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Full Length Research Paper

Stream water quality in the western regions of Iran

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Stream water quality of a part of the four western mountainous regions of Iran: Lorastan, Kordestan, Hamadan and Kearmanshah, with a total area of 101.102×10^3 km^2 was investigated. The chemistry of major elements such as Ca, K, Na, Mg, Cl, HCO_3, SO_4 and alkalinity from hydrological basins of the regions was examined based upon samples from the relatively important basins. The difference in these chemical elements of streams was verified on a region-by-region basis. Temporal changes of water quality in the stream water were examined using a seasonal classification of data. The results showed that the dissolved load of about 70% of all water samples (at all basins during all seasons) was less than 500 mg/l. The same result can be concluded for seasonal variability of EC for the entire area. It was less than 0.550 ds/m for 68% of samples. The pH variation was from 5.5 to 9 with an average of 8.2. The highest and lowest values are from autumn and summer samples, respectively. In summer, the sodium adsorption ratio (SAR) value was maximal, and the agricultural activities cause an increasing on its normal (average annual) rate in the rivers. The results also indicated a very good relationship between the total anions and total cations, during all of seasons. There were no significant relationships between the area of the basin and the chemical element concentrations. These results have been used for the water resources management of the mountainous regions of Iran and the modelling of water quality predication.

Key words: Surface water chemical quality, western regions of Iran, seasonal and spatial water quality variation.

INTRODUCTION

The growing populations in many of developing countries have been predicted further to intensify agricultural production requirements and the use of mineral and organic fertilizers to increase crop yield. Furthermore, industrial activities will add to natural environment contamination. The impact on water chemistry of anthropogenic pollution from industrial and agricultural sources has concerned environmentalists and scientists for decades. There are some effects of salinity and sodicity on plant growth (Fitter and Hay, 1987; Rowell, 1994). Jalali (2002) described the composition of irrigation waters of 311 wells in Hamadan region of Iran. His work indicated that salinity and sodium hazards generally limit the quality of Hamadan water supply. The strong seasonal cycles observed in the stream water chemistry of the two catchments on the Catoctin Formation result from seasonal hydrological processes superimposed on geologically controlled groundwater composition (Rice and Bricker, 1995).

Pervious studies indicate that the bedrock geology and weathering of surface rock also are the main influence on water chemistry of stream water (Probst et al., 1990; Jenkins et al., 1995; Tamasebi and Jafarian, 2006). This study presents the water quality of the some rivers and streams in the west part of Iran.

The objective was to characterize the chemical and physical properties of surface water of the geological environments and to determine the anthropogenic impacts on stream water quality.

METHODS

Description of study area

The area covers the four regions of the western part of Iran: the Lorastan, Kordestan, Hamadan and Kearmanshah (Figure 1). The total surface area is 101.102×10^3 km^2. Mean annual precipitation

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Abbreviations: EC, Electrical conductivity; TDS, total dissolved solid; and SAR, sodium absorption ratio.

Figure 1. Map of Iran showing the study area which include the four sampling zones; Lorastan, Kordestan, Hamadan and Kearmanshah.

Table 1. Descriptive statistic of water chemistry in the total of site. Units are meq/l except pH (log), TDS (mg/l) and EC (ds/m).

Elements	Max	Min	Mean	SD	CV
pH	9	5.55	8.2	0.30	0.04
TDS	4352	106	479	558.62	1.16
SAR	13.3	0.03	1.25	2.11	1.69
Cations	73.17	0	7.80	8.99	1.15
K	1.12	0	0.12	0.20	1.68
Na	46.19	0.03	2.65	5.83	2.2
Mg	17.5	0.06	1.71	2.14	1.25
Ca	13.4	0.68	3.38	1.24	0.37
Anions	74.97	0	7.86	9.13	1.16
SO_4	22.9	0	1.37	2.96	2.16
Cl	38.12	0.05	1.62	4.37	2.70
HCO_3	41.5	0.05	4.80	2.70	0.56
CO_3	12.92	0	0.13	0.55	4.04
EC	6.5	0.17	0.74	0.83	1.13

CV, Coefficient of variation; SD, standard deviation.

