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Geochemical Classification of Groundwater Quality and Its Mapping in a Dry Sub Climate (A Case Study of Lasbela Region)

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Abstract
The study was conducted on effect of ground water quality and its effect on soil and crop productivity during June 2012-13 in Tehsil Uthal, District Lasbella. Field data was collected through questionnaires. Water and soil samples were collected from 32 randomly selected sites. In groundwater samples Electrical Conductivity, pH, TDS, sodium, calcium, magnesium, carbonate, bicarbonate and sulphate were determined from water as well as from soil samples except sulphate. After analysis of groundwater samples 97% were moderate saline range, 3% of water samples were greater than 3 dSm^{-1} (highly saline).About 78% of groundwater samples were in category of moderate range with SAR values between 3-6, while 22% were of severe class range (SAR >9). The pH of groundwater samples ranged from 6.8 to 8.2 with an average of 7.5.The average value of TDS was 1365 mgL^{-1} ranged 697-2032 mgL^{-1}.Carbonates were totally absent in the groundwater samples. Bicarbonate concentrations were ranged from 1.8 to 2.5 $meql^{-1}$. Sulphate ranged between 7.9 to 14.1 $meql^{-1}$ with an average value of 11 $meql^{-1}$.
Keywords: Salinity, Sodicity, Groundwater, Electrical Conductivity, SAR, Total Dissolved Salts

1. Introduction

Water is undoubtedly is a requirement for all of the living organisms in the biosphere (Singh and Mishra, 1997). The quality of groundwater is constantly changing in response to daily, seasonal and climatic factors. Continues monitoring of water quality parameters is highly crucial because changes in the quality of water has far reaching consequences in terms of its effects on man and biota (Ackah *et al.* 2011). The agricultural lands where polluted water is used for growing crops in Tamil Nadu, India (Bhargava *et al*. 2006). Irrigation water quality directly affects soils and crops, and their management. It is possible to produce high quality crops only by using high-quality irrigation water when other inputs are kept optimal. With the source of the water there is a variation in characteristics of irrigation water. Due to variation of geology and climate results regional differences in water characteristics and climatic parameters' are the most important factors related to irrigation (Shirazi *et al.*, 2011). Moreover, there may also be great differences in the quality of water available on a local level depending on whether the source is from surface water bodies (e.g., rivers and ponds) or from aquifers with varying geology, and whether the water has been chemically treated. The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plant availability of nutrients (Ayers and Westcot, 1985; Rowe *et al.*, 1995). An important chemical parameter for judging the degree of suitability of water for irrigation is sodium content or alkali hazard, which is expressed as the sodium adsorption ratio (SAR). SAR measures the potential dangers posed by excessive sodium in irrigation water (Alagbe, 2006). It is recognized that the statistical approach (geostatistical methods or Kriging), has several advantages over the deterministic techniques.The fact of giving unbiased predictions with minimum variance and taking into account the spatial correlation between the data recorded at different locations is an important advantage of Kriging. Moreover, besides interpolation, Kriging provides information on interpolation errors. Such values can be mapped to generate error surfaces which inform about the reliability of estimates. (Gorai and Kumar, 2013).Geostatistics and Geographical Information System (GIS) are extensively used in assessing spatial and temporal variation of soil and water properties (Cemek *et al.* 2007). Arslan (2012) evaluated changes in groundwater salinity from 2004 to 2010 by Ordinary Kriging (OK) and Indicator Kriging (IK). Kai-Li *et al.* (2011) analyzed spatial and temporal changes in soil salinity by OK in China between 1981 and 2008 and they found that salinity of topsoil gradually decreased during the study time. Wang *et al.* (2008) studied changes in salinity, groundwater depth, and soil management practices from 1983 to 2005 using classical statistics, geostatistics.
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2. Study Area

The study was carried out in Tehsil Uthal, District Lasbella. It lies in south of Balochistan; it is dry sub-tropical region. Uthal is lying between the latitudes of 25^{o} 66 North and the longitudes of 66^{o} 37 East. The soil texture Uthal is alluvial, and is composed of light loose clay, mixed with fine sand.

