11.64
14	272.4	160.7	78.0	3.4	580.0	1155.0	86	3.2	2500	2400	7.40	1341.4	1.31	11.53

GROUNDWATER QUALITY

HYDROCHEMICAL FACIES

Groundwater quality is defined by the chemical constituents in the water and the chemical analysis data are helpful for determining the usefulness of groundwater as a potable resource.

Piper Diagram (Hem, 1985) is used to illustrate the major ions composition of groundwater samples (Figure 4). This diagram is particularly useful for detecting changes or trends in groundwater chemistry across an area or through time (Sanders, 1998). Piper diagram shows that most samples are of mixed cations- SO_4 type and samples 1,2,3 and 4 are of mix- HCO_3 type while sample 10 of mix Ca-Mg-Cl type of water.

LITHOLOGY AND WATER CHEMISTRY

The most important process that adds salt to groundwater is mineral dissolution reaction in the subsoil and to a lesser extent, along the entire flow system (Salama et al., 1999).

Water can be classified by its chemical character and by determining the dominant cation and anion. The prevalent chemical character of the ground water of the area under study can be categorized into two groups;

Calcium–Sulfate waters.- Calcium- Sulfate waters are probably produced by the solution of anhydrite ($CaSO_4$) and / or gypsum ($CaSO_4$. $2H_2O$).

Al-Fatha Formation probably contains sufficient gypsum or anhydrite and account for the increase in SO_4 and TDS, as a result of increasing residence time and contact of water flow with minerals present in the sediments.

Calcium-Bicarbonate waters.- As water enters the formation acquire initial chemical character by contact with limestone and other carbonate rocks. Solution of calcium carbonate would result in the formation of a calcium – bicarbonate water. $CaCO_3$ is soluable in water if there is an abundant of H ion (Krothe and Bergeron 1981). The equilibrium equations involved in these reactions are as follows:

$$CaCO_3 + H \longrightarrow Ca + HCO_3$$

$$CaCO_3 + H_2O + CO_2 = Ca + 2HCO_3$$

WATER QUALITY FOR IRRIGATION

Irrigation water quality can be understood by determining Sodium Adsorption Ratio (SAR) and Sodium Percentage (Na%).

