CHEMICAL CHARACTERISTICS OF GROUND WATER ALONG THE COASTAL AREA BETWEEN WADI LIBDA AND WADI-KAAM, NORTHWEST LIBYA

A. Y. OKASHA, * M. ELATRASH* and M. ABDEL GALIL**

* Department of Earth and Environmental Sciences, Faculty of Science at Al-Khums, Al-Mergib University, Libya.
** Environmental Sciences Department, Faculty of Science at Damietta, Mansoura University, Egypt.

ABSTRACT

Libya is considered as one of those countries having limited renewable water resources where most parts of the country are arid. The present study represents an attempt to evaluate the ground water quality along 20 km coastal stretch east of Al-Khums city, northwest Libya. A total number of thirty ground water samples were analyzed for their chemical characteristics including pH, total dissolved solids (TDS), chloride, sulphate, bicarbonate, nitrate, sodium, potassium, magnesium and calcium content. Higher concentrations of some cations and anions were observed specialty in wells near the sea. An over-reliance on ground water to meet an ever-increasing water demand has resulted in an excessive depletion of the fresh ground water stock and the situation is being exacerbated by seawater intrusion. However, Wadi Kaam and Wadi libda play an important role in decreasing seawater intrusion around their basins.

INTRODUCTION

The study area is 20 km coastal stretch, bounded by wadi libda from the northwest and wadi kaam from southeast, lies between latitudes 32^o 28` and 32$^o$ 38` N and longitudes 14^o 14` and 14$^o$ 27` E (Fig. 1).

In recent years seawater intrusion has become more pronounced problem due to high rats of consumption of ground water heavily employed for domestic, agricultural and industrial uses (Minas et al, 2005).

Most of the mass of Mediterranean Sea water has salinity ranging between 3.8% and 3.9% (Thurman, 1981). The pollution in the shore waters of the Mediterranean Sea has reached a critical level. This is chiefly due to the high quantity of domestic sewage and the virtually total absence of control on toxic components (Naeve, 1974). Shallowness, water discharge and tidal currents have a very significant effect on the nature of coastal water. Fresh water discharge has the salinity of the surface layer, while tidal currents have a considerable influence on the vertical mixing of shallow water near the coast (Nelson, 2004).

The study free ground water aquifer is bounded from northeast by Mediterranean Sea and is mainly recharged by rainfall, which is relatively high along the coastal area, and subsurface from Jabal Nafusa in the south.

Surface runoff across the study area is mainly affected by the main water divides and is represented mainly by Wadi Kaam, Wadi Sok Al-khames and Wadi Libda (Fig.1) Two dams were constructed in Wadi Kaam and Wadi Libda for water conservation which is relatively high along Wadi Kaam.

The present study aims to investigate the chemical characteristics of the ground water along the coastal stretch and evaluate its quantity.

GEOLOGY

The Cenomanian rocks which represented by Sidi As Said Formation is clearly exposed at the lower part from the stratigraphic sequence of Kaam valley, Hinawy, (1974) divide the formation into two members: the Lower Ain Tobi Member, which is characterized by dominant dolomitic sediments, and the upper Yafrin Member, composed of limestone and dolomite containing lutite admixture and marls. Sidi As Said Formation unconformable underlies the carbonate sediments of middle Miocene.

The middle Miocene sediments has been recognize in the studied area, and named by Mann, (1975) as Al-Khums Formation, reflect carbonatic development of the succession marl, marlstone, calcilutite, and cacarenite. Quaternary sediments lie disconformably on Sidi As Said Formation and Al-Khums Formation, classified lithostratigraphically and genetically into ; pliestocene sediments which is include Gargaresh Formation, forming low ridges that exending especillyalong the coastline of the Mediterranean sea, divided by Minas (2003) into an upper Kaam Member (aeolian) shoreline dune and lower Karrot Memper (backshore-foreshore environment), the Formation mainly consis cross bedded calcarenite sediments, red soil, and cliché sediments,2) Holocene sediment characterized by sediments of recent wadi, Aeolian, fluvio-aeolin, and sabkha.

MATERIALS AND METHODS

A total number of thirty ground water samples (Fig. 1) were collected after the rainy winter season in March 2007.

Water temperatures were recorded in the field and pH and E.C values were measured by using pH-meter type HANNA model HI8014 and electric conductivity meter model 4520 respectively. Amount of total dissolved solids were determined by evaporation. Chloride, carbonate, bicarbonate, calcium and magnesium were determined according to Adams (1990), while sodium and potassium were determined by using flame photometer type JENWAY model PFP7. Nitrate were determined by Ultraviolet Spectrophotometer Screening.

RESULTS AND DISCUSSIONS

Salinity Content Distribution:

Ground water salinity varies between 4276 ppm near the Mediterranean Sea and 3124 ppm landward northwest and southeast the study area (Table 1 & Fig. 2).

The variation in salinity content indicates that, salinity decreases gradually landward. The decrease in salinity is more pronounced toward the northwestern and southeastern boundaries that may reflect local recharge from surface runoff along the main water divides (W. Kaam and W. Libda) northwest and southeast the study area respectively (Fig. 2).

Comparing the present salinity values with that reported by Ministry of Agriculture (1978) show an increase in water salinity (ranging between 1500 ppm and 3000 ppm for the studied water wells).

Chloride Content Distribution:

The variation of chloride content (Fig. 3 & Table 1) shows that, chloride varies between 1424.2 ppm near the Mediterranean Sea and 829.4 ppm landward northwest and southeast the study area.

The gradual decreasing in chloride content landward may be related to the effect of salt water intrusion from the Mediterranean Sea. However, the decreasing in chloride toward the northwest and southeast may be attributed to the local surface recharging through the main water divides represented by W. libda and W. Kaam respectively, where two dams were constructed for water conservation. Field observations show that, Kaam dam is bigger than Libda dam.

Local concentration in chloride content at the southwestern part of the study area may attribute to local surface evaporites and subsurface environments related to lithology of water –bearing rocks.

Comparing the present chloride content (average value 1064 ppm) with that reported by Ministry of Agriculture (1973), show increase in chloride content which average value was 640 ppm for the studied water wells. Also, Ministry of Agriculture (1978) reported chloride content varies between 489 ppm and 935 ppm for the studied water wells.

Sulphate Content Distribution:

Sulphate constitutes the second predominant anion after chloride and varies in content between 1089 ppm near the Mediterranean Sea and 762.7 ppm landward northwest and southeast the study area (Table 1 & Fig. 4).