(total rainfall and snowfall) is 550, 450, 350 and 470 mm and mean annual air temperatures of the regions are 17, 13.1, 12 and 13°C, respectively. Based on the Koppen climatological classification, the climate of Lorastan, Kordestan, Hamadan and Kearmanshah are Cfa, Dfa, Bfh and Cfa, respectively. The climates of regions are correlated with altitude variations. At lower elevations (less than 2500 m) rainfall commonly occur during the fall and winter months. Above this elevation, snowfall occurs during winter and at the fall, but rain is also dominant precipitation. Generally, in all of area, during the April and March, precipitation is often minimal but the rainfall events occur with high intensity.

The sites are mountainous and range in altitude form 1000 to 3550 m. Based on the water sampling stations, 30 catchments are considered in the area. The catchments surface varies from 0.5 to 3000 km^2. About 25% of these involved the great catchments, which are larger than 1500 km^2. In Hamadan and Kordestan regions, the catchments are located at the low hills and high elevations, compared to the other regions. About 70 percent of the areas are occupied by agricultural lands that have impact on surface water quality of the regions.

The geological trend of the regions consists of Sanandaj-Serjan and Zagros zones with a faulted boundary, which are parallel from north-west to south-east direction. The lithological formations of regions contain metamorphic and igneous rocks such as Malayer metamorphic or Borojared intrusive rocks. The dominant lithology of Sanandaj-Serjan and Zagros zones are Mesozoic and Tertiary Limestone, respectively. Natural vegetation in all of the regions is relatively zoned by altitude. In the Lorestan and a part of Kearmanshah, Oak arid forests are poorly predominated. Agricultural activeties in these regions consist of depression, glacier and terraced cultivation. Pesticides, as well as of fertilizer, in the form of farmyard manure, inorganic nitrogen and phosphorous compounds are almost commonly using on crop production. Wheat, barley, corn, forge, potato and sugar beet are the major crops of the regions.

Sampling and method of study

Sampling was undertaken from 1978 to 2003, one time on each season by the West Water Authority Laboratory. A network of fixed hydromeretic stations were used for sampling and hydrochemistry monitoring was developed systematically during hydrological cycles. Water sampling was based on the Depth Integration method by use of a bottle. The flows of all rivers sampled are permanent and drain into the different grand basins of south (Karghaeh), north (Simineh Roud), west (Ghazael Ozon) and central (Ghom Salt Lack) of Iran.

A temporal classification was considered for better understanding of the seasonal changes in the streams water. The data were divided into the four groups: winter, spring, summer and autumn and statistical interpretation was applied for each class, separately.

Statistical parameters of chemical elements of the samples were calculated to present the variation of the water quality characters. Pearson's correlation coefficient (r) was used to show correlation between the parameters, using the SPSS software. The Student's t-test was used to determine the statistical significance. Probability was set at $p<0.05$.

RESULTS AND DISCUSSION

The chemistry of major elements and compounds such as Ca, K, Na, Mg, Cl, HCO_3, CO_3, SO_4 and alkalinity from the watersheds of the regions was examined based upon the water, which were collected from the sampling locations of area. The result is presented in the Table 1.

Cations and anions

The result shows that the total cations and total anions concentration have the same statistical characteristics. The relation between the cations and anions is relatively constant and linear during all season of hydrological cycles. The concerning correlation coefficient (r) is near to 1. The highest and lowest values were observed in summer and winter, respectively. The result also suggests that the difference between the total cations and total anions which was observed during autumn and