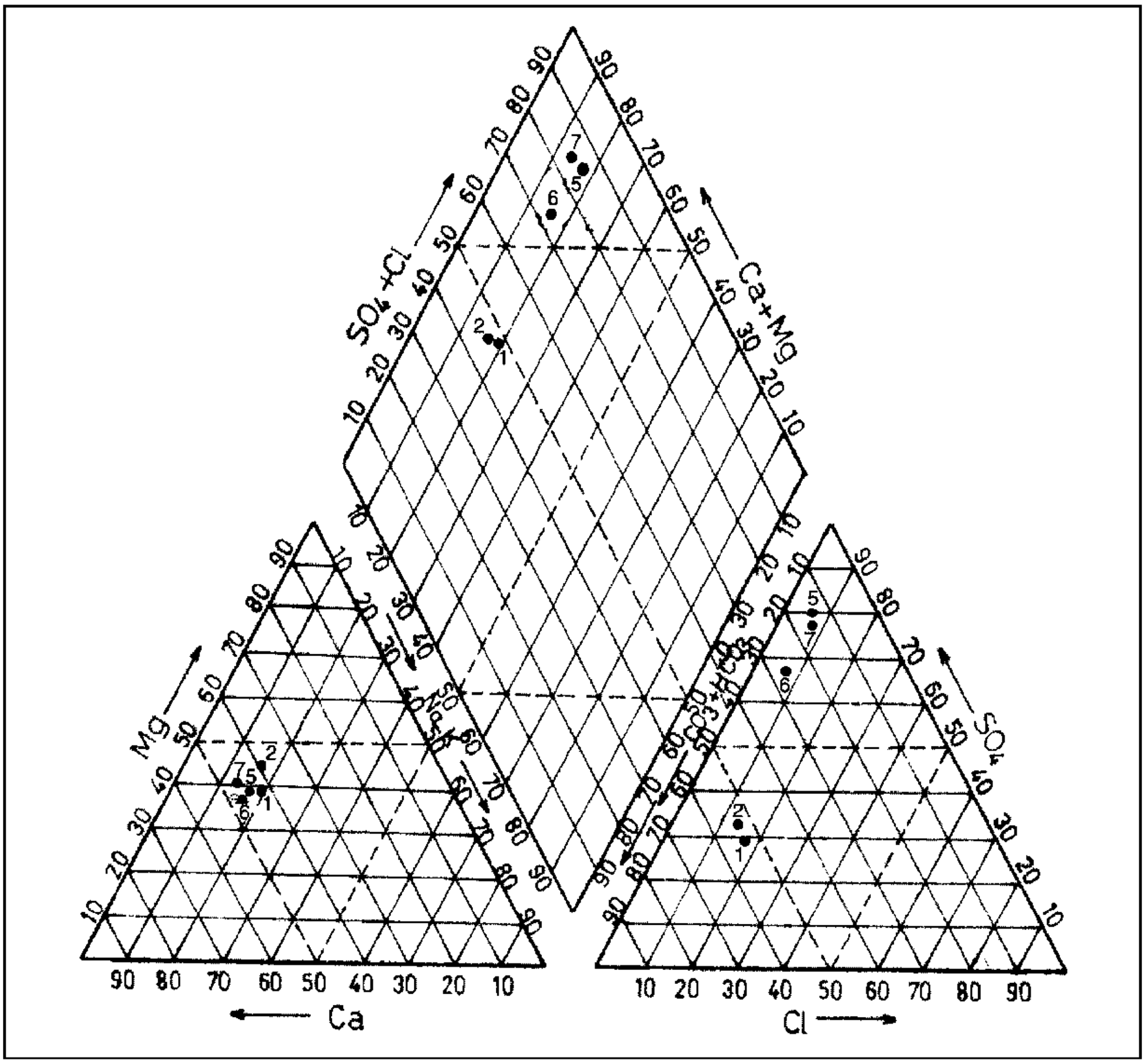

Figure 4a- Piper diagram of chemical facies of groundwater

SODIUM ADSORPTION RATIO (SAR)

SAR is an important parameter for determining suitability of groundwater for irrigation because it is a measure of alkali / sodium hazards to crops. SAR is defined by (Karanth, 1987):

$$SAR = \frac{Na}{((Ca^{2+} + Mg^{2+})/2)^{\frac{1}{2}}}$$

Where concentrations are in meqv/l.

Plotting of SAR and electrical conductivity (Ec) on the US salinity diagram (Richards 1954) illustrates that most groundwater samples fall in the field of C3S1, indicating high salinity and low Na water, which can be used for irrigation (Figure 5). Some of the groundwater samples fall in the field of C4S1, indicating very high salinity and low alkalinity hazard. This type of water can be suitable for plants having good salt tolerance and also restricts their suitability for irrigation.