Generally, the sulphate distribution pattern is similar to that of chloride and salinity content indicating that, sulphate enrichment is associated with salinity rise (Figs 2, 3 & 4).

Comparing the present sulphate contents with that reported by Ministry of Agriculture (1973), show increase in sulphate content which was varying between 542 ppm and 988 ppm for the study area.

Bicarbonate Content Distribution:

The studied water wells lack carbonate ion and show low contents of bicarbonate. Bicarbonate ranges between 498 ppm at the southern part of the study area and 405 ppm at the northwestern part (Table 1 & Fig. 5).

The increase in bicarbonate content at the southern part of the study area may attribute to local calcareous water bearing sediments. However, the distribution pattern of carbonate content shows gradual decrease in bicarbonate content toward northwest (Fig. 5).

Nitrate Content Distribution:

The studied water wells show low contents of nitrate (Table 1). The variation in nitrate content (Fig. 6) show that, nitrate varies between 44.58 ppm near the Mediterranean Sea and 12.13 ppm at the southeastern part of the study area.

Generally, nitrate shows reverse distribution to that of bicarbonate where there is gradual decrease in nitrate values landward and toward southeast (Figs 5 and 6).

Sodium Content Distribution:

Sodium content ranges between 923.25 ppm near the Mediterranean Sea and 606.33 ppm at northwestern and southeastern parts of the study area (Table 1 & Fig. 7). Variation of sodium content shows that, the sodium content decreases gradually landward, with its higher content near the Mediterranean Sea (Fig. 7).

Comparing the distribution pattern of sodium content with that of chloride content (Figs. 3 and 7) indicates a great similarity, a state which favors the presence of sodium as NaCl.

Sodium content was ranging between 322 ppm and 602 ppm for the studied water wells (Ministry of Agriculture, 1973), which indicates present rise in sodium content.

Potassium Content Distribution:

Potassium content is generally lower than that of sodium. The potassium content ranges between 27.30 ppm near the Mediterranean Sea and 9.71 ppm at southeastern part of the study area (Table 1 & Fig. 8). Generally, potassium content distribution is rather similar to that of sodium content (Figs 7 and 8).

Magnesium Content Distribution:

Magnesium content varies between 256 ppm near the Mediterranean Sea and 124.8 ppm at the northwestern and southeastern parts of the study area (Table 1 & Fig. 9).

The spatial distribution of magnesium content (Fig. 9) indicates that, the highest concentration of magnesium is observed near the Mediterranean Sea with gradual decreasing landward and toward southeastern and northwestern parts of the study area.

The relatively high magnesium content at the southeastern part of the study area (Fig. 9) may be attributed to local surface and subsurface environments related to the lithology of water – bearing rocks. Moreover, surface evaporites intercalated with the water – bearing sediments are a possible local source for magnesium.

Calcium Content Distribution:

Calcium content varies between 269.33 ppm and 153.3 ppm (Table 1). The distribution pattern of calcium content shows gradual decrease in calcium content toward the Mediterranean Sea (Fig.10) .This may give an indication about its source mainly from the land.

The high values of calcium may be related to the lithology of water – bearing sediments and surface calcareous materials which is dominant along the study area.

Temperature Versus Salinity:

The studied ground water samples have temperature values ranging between 29.9 ^{O}C at northwestern part of the study area and 20 ^{O}C near the Mediterranean Sea (Table 1 & Fig. 11).

Temperature and salinity distributions show consistent patterns, lower temperature and higher salinity near the shore line and higher temperature and lower salinity landward. The gradual decreasing in temperature values toward the Mediterranean Sea may indicate the effect of the relatively cooler seawater intrusion along the coastal area.

pH Value Distribution:

The studied samples have pH values ranging between 6.67 (slightly acidic) and 7.61 (slightly alkaline) (Table 1). The variation in pH values across the study area (Fig. 12) indicates that, the ground water is dominantly slightly alkaline and becomes slightly acidic near the shore line. This may give indication that, the salinity is not the single factor affecting the pH value of the studied ground water and may be attributed to the recharging of the ground water by rainfall, which is relatively high in the study area.

Electrical Conductivity (E.C) Distribution:

The variation in E.C values across the study area is shown in (Table 1 & Fig. 13). The ground water show high electrical conductivity values ranging between 6.60 mmohs/cm near the Mediterranean Sea and 4.51 mmohs/cm northwest and southeast the study area.

Comparing the distribution of E.C Values with that of cations and anions, it is clear that, E.C Values increase with the increase of salt content. Also, the variation of salinity is very similar to that of chloride, sulphate, sodium, potassium and magnesium. This indicates that, their enrichment is associated with salinity rise and therefore, shows higher E.C Values.

Water type:

Variations in chemical composition of the studied ground water are represented in the trilinear diagram of Piper (1944). The diagram (Fig. 14) indicates that, sodium is the dominant cation in the cation triangle, chloride is the dominant anion in the anion triangle and is the dominant salt.

The alkali elements (Na^{+} + K^{+}) exceed the alkali earths (Ca^{++} + Mg^{++}) and the analyzed ground water samples fall in the right side of the upper triangle of the diamond shape. This indicates that, the ground water posse's secondary salinity character (where SO_4^{--} + Cl^{-} exceed CO_3^{--} + HCO_3^{-})

which may be related mainly to sea water intrusion along the studied coastal area.

Evaluation of Ground Water for Domestic And Irrigation Purposes:

The studied water wells show high salinity (3124 ppm to 4276 ppm). According to Jaster et al. (1978) and Beede (2005), the water of studied coastal wells are unsuitable for human drinking. The permissible limits for animals are considerably higher than that considered satisfactory for humans. Therefore, the ground water along the coastal area is suitable for consumption by livestock except poultry where its permissible limit is 2860 ppm.

The calculated sodium adsorption ratio (SAR) for studied water wells are ranging between 5.35 and 7.16. However, lower SAR values can be attributed to higher content of calcium and magnesium.

According to Tanjj (1990) and Mills (2001), the ground water across the study area are excellent for irrigation purposes where SAR<10, but due to their high salinity (>3000ppm) they are unsuitable for irrigation purposes. Therefore, only the more salt-tolerant crops can be grown with such water, and only when the water is used copiously and the subsoil drainage is good. However, people use the ground water for washing purposes.

CONCLUSION

The distribution patterns of total dissolved solids, chloride, sulphate, sodium potassium, magnesium and electrical conductivity show gradual decreasing in their values landward and reflect the Mediterranean Sea water intrusion. Wadi Libda and Wadi Kaam play an important role in decreasing seawater intrusion around their basins.