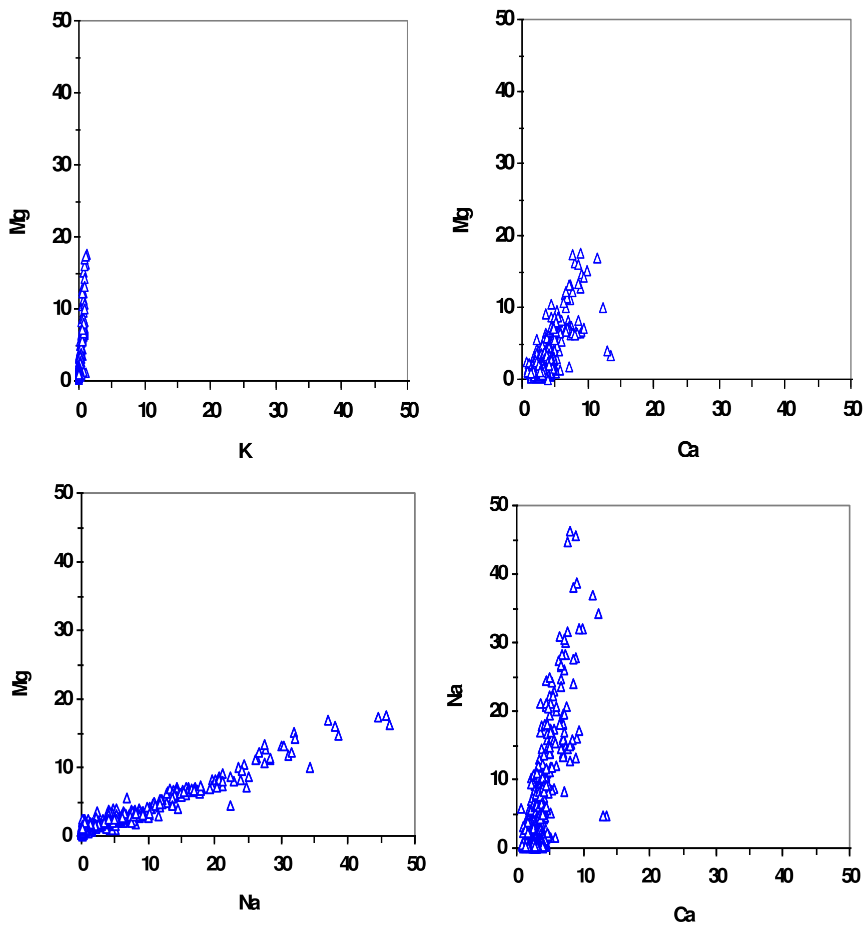

Figure 2. Base cations relationship across all regions (units are meq/l)

spring is significant (P<0.05).

In all the samples, calcium and HCO_3 are the dominant cations and anions, respectively. This is consistent with studies in other relatively similar environments (Bhatt and Pathak, 1992; Jenkins et al., 1995). Conversely, potassium and CO_3 have low concentration across the regions. Compared to the total amount of the cations, the high value of calcium (43%) and sodium (34%) suggests that the bedrock geology probably is the main influence on water chemistry of the regions (Tamasebi and Jafarian, 2006). They are the same hypotheses concerning the HCO_3 that has the highest concentration (61% of anions and 30% of all the ions). The HCO_3 may be supplied eventually from the atmospheric CO_2 and weathering of limestone and decomposition of soil organic materials (Holland, 1978).

The high value of coefficient of variation (CV) of the CO_3 illustrates the spatial variability of carbonate concentration on water chemistry of the regions. The importance of the cations and the anions concentrations are followed by Ca>Na>Mg>K and HCO_3>Cl>SO_4>CO_3, respectively. The basic cations relationships are shown in the Figure 2.

In Figure 3, the relationship between the cations and anions is presented. In the case of the cations, the range of correlation coefficient (r) varied from 50% to 95%, and the highest involved the relation between Mg and Na. In the case of anions, the correlation coefficient (r) varied from 49 to 96%. The highest value relates to the relation between SO_4 and Na.

