

## Assessing Geo-Spatial Distribution of Soil Profile: A study of Bardoli, Mandvi and Umarpada Talukas

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### ABSTRACT

Concentration of soil chemical properties and its nutrients has always been a matter of concern for farmers to optimize usage of fertilizers to improve agricultural yield. The basic aim of this paper is to assess the spatial distribution of relevant chemical properties, macro and micro nutrients of the sugarcane fields located in three talukas of Surat district situated in the state of Gujarat. The paper highlights the soil quality between three talukas using descriptive statistics namely average, minimum and maximum values have been used to compare with the soil standard values for this region. Further correlation is also used to know the impact of soil chemical properties on its micro and macro nutrients. R platform have been used to carry out the calculations. The results indicated that soil structure is similar and poor for Bardoli and Umarpada talukas as compared to Mandvi taluka. Thus paper draws an attention towards gradual degradation in soils of these regions.

### KEYWORDS

*Descriptive statistics, Correlation, Soil, chemical properties, nutrients.*

### 1. INTRODUCTION

Soil health plays an important role for agricultural yield for a country like India where agriculture is at the core. Correlation analysis to study the chemical properties namely P, K, C and S of the soils of Kutch district of Gujarat has been carried out and soil fertility status have been presented [1]. Further fertility of the soil is also compared with the standard limits for fertility [2]. Usage of mean, and min and max to study the soil chemical properties and used bar graphs have been presented in literature [3, 4]. Southern Gujarat soil have been highlighted from spatial variability point of view in [6, 7, 8]. Therefore this paper emphasizes southern part of Gujarat state especially on district Surat mainly with three talukas Bardoli, Umarpada and Mandvi. Moreover, all the representations have been made in R platform using R studio an open source platform for spatial and non-spatial data.

**Table 1. Soil sampling profile**

Talukas	Number of Villages	Sample Size
Bardoli	13	1620
Umarpada	43	2910
Mandvi	47	5610
Total	103	10140

**Table 2. Standard Ratings for classification of soil chemical properties**

Soil Properties & Nutrients	Rating		
	Low	Medium	High
pH(1:2)	<6.5	6.5-7.5	>7.5
EC(ds/m)	<0.8	0.8-2.5	>2.5
OC (%)	<0.5	0.50-0.75	>0.75
K(kg/ha)	<108	108-280	>280
Ca (Meq/100gm)	6.0 to 18.0		
Mg (Meq/100gm)	2.0 to 10.0		
P(kg/ha)	<28	28-56	>56
S(ppm)	<10	10-20	>20
Fe	<4.0	4.0-10.0	>10
Mn	<1.2	1.2-6.0	>6
Zn	<1.0	1.0-5.0	>5.0
Cu	<0.3	0.3-3.0	>3.0