The Mediterranean Sea water intrusion is relatively high nearly at the mide area between the basins of Wadi Libda and Wadi Kaam.

The ground water across the study area are unsuitable for human drinking and suitable for consumption by livestock except poultry.

Due to seawater intrusion, the studied water wells are unsuitable for irrigation purposes and only more salt-tolerant crops can be grown with the studied ground water. Across the study area people use the ground water for washing purposes.

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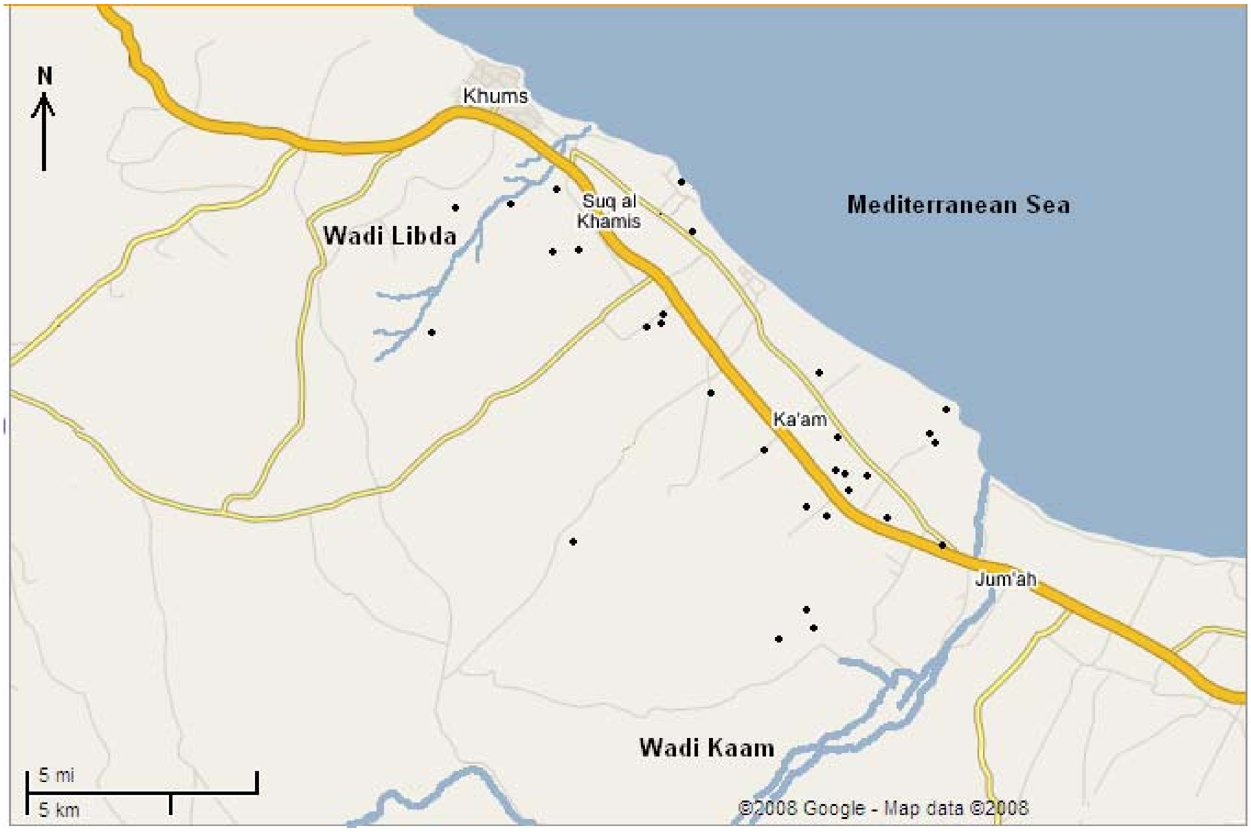

Fig (1): Location map showing the sites of studied wells

Table (1): Chemical characteristics of the ground water along the study area

	Unit	Maximum	Minimum	Mean	Std. Dev.
TDS	ppm	4276	3124	3554	403
Cl^-	ppm	1424.2	829.4	1064	186
SO_4^{--}	ppm	1089	762.7	890.19	92.02
NO_3^-	ppm	44.58	12.13	23.57	10.39
HCO_3^-	ppm	498.00	405.00	449.54	26.42
Na^+	ppm	923.25	606.33	730.25	107.64
K^+	ppm	27.30	9.71	19.93	4.68
Mg^{++}	ppm	256.00	124.80	174.41	41.23
Ca^{++}	ppm	269.33	153.30	200.08	32.71
Temp.	^oC	29.9	20.00	24.14	2.49
pH	----	7.61	6.67	7.14	0.19
E C	mmohs/cm	6.60	4.51	5.36	0.70