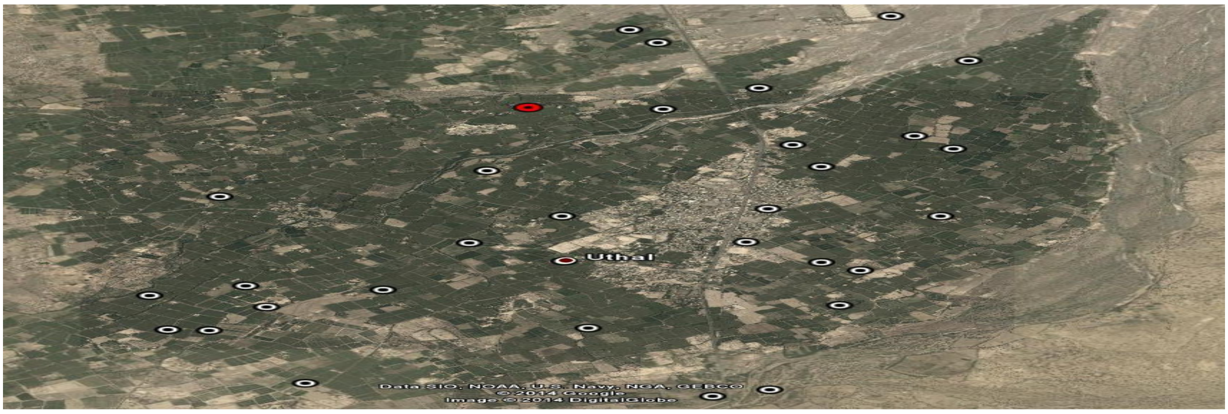

Figure 1 Study Area Map

2.2 Materials and Methods

Water samples for determining the water quality in general and other elements were collected in 1.0 liter plastic bottles according to standard methods. Before collecting the samples, the bottles were washed properly and rinsed thoroughly with distilled water so as to remove any contamination. Electrical Conductivity (EC), Total Dissolved Salts (TDS) and pH in groundwater samples were determined by portable conductivity meter. The concentration of Na was determined in the water sample by using flame photometer using appropriate standard following Richard (1954). Ca^{+2} + Mg^{+2} was be determined by Titration method. SAR was determined by determination of sodium through Flame photo meter by using standard procedures**.** The readings taken by GPS in degrees and minutes were changed to meters and kilometers using Google Earth software. Soil test values at un-sampled locations were interpolated using geostatistical technique of kriging and detailed contour maps were prepared at smaller grid spacing by using Surfer 32 (Rashid and Bhatti, 2005).

3. Results and Discussion

In this chapter results related to the groundwater quality, the effect of water quality on soils and yield of major crops (Banana and Cotton) in Tehsil Uthal, District Lasbela are presented and discussed. Water quality parameters were compared with standards developed by research organization.

3.1 Chemical Parameters for Groundwater

3.1.1 Electrical Conductivity (EC_w)

Table 4.1 shows that the groundwater samples which were taken from different locations had an average EC_w value of 1.89 dS/m. The EC_w ranged between the lowest values (0.99 dSm^{-1}) in all locations to the highest value (2.8 dSm^{-1}). Average values verify that the groundwater salinity of the study area lies in the moderate range. According to the FAO for Irrigation Water (1974) the groundwater samples collected at different sites 0% of the samples were non saline while most of the samples (97%) were moderately saline, which include some samples of highly saline (3%) as well. This is confirmed by Thirumathal and Sivakumar (2003) who reported after finding that the EC_w of groundwater in Haryana (India) 63.4% of the samples had EC_w values <4 dSm^{-1} with respect to the other samples having EC_w values >4 dSm^{-1} which were falling either in saline or SAR categories. However in this study maximum no of samples fall in the category of marginally saline or slight to moderate due to the reason that 97% of soil samples have EC_w less than 3.