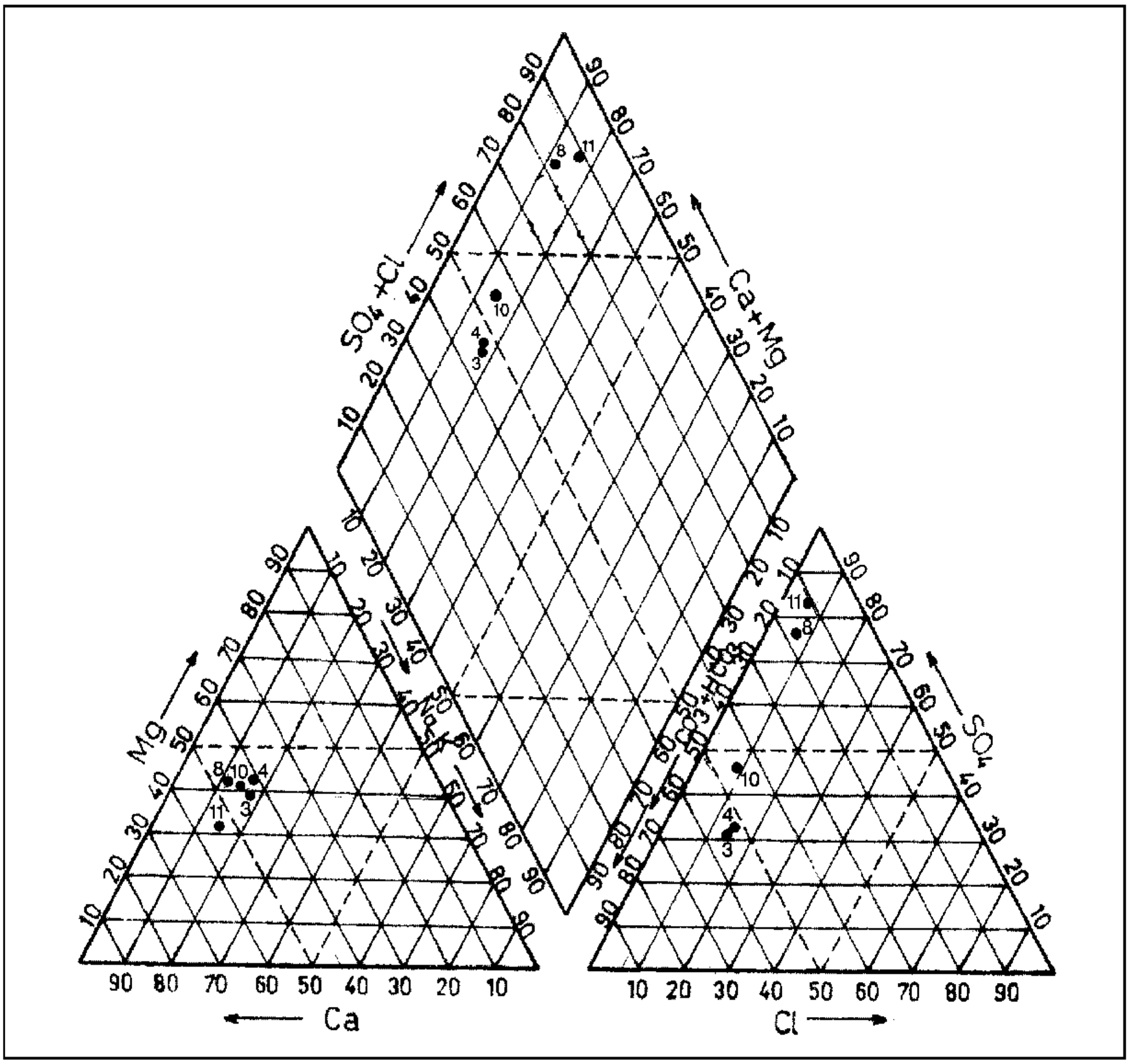

Figure 4b- Piper diagram of chemical facies of groundwater

SODIUM PERCENTAGE (NA%)

Na% is calculated by using the following formula:

$$Na\% = \frac{(Na^+ + K^+)}{(Ca^{2+} + Mg^{2+} + Na^+ + K^+)} \times 100$$

Where concentration are in meqv/l.

The plot of Na% and total concentration of ions on the Wilcox (1955) diagram figure 6 shows that most of the groundwater samples fall in the field of doubtful and unsuitable for irriga ion. High concentration of sodium in water reduces soil permeability.

CONCLUSION

This paper presents general guide lines for the suitability of groundwater for domestics and agricultural purposes.

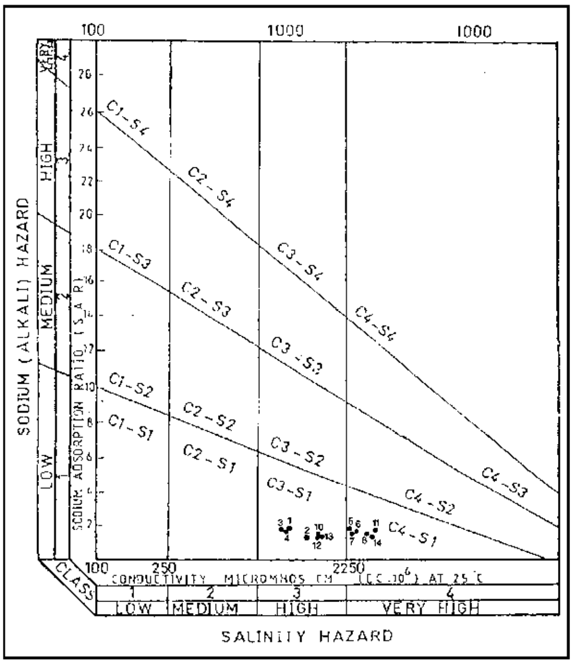

Figure 5- Salinity hazard of groundwater samples in Richard Diagram

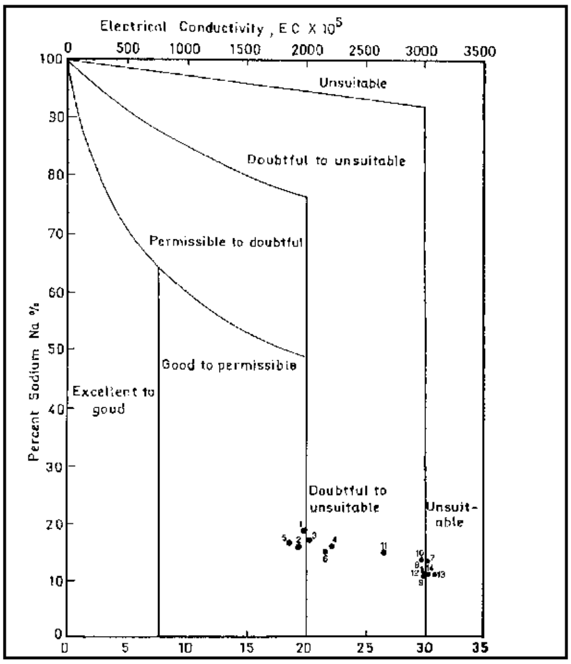

Figure 6- Wilcox (1955) classification of groundwater samples for irrigation

The chemical analysis of groundwater reveals that the groundwater is hard, fresh to saline and alkaline in nature. The pH value range between (7.1 - 7.63). The Ec value range from 1500 µS/cm to 2659 µS/cm. Total hardness value range from 757.1–1388.6 and shows that the majority of groundwater samples fall in the hard water category. TDS values range from 1450 mg/l to 3000 mg/l. The abundance of the major ions in groundwater samples in the northern part of the area, is in the following order:

$$Ca > Mg > Na > K = HCO_3 > SO_4 > Cl$$

type. The groundwater samples of the southern part of the area is in the following order:

$Ca > Mg > Na > K = SO_4 > HCO_3 > Cl > NO_3$. This lead to that alkali earths (Ca and Mg) slightly exceeds alkalis (Na and K) and strong acids (Cl and SO_4) exceed weak acids (HCO_3 and CO_3), and this leads to a mixed cation – SO_4 type of water.

High to very high salinity hazard shows that groundwater in the south part of the study area can be used for plants having good salt tolerance and also restricts its suitability for irrigation.

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