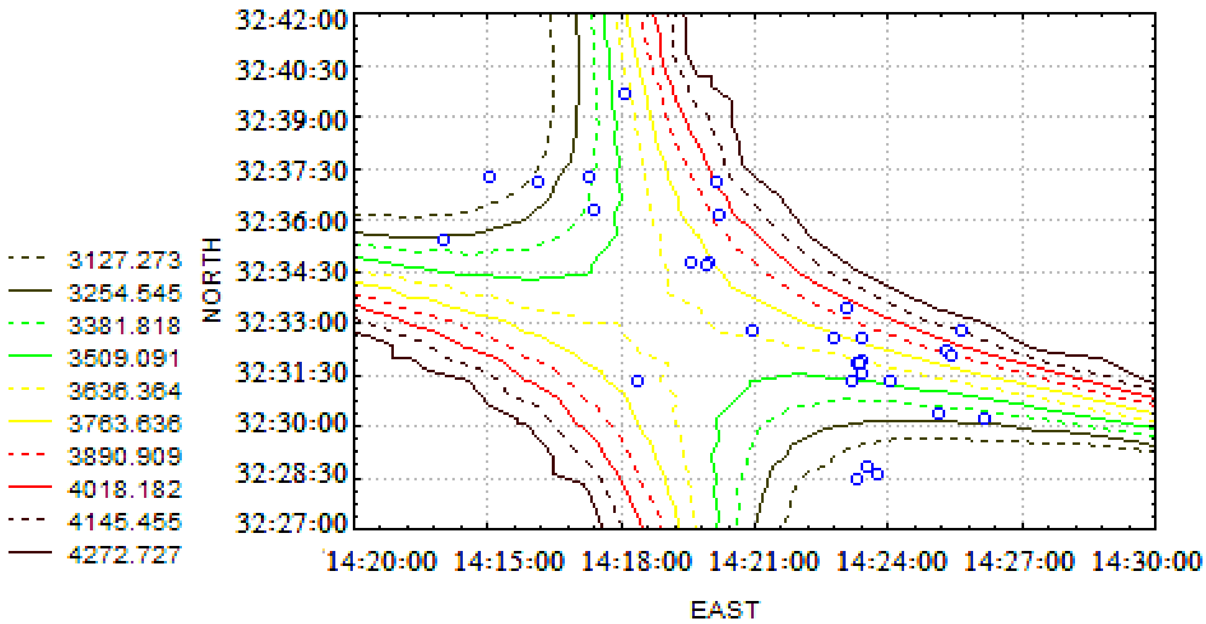

Fig (2): Variation of salinity content (ppm) along the study area

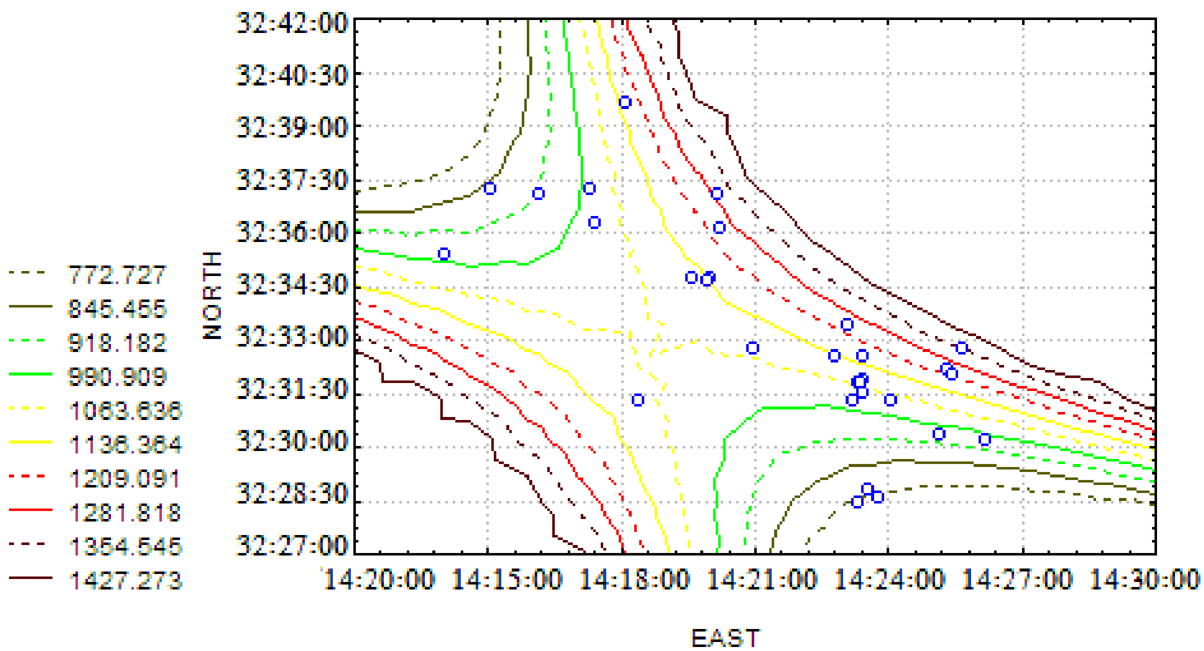

Fig (3): Variation of chloride content (ppm) along the study area

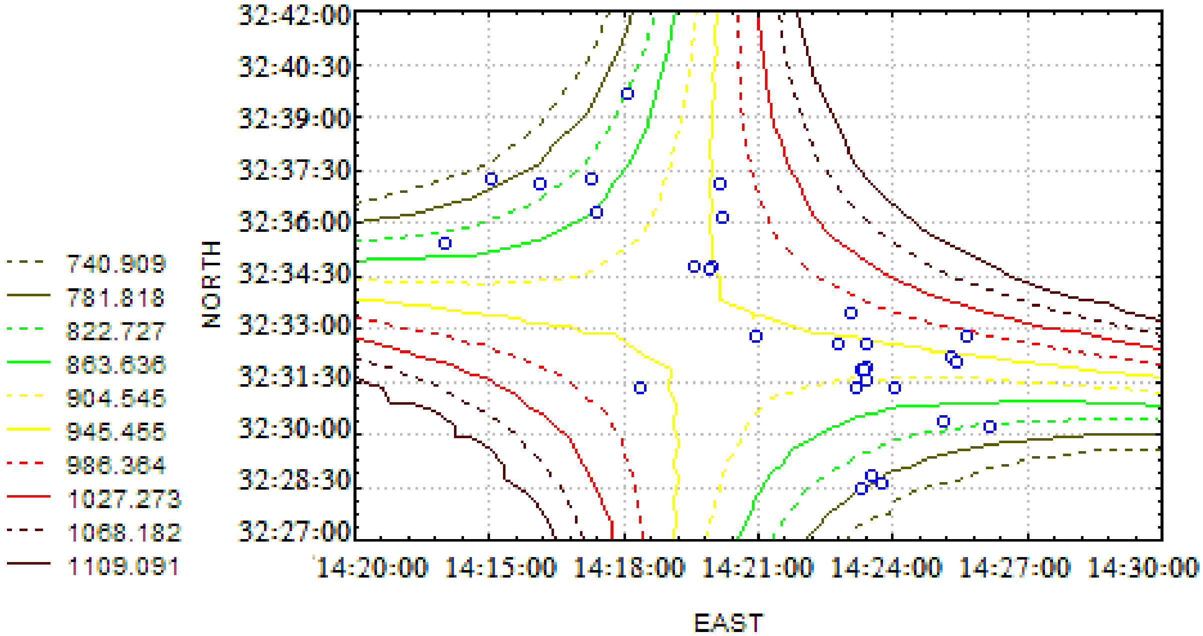