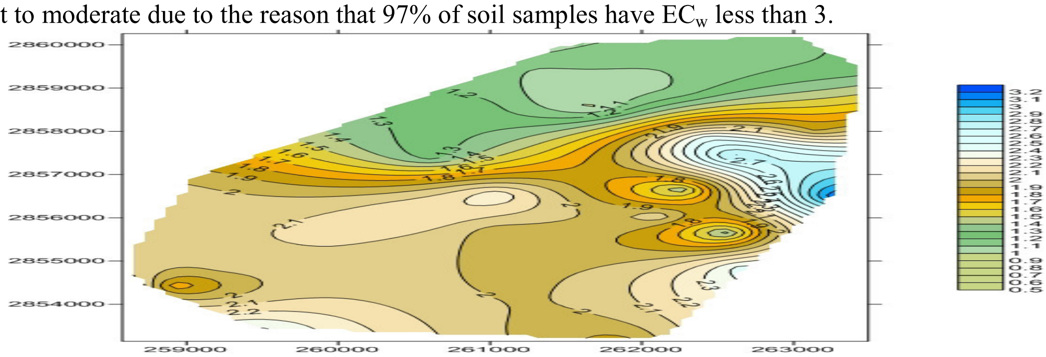

Figure 3.1 Electrical Conductivity contour Map of the Study Area

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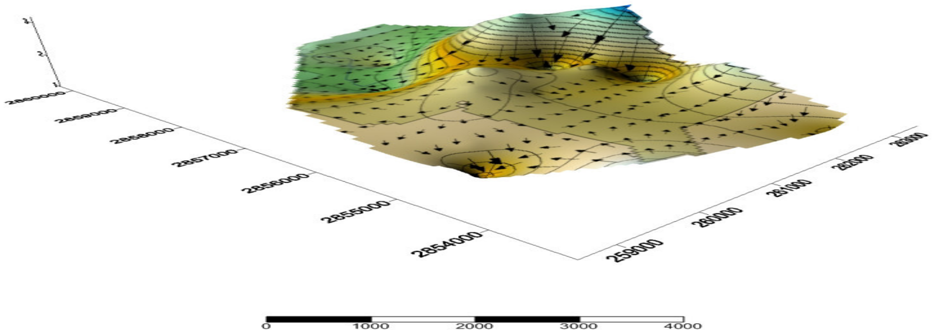

Figure 3.2 Flow of Electrical Conductivity in the Study Area

Table 3.1 Average Water Quality Parameters at Different Locations

Parameters	**Minimum**	**Maximum**	**Average**	**Standard Deviation**
EC_w (dSm^{-1})	0.99	2.8	±1.89	0.49
pH	6.8	8.2	±7.5	0.31
TDS (mgL^{-1})	697	2032	±1365	411
HCO_3^-	1.8	2.5	±2.15	2.20
SO_4^- ($meql^{-1}$)	7.9	14.1	±11.1	1.38
SAR	6.7	7.2	±6.95	7.60

3.1.2 Sodicity of Groundwater

The groundwater sodicity status of different sites is shown in the Figure 4.2.The groundwater samples which were taken from different locations had average SAR contents of 6.95 which falls in the moderate range according to FAO for Irrigation Water (1974). The SAR values determined at different sites ranged from 6.7 to 7.2. The water samples collected at different sites 0% of the samples were non range while most of the samples (78%) were moderately range, which include samples in severe range (22%) as well. These results are similar to those reported by Phogat *et al.* (2004) after conducting their experiment and said that high SAR saline category accounted for 10.45% samples. The samples in sodic classes were 2.99, 8.21 and 18.66% which were in following categories of marginally alkali, alkali and high alkali classes. According to Ayer and Westcot (1985) who stated that in irrigation water having low SAR prefers dilution of calcium and magnesium over sodium. Sodicity is not big problem in sandy soils because sandy soils have good infiltration characteristics.

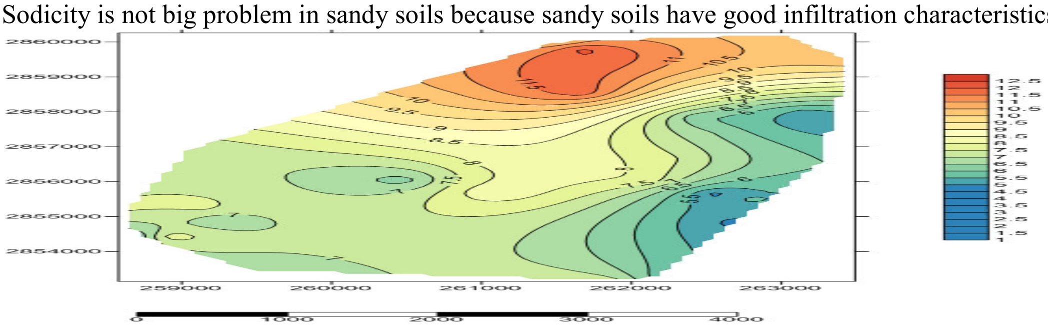

Figure 3.3 SAR contour Map of the Study Area

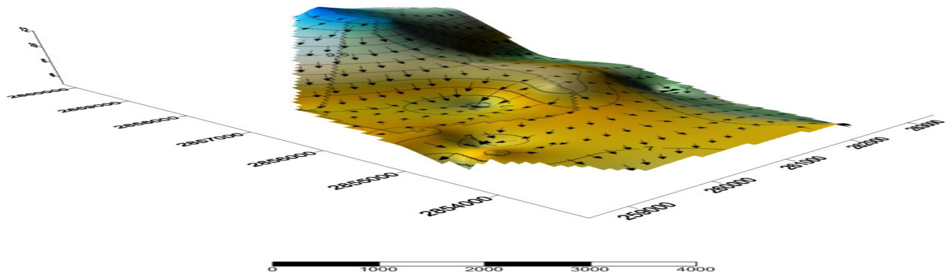

Figure 3.4 SAR Flow Map of the Study Area

3.1.3 pH

The pH of groundwater samples ranged from 6.8 to 8.2. The average pH value was 7.5. According to Shainerg and Oster (1986) the pH of water is not an accepted criterion for water quality because it changes in soil. Hence most of the crops tolerate a wider range of pH.