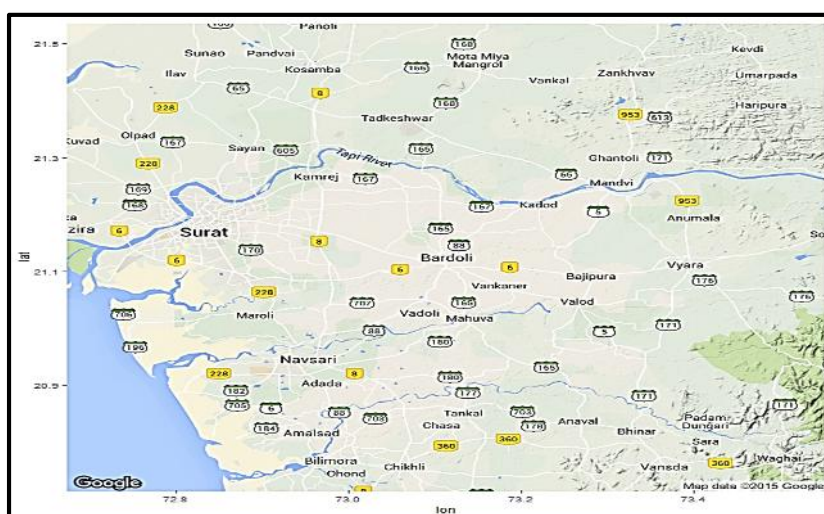
## 2. MATERIALS AND METHODS

### 2.1. Study Area

The study area highlighted in this paper is three talukas of district Surat that falls in the southern region of Gujarat with minimum latitude value of  $20.97^{\circ}$  and maximum  $21.51^{\circ}$  whereas the range of longitude is between  $72.77^{\circ}$  and  $73.79^{\circ}$ . The soil sample dataset under consideration is of three talukas of Surat namely Bardoli, Mandvi and Umrpada for the March (2013). The major crops yielded in this area as taken in this study are sugarcane, banana, tuwar, jowar, dangar, wheat and cotton. The basic soil type found in these regions is mainly deep black or medium black. Moreover, few areas do have sandy loamy soils. The sampling profile is depicted in Table 1. Figure represents the map that has been prepared using qmap function of R.

### 2.2. Tools and Techniques

R 3.2.2 version along with R Studio is used to calculate descriptive statistics which is presented in Figure 2. Mean, Median, Quartiles have been calculated to understand the central tendency of the soil values. Minimum and maximum values to represent extreme values if any. Standard deviation is used to understand the variation. Correlation analysis is employed to present the relationship amongst the soil basic properties (pH, EC, OC) that with soil macro and micro nutrients.


**Fig. 1. Map of Surat district with 3 talukas using qmap() in R**

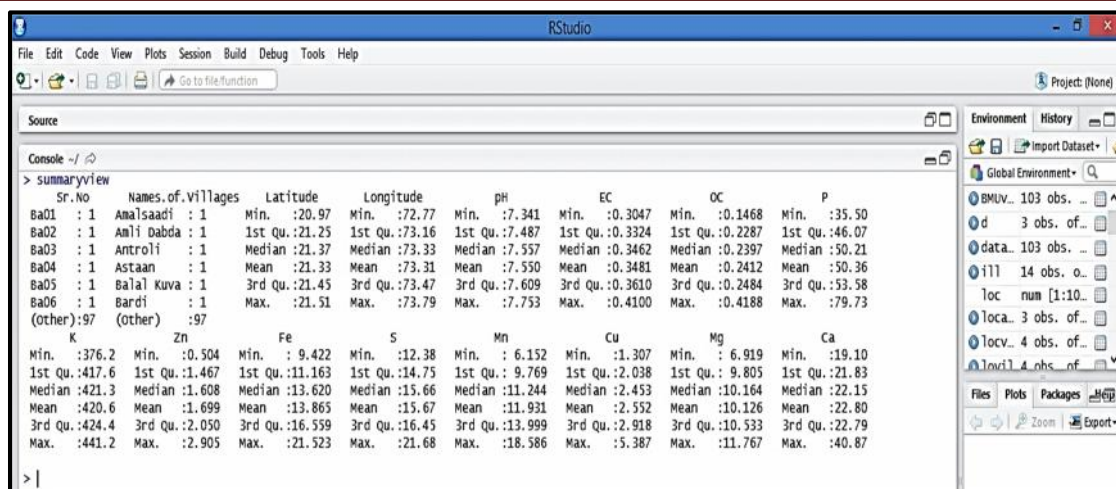


Fig. 2. Showing summary and descriptive statistics using summary () command in R

Table 3. Showing Descriptive Statistics of pH, EC, OC and K

Measures	Soil Property											
	pH			EC			OC			K		
	B	M	U	B	M	U	B	M	U	B	M	U
Min	7.5	7.3	7.4	0.3	0.3	0.3	0.2	0.2	0.2	414	376	402
Max	7.68	7.6	7.8	0.4	0.4	0.4	0.3	0.3	0.4	426	431	441
Mean	7.61	7.5	7.6	0.4	0.4	0.4	0.2	0.2	0.3	421	421	421
Q1	7.56	7.5	7.56	0.3	0.3	0.3	0.2	0.2	0.2	418	417	417
M	7.62	7.5	7.6	0.4	0.3	0.4	0.2	0.2	0.2	420	422	420
Q3	7.64	7.5	7.62	0.4	0.4	0.4	0.2	0.3	0.3	423	425	424
S.D.	0.1	0.1	0.1	0	0	0	0	0	0	3.2	9.1	6.7