Fig (4): Variation of sulphite content (ppm) along the study area

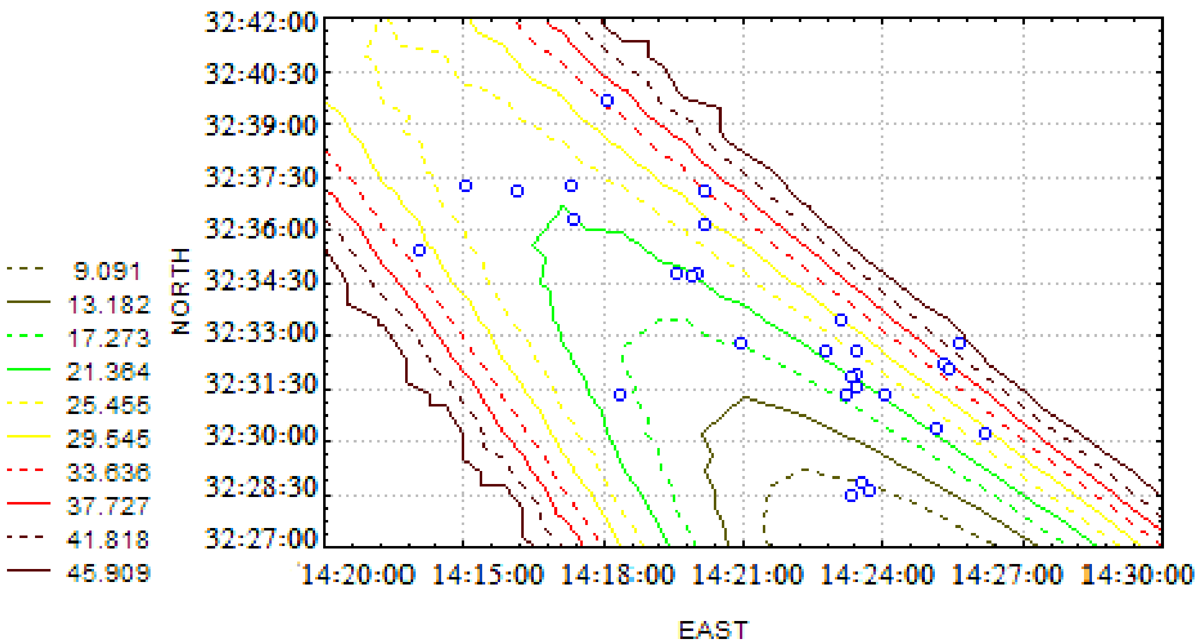

Fig (5): Variation of nitrate content (ppm) along the study area

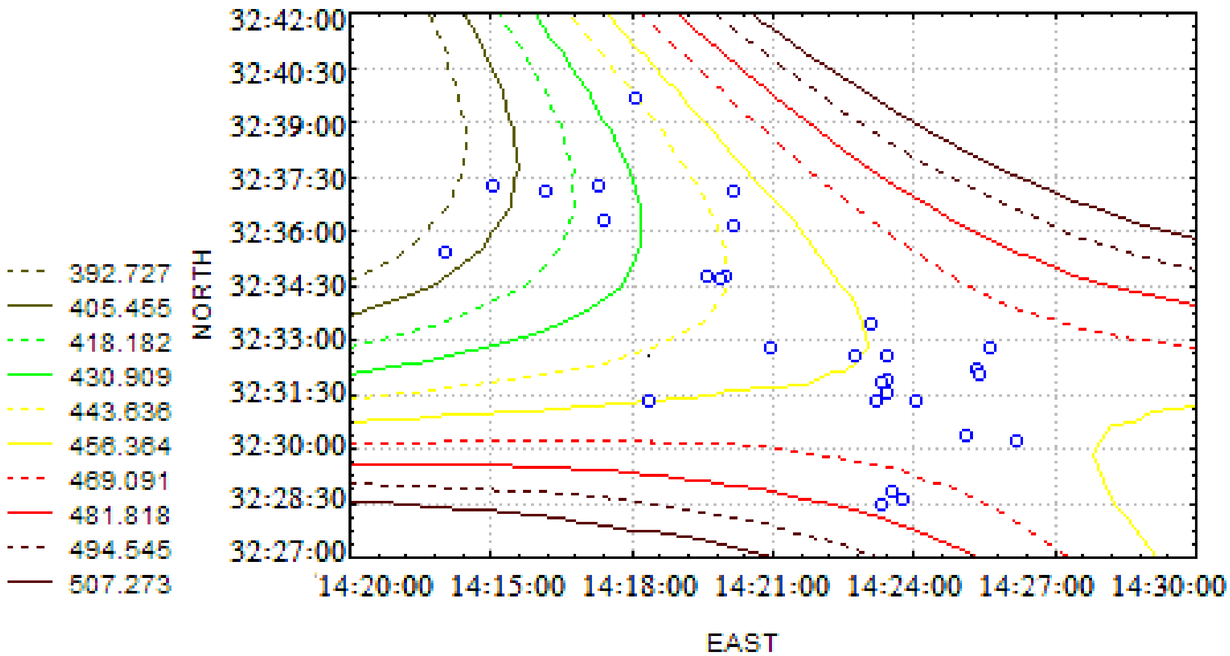

Fig (6): Variation of bicarbonate content (ppm) along the study area