3.1.4 Total Dissolved Salts (TDS)

The average value of TDS in groundwater samples was 1365 mgL^{-1}. The minimum and maximum values were 697 to 2032 mgL^{-1}. Average value verifies that the groundwater salinity of the study lies in the moderate range. According to the FAO for Irrigation (1974) the groundwater samples collected at different sites were absent in none range while most of the samples (94%) were moderate range, which include some samples of highly severe range (6%) as well. According to Thirumathal and Sivakumar (2003) who found that TDS ranged for 86-1165 450 mgL^{-1}. However in this study the TDS concentration in groundwater is more than reported by the author.

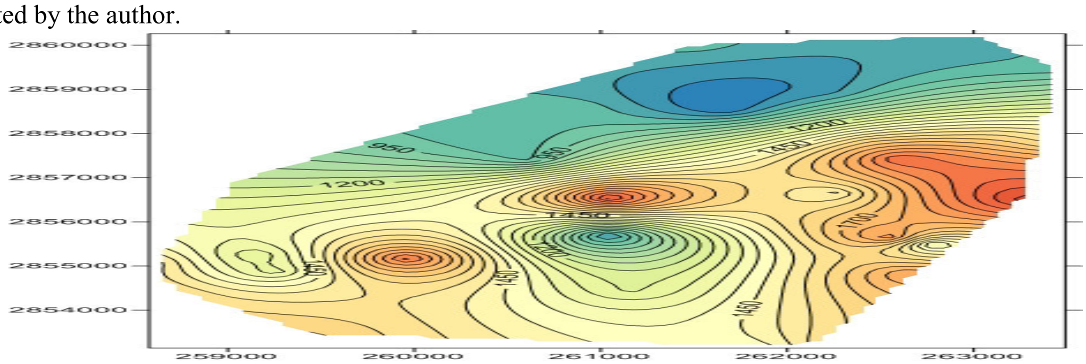

Figure 3.5 TDS Contour Map of the Study Area

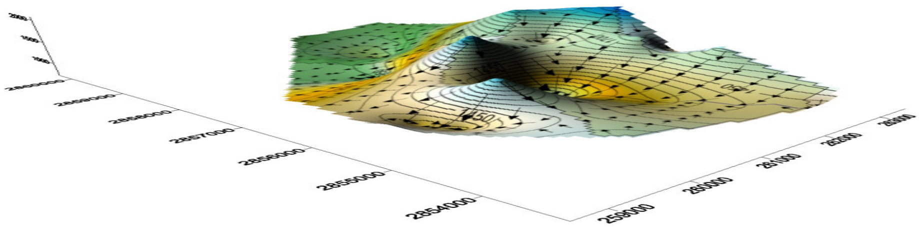

Figure 3.6 TDS Flow Map of the Study Area

3.2 Soluble Anions of Groundwater

3.2.1 Carbonate Concentration

Carbonates were totally absent in the groundwater samples due to the reason that most of the samples were saline in nature. Generally the saline soils do not contain carbonate contents. The results were similar to those reported by Phogat *et al.* (2004) that HCO_3^- were in appreciable quantities quantities in the irrigation water, while CO_3^-were in absent.

3.2.2 Bicarbonate Concentration

The bicarbonates having values 0 to 10 $meql^{-1}$ lies in acceptable range. While the groundwater used for irrigation ranged between 1.8 to 2.5$meql^{-1}$. It indicates that bicarbonate is not a problem in groundwater. However Sarkar and Hassan (2006) reported that the RSC values were higher (3.26 to 4.16 $meql^{-1}$) than the permissible limits (>2.5 $meql^{-1}$) due to higher HCO_3^- content in the irrigation water. The higher may induce some permeability problem. However in this study bicarbonates are in acceptable range which did not too much affected the quality of groundwater.

4.2.3 Sulphate in Groundwater

The table 3.1 shows that the groundwater for irrigation contain sulphate contents which ranged from 7.9 to 14.1 $meql^{-1}$ makes an average of 11.1 $meql^{-1}$. All the water samples from different sites lie in this in range indicates that sulphate is not problem in groundwater concerned.

Conclusions

The EC_w shows that the groundwater of the area is saline. On basis of EC_w 97% ranges between moderate level and 3% of the region the groundwater is in severe class.The average SAR value of 6.95 indicates that the study area is in the moderate range. With in the area of 78% of groundwater were marginal and 22% were severe to be utilized for irrigation. Average value verifies that the TDS groundwater salinity of the study lies in the moderate range. Carbonates were totally absent in the groundwater samples due to the reason that most of the samples were saline in nature. Bicarbonates are in acceptable range which did not too much affected the quality of groundwater.

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