Table 4. Showing Descriptive Statistics of Ca, Mg, P and S

Measures	Soil Property											
	Ca			Mg			P			S		
	B	M	U	B	M	U	B	M	U	B	M	U
Min	21.4	21.3	19.1	9	9.54	6.92	43.9	49.8	35.5	14.5	13.8	12.4
Max	22.3	23.1	40.9	11.1	11.2	11.8	53.8	68.4	79.7	18	18	21.7
Mean	22	22.2	23.6	10.2	10.2	9.99	49.8	54.6	46.7	16.3	15.5	15.6
Q1	21.8	21.8	21.9	10.1	9.94	9.56	47.5	52.2	44.6	15.6	14.8	14.2
M	22	22.1	22.4	10.3	10.3	9.99	50.3	53.9	46.1	16.3	15.6	15.7
Q3	22.2	22.4	23.6	10.6	10.5	10.5	52.2	55.1	48	17.2	16.1	16.8
S.D.	0.3	0.5	4.6	0.5	0.4	0.9	3.1	3.4	5.6	1.1	1	1.8

**Table 5. Showing Descriptive Statistics of Fe, Mn, Zn, Cu**

Measures	Soil Property											
	Fe			Mn			Zn			Cu		
	B	M	U	B	M	U	B	M	U	B	M	U
Min	10.7	12.6	9.42	6.15	9.95	7.35	0.5	1.1	0.6	1.3	1.9	1.7
Max	13.7	21.5	14.9	10.8	18.6	14.6	2	2.9	2.3	2.4	5.4	4
Mean	11.8	16.8	11.7	8.88	13.6	11.2	1.3	1.8	1.8	1.9	2.6	2.7
Q1	11.2	15	9.95	7.82	11	9.22	0.9	1.5	1.6	1.5	2	2.4
M	11.6	17.3	11.2	9.68	13	11.2	1.5	1.5	1.9	2	2.3	2.8
Q3	12.3	18.8	13.9	9.86	17	13.8	1.8	2.2	2.1	2.3	3.1	2.9
S.D.	0.8	2.3	1.8	1.5	2.9	2.4	0.5	0.5	0.5	0.4	0.7	0.5

### 3. RESULTS AND DISCUSSION

This section emphasizes upon the results and analysis of the soil samples. The standard limits of the soils have been taken from general interpretation of soil properties (followed by MMSOIL-Gov. of India-2011 in Table 2. The mean in Table 3 specifies that pH content in soils of Bardoli and Umarpada is on an average 7.61 which is higher than the standard value which indicates poor soil structure with high alkalinity and soils in future may turn out to be hard. In-case of Mandvi average value 7.48 indicates that soils are neither alkaline nor acidic. The average EC contents in all the three talukas is 0.36 and 0.35 respectively thus soils are not saline. While the OC coverage is low with an average of 0.15 and 0.21 which means the soils have low mineral holding capacity, which in turn is dangerous for fertility because micro-organism formation in such type of soils is low thus affects growth and production of plants in these regions.

The average values of K that is potassium is 420 in all the talukas that means soil enjoys “luxury consumption” situation. Potassium helps in tissue building, growth, efficient water usage, protein production etc.

**Table 6. Correlation Matrix of soil chemical properties and nutrients**

Soil Properties	Bardoli			Mandvi			Umarpada		
	P.H	E.C	O.C	P.H	E.C	O.C	P.H	E.C	O.C
P.H	1	-	-	1	-	-	1	-	-
E.C	0.30	1	-	-0.07	1	-	-0.13	1	-
O.C	0.36	-0.02	1	-0.23	0.10	1	0.26	-0.19	1
P	-0.33	0.43	-0.31	-0.09	-0.09	-0.26	0.07	0.01	-0.02
K	0.14	-0.16	0.57	0.05	-0.35	-0.09	-0.04	-0.04	0.46
Zn	-0.51	-0.22	-0.48	0.49	0.07	0.10	0.13	-0.19	-0.06
Fe	-0.46	0	0.04	0.15	-0.14	-0.68	-0.15	-0.09	-0.21
S	0.07	0.68	-0.37	-0.08	0.18	0.27	0.12	0.38	-0.17
Mn	-0.21	-0.51	-0.36	-0.12	-0.03	0.32	-0.18	-0.01	-0.26
Cu	-0.16	0.10	0.13	0.26	0.06	-0.06	-0.05	-0.11	0.02
Mg	-0.32	0.06	-0.13	0.21	0	-0.06	-0.09	0.28	0.06
Ca	-0.01	-0.19	-0.04	-0.01	0.13	-0.20	0.13	-0.08	-0.01

+r indicates increase or decrease of the chemical properties or nutrients causes equal effect on the other.