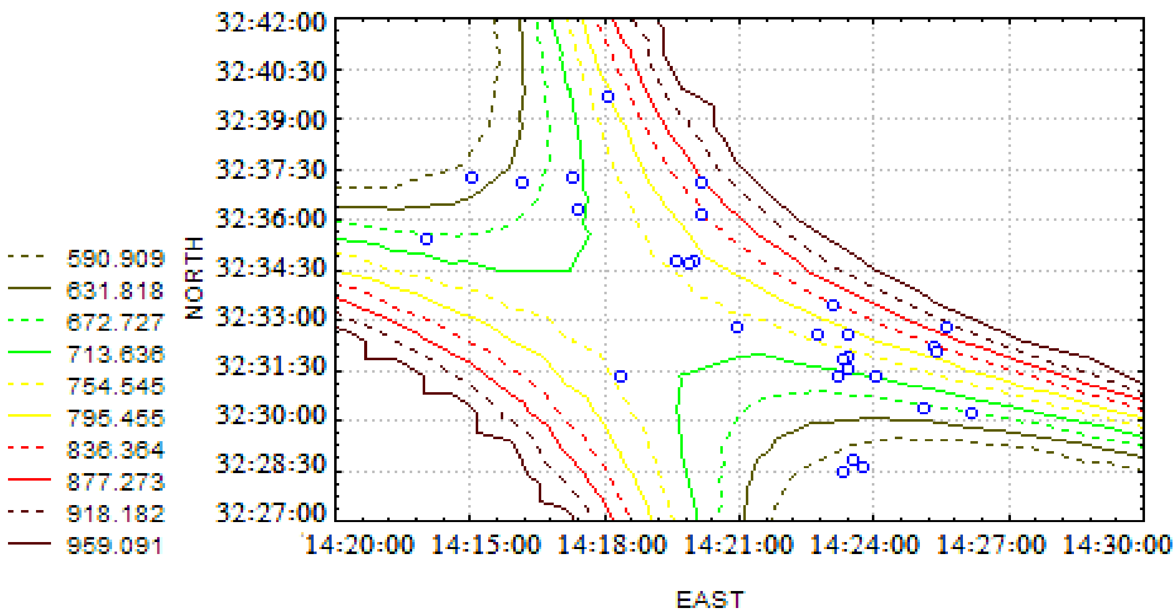

Fig (7): Variation of sodium content (ppm) along the study area

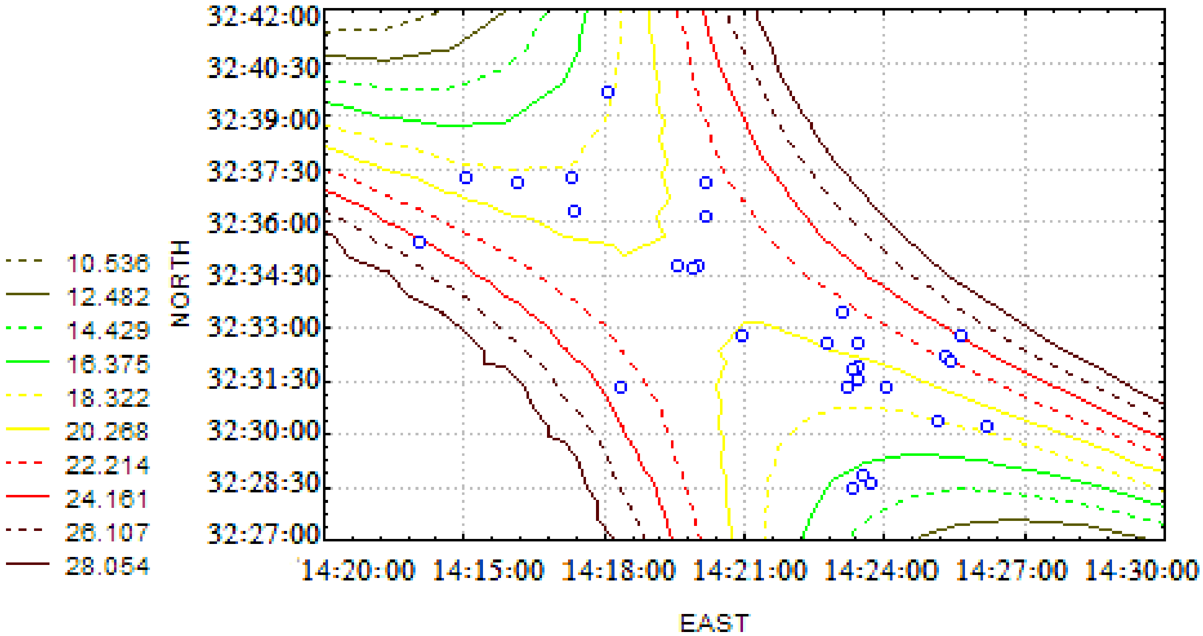

Fig (8): Variation of potasium content (ppm) along the study area

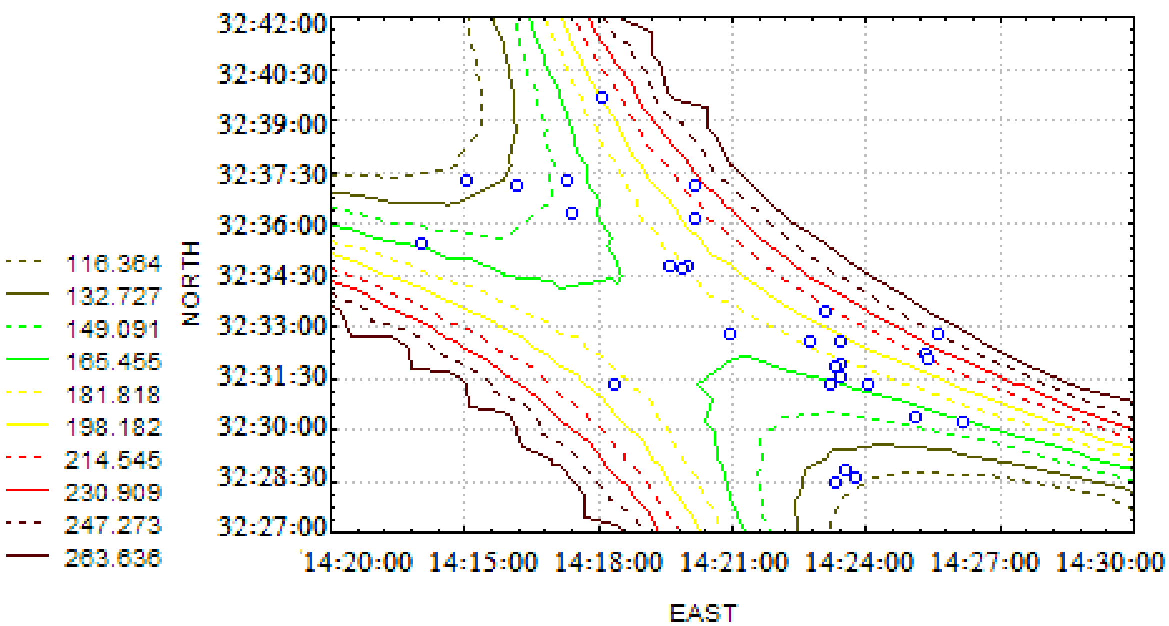

Fig (9): Variation of magnisium content (ppm) along the study area