Salinity, sodicity, TDS and pH

Salinity ranges from EC 1.69 to 6.5 ds/m. The seasonal variation of EC is 0.58 (winter), 0.63 (spring), 1.03 (summer) and 0.76 (autumn) ds/m. The data analyses also show that during the observation period (1978 - 2003), EC increased slowly in all seasons of year, especially in summer. The value of sodium adsorption ratio (SAR) is between 0.03 and 13.3. The seasonal variation of SAR is 0.86 (winter), 1.02 (spring), 1.98 (summer) and 1.3 (autumn). The data indicate that the increased value of SAR in summer and fall could be influenced by the agricultural activity.

The dissolved load (TDS) ranges from 106 to 4352 mg/l. The seasonal variation of TDS is 383 (winter), 401

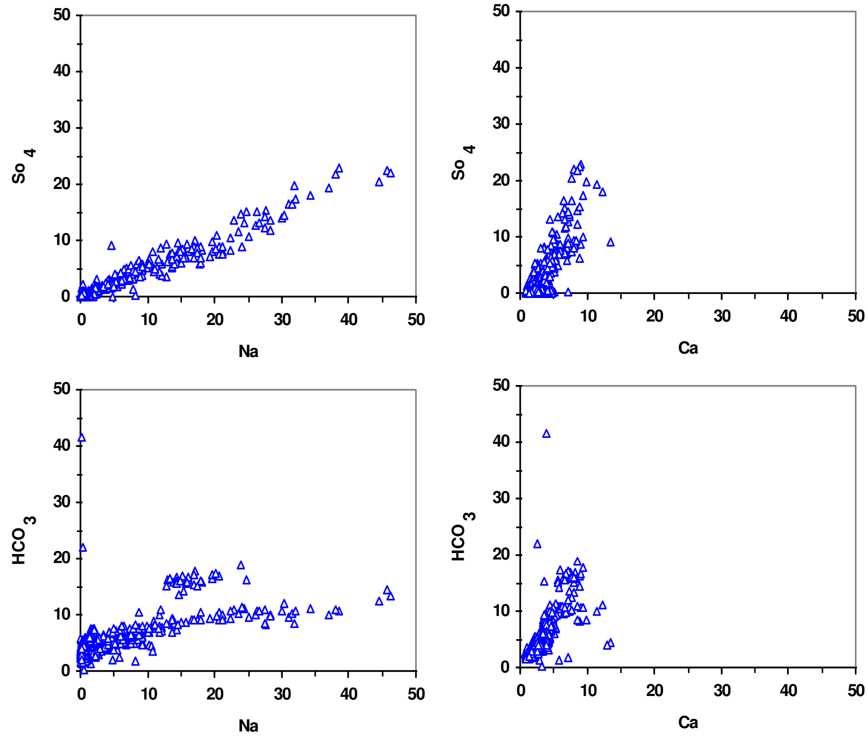

Figure 3. Relationships between the major cations and anions (units are meq/l).

(spring), 689.3 (summer) and 496.7 (autumn) mg/l. The range of pH is from 5.55 to 9. The highest and lowest values receptively concern to autumn and summer samples. High pH value indicates that a large buffering capacity exists within the sites. According to the chemical element analyses such as SAR, TDS, EC and pH, a strong spatial variability has been identified on the water chemistry of the region.

Conclusion

Major chemistry of stream water of a part of the western regions of Iran was examined based on the data, collected from a period of 25 years. The results illustrated that no any significant relationships between the area of the basin and the chemical element concentrations, SAR, TDS, pH and EC (P>0.05). Cations and anions concentrations in surface water of basins depend to temporal conditions of flow (Neal et al., 1995). The result of this research shows that HCO_3 and Ca are the dominant cations and anions, respectively. The same result was showed by the study of Jenkins et al. (1995), which was down in four hydrological basins of Nepal. Bicarbonate, calcium and sodium are the major element concentrations in the sites. Bicarbonate is the major ion that may be affected by bedrock geology, weathering of limestone and decomposition of soil organic materials. Carbonate also probably is the important source of calcium. The high pH value indicates the large buffering capacity of area. The EC and TDS concentrations indicate an important spatial variation between the sampling stations.

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