-r indicates increase or decrease of the chemical properties or nutrients causes inverse effect on the other.

The calcium (Ca) content in Table 4 shows an average of 22.26 for Bardoli, 22.26 for Mandvi and 40.87 for Umarpada which is high as per the standards. Soil rich in Ca assists in regulating other nutrients, hence plants with this level have good structure, but if mixes with other minerals adversely make soils saline. The magnesium levels are high for are high with mean values of 10.22, 10.24 and 9.99 respectively resulting into appropriate regulation of chlorophyll but if it's too high than the soils in near future might turn saline. The Phosphorous level in the soils ranges from 46 to 54 for the three talukas which means it is within the standard limits and are adequate enough to generate good energy agent as well as Nitrogen and other nutrients amongst the plants of these regions.

The Sodium contents are scattered with an average of 15.5 to 16 that means younger plants are likely to have good tissues with adequate quality of amino acids and vitamins. On the contrary Iron and Manganese contents are alarming with higher average of 11.8 and 8.88 respectively for Bardoli, 16.8 and 13.64 for Mandvi, 11.7 and 11.21 for Umarpada as shown in Table 5. Increase in Fe and Mn have close relations with increase in pH levels thereby increasing the risk of toxicity in soils and also might lose the capacity of holding these minerals due to higher content. However, adequate levels of Mn is very important for photosynthesis in the plants. Finally zinc and copper are in acceptable level indicating apt formation of enzymes and DNA transcription followed by suitable growth and productivity amongst the plants. Table 5 shows the correlation matrix for all the talukas which indicates that pH has positive correlation with EC, OC, K and S for Bardoli, whereas for Mandvi pH has positive correlation with K, Zn, Fe, Cu and Mg. For Umarpada pH shows positive relationship with OC, P, Zn, S and Ca, which mean increase or decrease in pH will have a corresponding increase or decrease in above chemical properties or nutrients and vice versa. While analyzing the correlation of EC it was found that for Bardoli it had positive correlation with P, S, Cu and Mg, for Mandvi it had positive association with OC, Zn, S, Cu, Mg, Ca whereas as for Umarpada it has positive correlation again with P, S and Mg only. While EC had positive correlation with K, Fe, Cu for Bardoli, with Zn, S, Mn for Mandvi and with K, Cu and Mg for Umarpada.

Negative correlation persisted between pH and P, Zn, Fe, Mn, Cu, Mg, and Ca for Bardoli which means increase in the value of pH would correspondingly decrease in the values of above nutrients and vice versa. Likewise negative correlation between pH and EC, OC, P, S, Mn, Ca was found for Mandvi and for Umarpada negative correlation existed amongst pH and EC, K, Fe, Mn, Cu and Mg. EC had negative correlation with OC, K, Zn, Fe, Mn and Ca for Bardoli, with P, K, Fe and Mn for Mandvi and finally for Umarpada it was with OC, K, Zn, Fe, Mn, Cu and Ca. Correlation interpretation for OC showed negative association with (P, Zn, S, Mn, Mg, Ca), (P, K, Fe, Cu, Mg, Ca) and (P, Zn, Fe, S, Mn, Ca) respectively for the three talukas.

#### 4. CONCLUSION

From the correlation analysis it can be concluded that soil profiles of Bardoli and Umarpada are much similar as compared to Mandvi, which proves that soils located nearby have more or less the same properties than those which are located far off. Higher pH & Fe values for both Bardoli and Umarpada as well as lower Organic Carbon(OC) and Mn levels for all the three talukas indicates poor soil structure with alkalinity and toxicity further leading to low mineral holding capacity of these soils which is a danger for fertility. On the contrary the penetration of EC and other soil macro and micro nutrients is adequate which reveals that the quality of soil still enjoys luxury which respect to Zn, Cu, P, S, Mg and Ca. Thus this study will help the policy makers to take appropriate actions to restore the fertility of the soils in these regions. Further, this study can be enhanced for geo-spatial variability by studying spatial correlation between the talukas[7], predicting soil properties at an unknown location with given sample points through various kriging techniques..

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