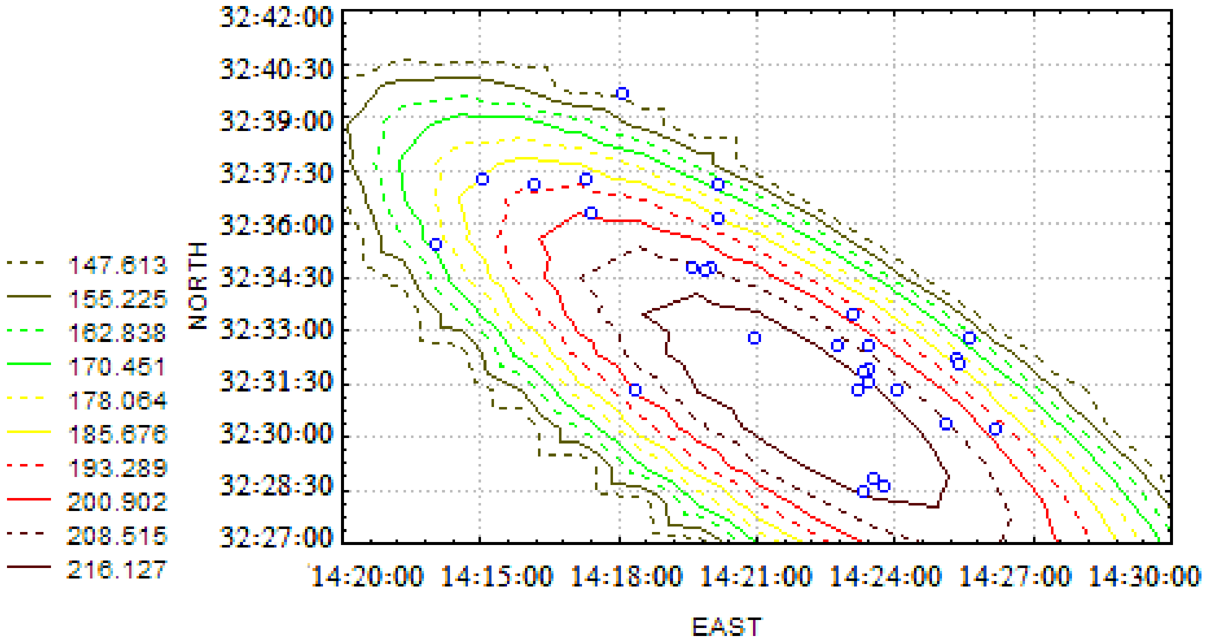

Fig (10): Variation of calcium content (ppm) along the study area

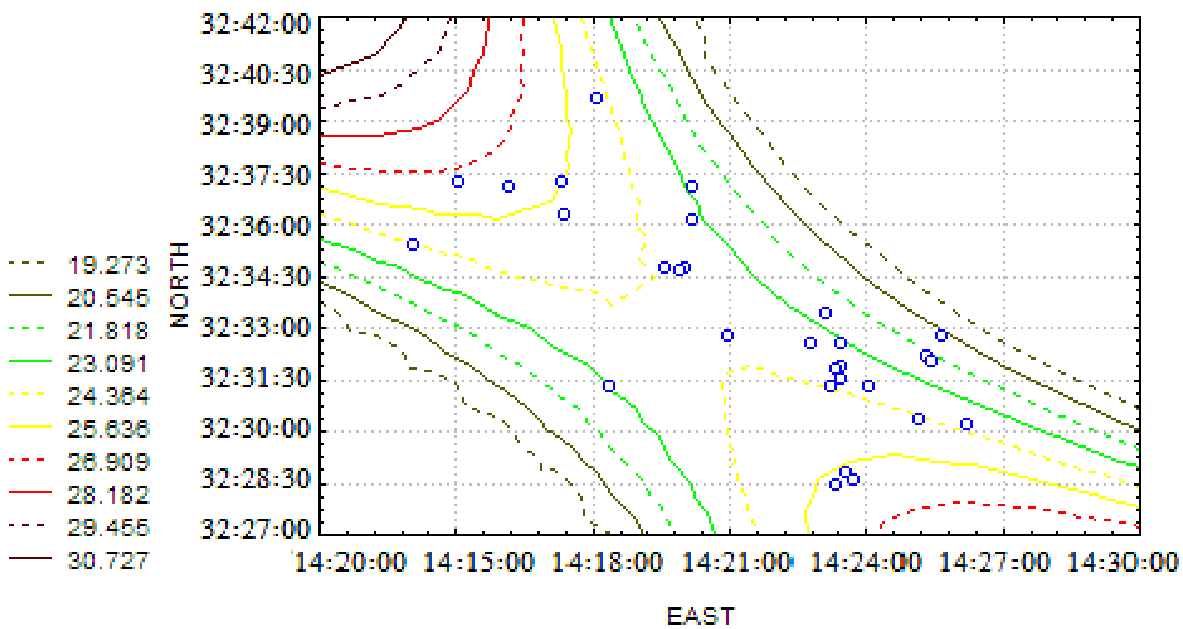

Fig (11): Variation of temperature content (ppm) along the study area

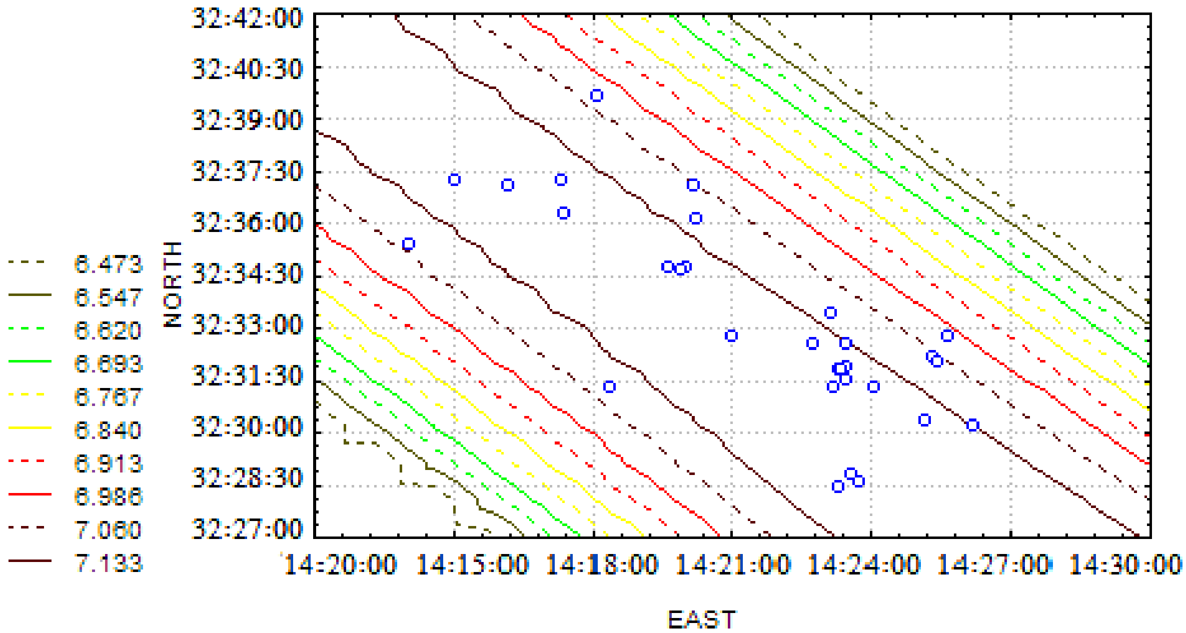

Fig (12): Variation of pH values along the study area

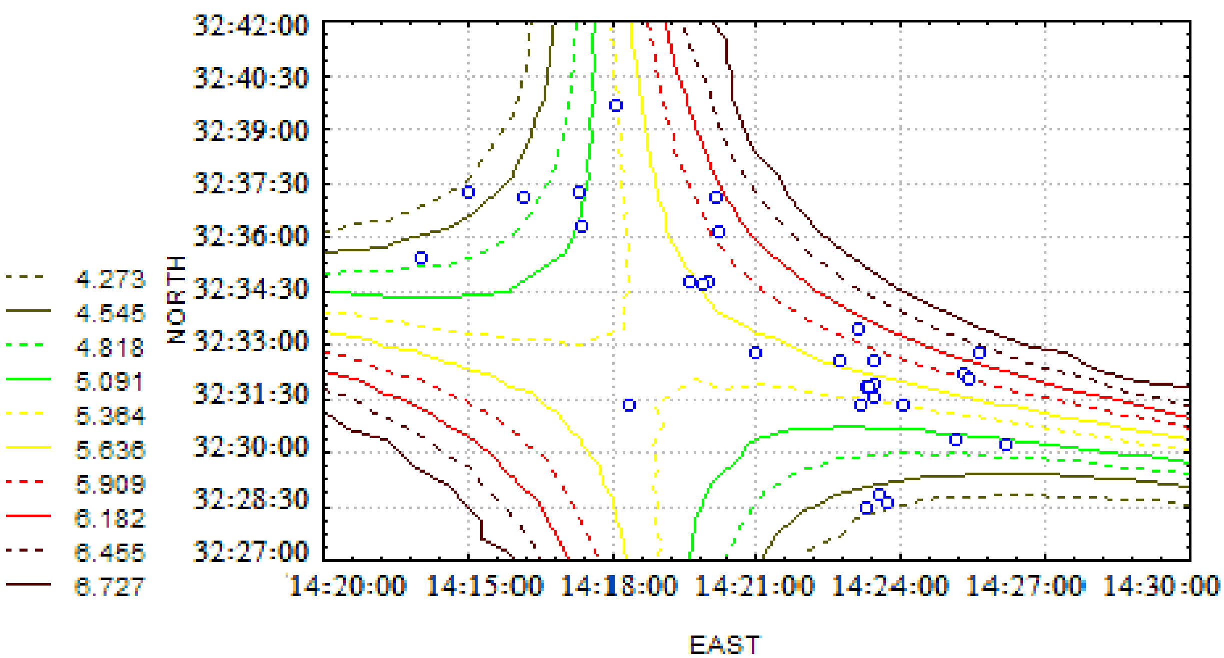

Fig (13): Variation of E. C. values (mmohs/cm) along the study area

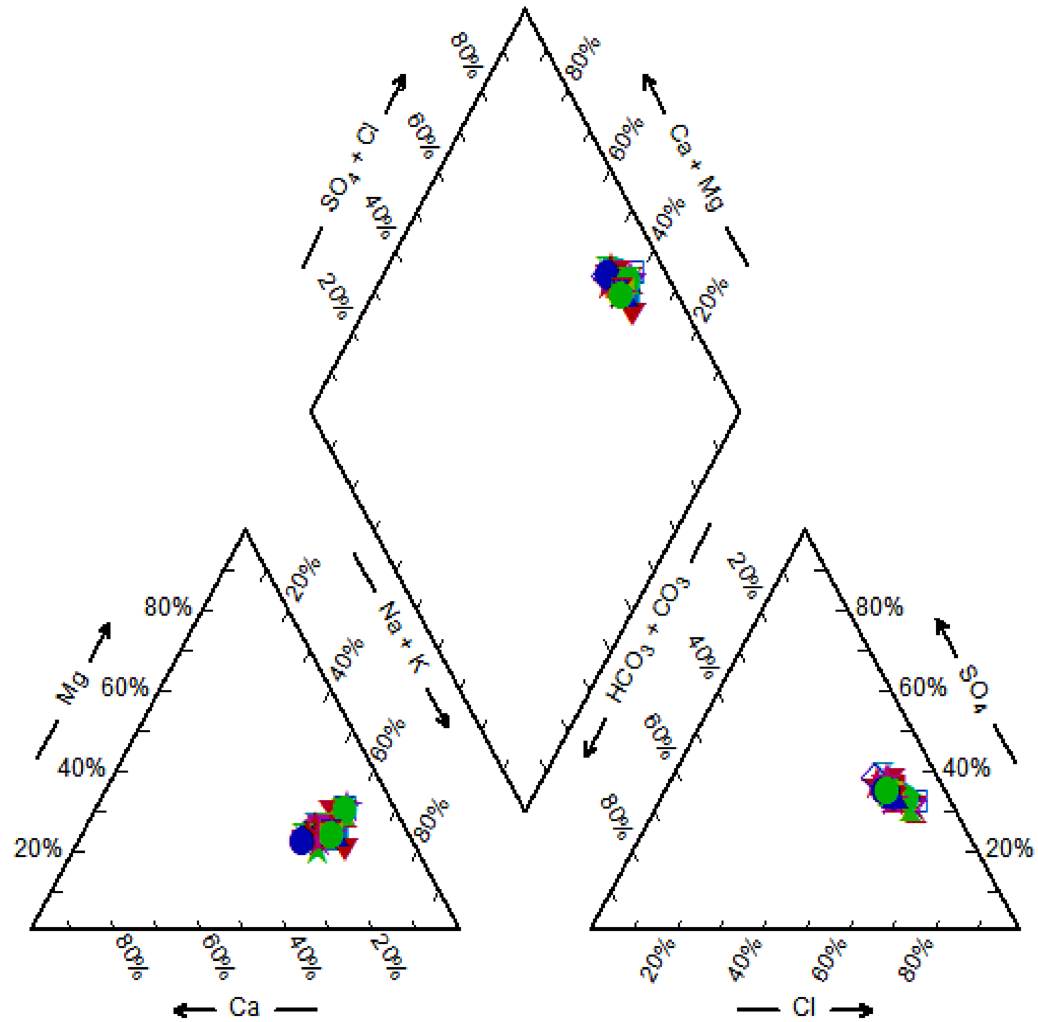

Fig (14): Piper Digram of ground water studied samples